Current Concepts of Physical Therapy Patient Management The Knee

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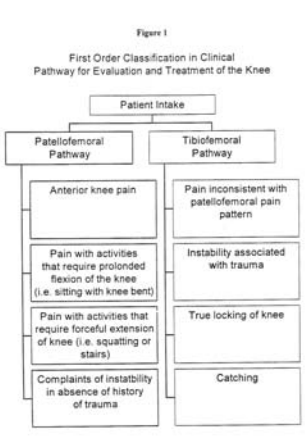
The Plan

- Anatomy and Biomechanics
- Evaluation
- Diagnosis
- Modalities and Intervention
- Procedure Modified and Pathology Modified Rehab Guidelines
- ACL
- PCL
- Collaterals
- PFJ
- Special Conditions
- OA/TKA
- Arthrofibrosis

Clinical Pathway for the Rehabilitation of the Knee

- History
- Relevant Tests
  - Look for sign or symptom
  - Administer Test
- Sequence Tests
- Cluster Results
  - Signs
  - Symptoms
  - Tests
- Weight and Combine
  - Confirm
  - Disconfirm
- Consider Diagnosis
- Use Best Available Evidence
  - Eval
  - Treatment



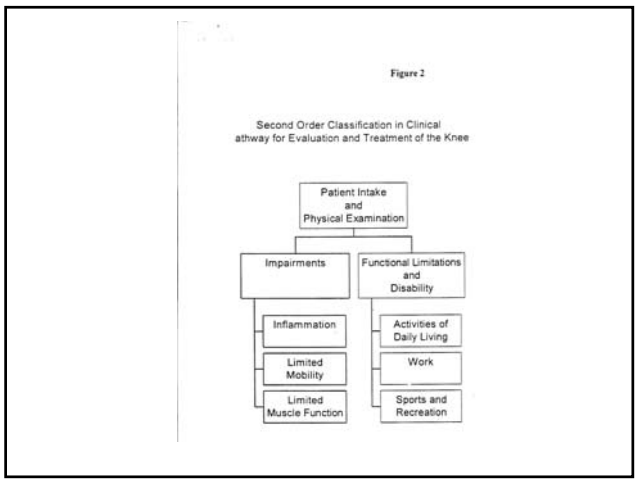
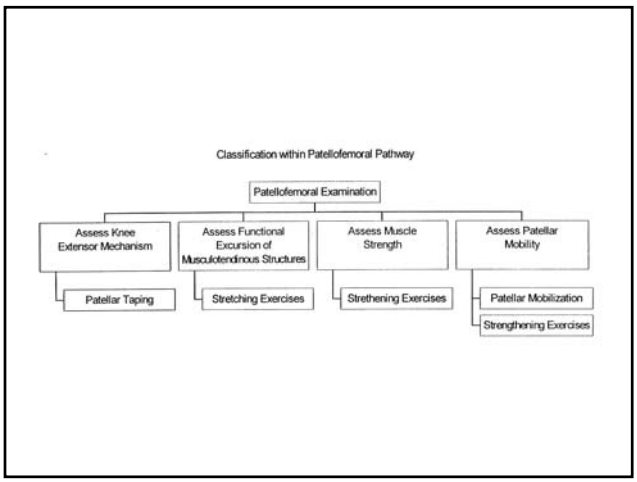
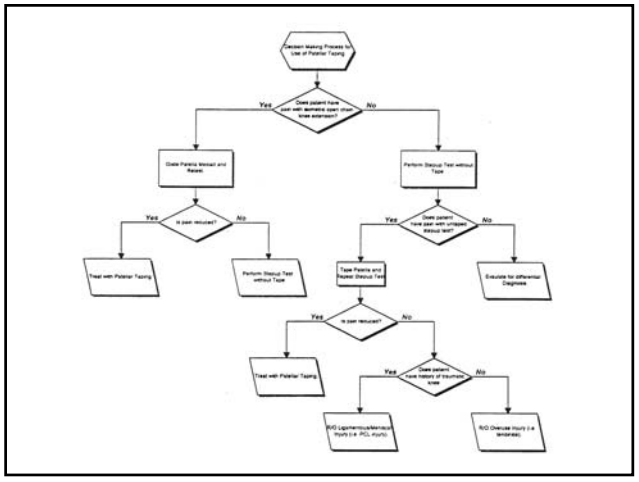
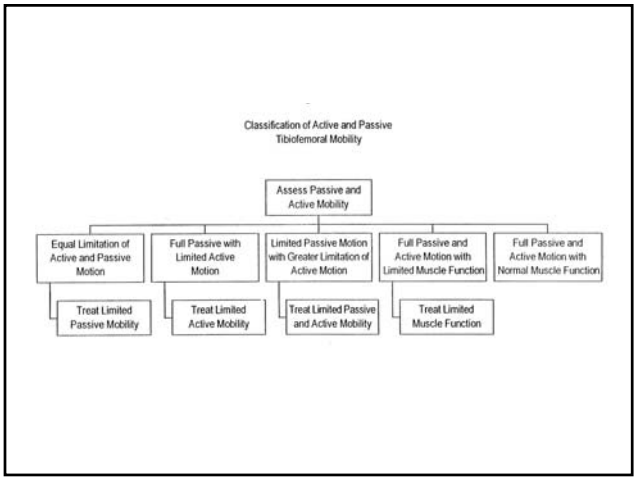
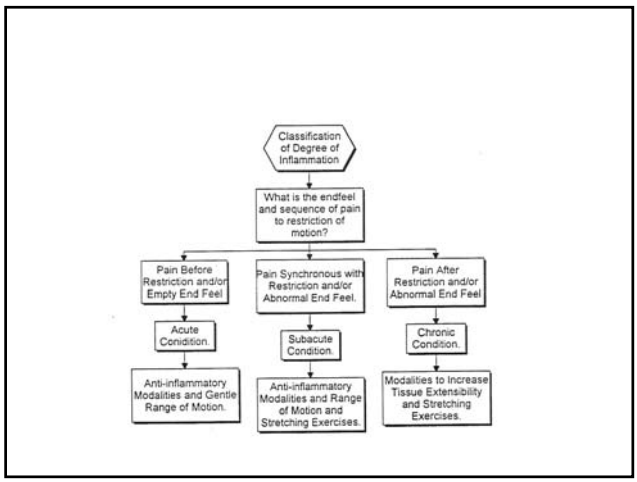


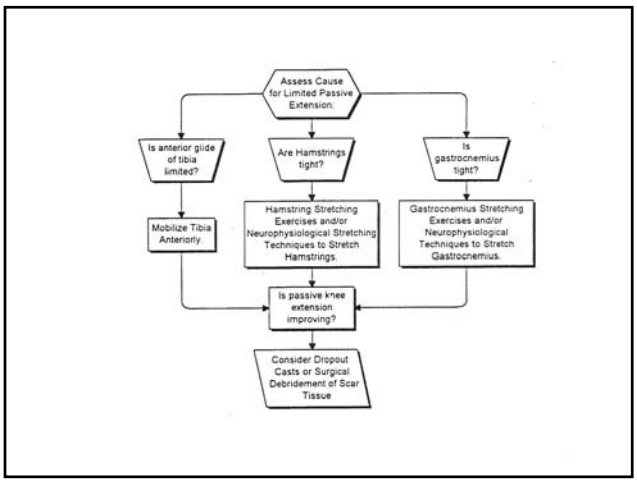
Figure 2
Second Order Classification in Clinical athway for Evaluation and Treatment of the Knee
Patient Intake and Physical Examination
Impairments
Functional Limitations and Disability
Inflammation
Limited Mobility
Limited Muscle Function
Activities of Daily Living
Work
Sports and Recreation

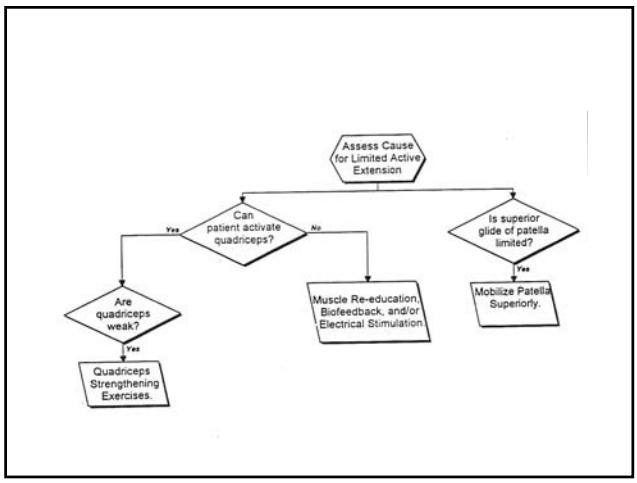

Classification within Patellofemoral Pathway
Patellofemoral Examination
Assess Knee Extensor Mechanism
Assess Functional Excursion of Musculotendinous Structures
Assess Muscle Strength
Assess Patellar Mobility
Patellar Taping
Stretching Exercises
Strethening Exercises
Patellar Mobilization
Strengthening Exercises

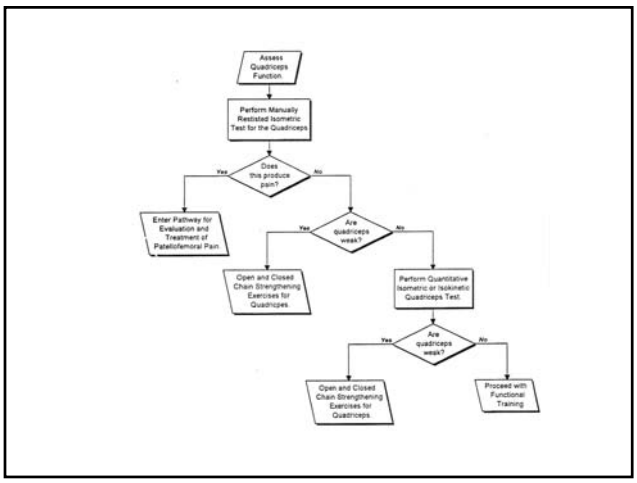

Yes
No


Classification of Active and Passive Tibiofemoral Mobility
Assess Passive and Active Mobility
Equal Limitation of Active and Passive Motion
Full Passive with Limited Active Motion
Limited Passive Motion with Greater Limitation of Active Motion
Full Passive and Active Motion with Limited Muscle Function
Full Passive and Active Motion with Normal Muscle Function
Treat Limited Passive Mobility
Treat Limited Active Mobility
Treat Limited Passive and Active Mobility
Treat Limited Muscle Function


Classification of Degree of Inflammation
What is the endfeel and sequence of pain to restriction of motion?
Pain Before Restriction and/or Empty End Feel
Pain Synchronous with Restriction and/or Abnormal End Feel.
Pain After Restriction and/or Abnormal End Feel
Acute Conidition.
Subacute Condition.
Chronic Condition.
Anti-inflammatory Modalities and Gentle Range of Motion.
Anti-inflammatory Modalities and Range of Motion and Stretching Exercises.
Modalities to Increase Tissue Extensibility and Stretching Exercises.


Assess Cause for Limited Passive Extension:
Is anterior glide of tibia limited?
Are Hamstrings tight?
Is gastrocnemius tight?
Mobilize Tibia Anteriorly.
Hamstring Stretching Exercises and/or Neurophysiological Stretching Techniques to Stretch Hamstrings.
Gastrocnemius Stretching Exercises and/or Neurophysiological Techniques to Stretch Gastrocnemius.
Is passive knee extension improving?
Consider Dropout Casts or Surgical Debridement of Scar Tissue


Assess Cause for Limited Active Extension
Can patient activate quadriceps?
Yes
No
Is superior glide of patella limited?
Yes
Are quadriceps weak?
Yes
Muscle Re-education, Biofeedback, and/or Electrical Stimulation.
Mobilize Patella Superiorly.
Quadriceps Strengthening Exercises.


Assess Quadriceps Function.
Perform Manually Resisted Isometric Test for the Quadriceps
Does this produce pain?
Yes
No
Enter Pathway for Evaluation and Treatment of Patellofemoral Pain
Are quadriceps weak?
Yes
No
Open and Closed Chain Strengthening Exercises for Quadriceps.
Perform Quantitative Isometric or Isokinetic Quadriceps Test.
Are quadriceps weak?
Yes
No
Open and Closed Chain Strengthening Exercises for Quadriceps
Proceed with Functional Training

Tibiofemoral vs Patellofemoral

- Mechanism of Injury
- Onset
- History of previous injury
- Swelling after Injury
- Symptoms

History

- Previous knee history
  - Old injuries may explain current symptoms
    - Old MVA with dashboard and PFJ symptoms with presence of a negative PFJ eval
  - Acute Injury or Acute on Chronic
  - Specific Symptoms
    - Giving Way- ligamentous
    - Locking- loose body
    - Pain from overuse or trauma
    - Stiffness and weakness

Injury Onset

- Traumatic vs Gradual Onset
  - Ligament, meniscus, bone bruise, muscle
- Ability to Bear Weight
  - Ottawa Knee and Ankle Rules
- Pain
  - Identify underlying structure
    - Posterior knee- Baker's cyst, posterior lateral corner, popliteus, gastroc
- Knee Pain as referral from spine
  - Anterior- L2-4, Posterior SIJ, Sciatic, Nerve Root
- Knee Pain as referral from other problem

- **Ottawa knee rules**
- A knee x-ray is only required for knee injury patients with any of these findings:
- age 55 or over
- isolated tenderness of the patella (no bone tenderness of the knee other than the patella)
- tenderness at the head of the fibula
- inability to flex to 90 degrees
- inability to weight bear both immediately and in the casualty department (4 steps - unable to transfer weight twice onto each lower limb regardless of limping).

Health Status Indicies

- SF- 36
- Sickness Impact Profile
- Kinesophobia

"We can't find anything wrong with you, so we're going to treat you for Symptom Deficit Disorder."

Lower Extremity Functional Scale

We are interested in knowing whether you are having any difficulty at all with the activities listed below because of your lower limb problem for which you are currently seeking attention. Please provide an answer for **each** activity.

Today, do you or would you have any difficulty at all with:

(Circle one number on each line)

Activities	Extreme Difficulty or Unable to Perform Activity	Quite a Bit of Difficulty	Moderate Difficulty	A Little Bit of Difficulty	No Difficulty
a. Any of your usual work, housework, or school activities.	0	1	2	3	4
b. Your usual hobbies, recreational or sporting activities.	0	1	2	3	4
c. Getting into or out of the bath.	0	1	2	3	4
d. Walking between rooms.	0	1	2	3	4
e. Putting on your shoes or socks.	0	1	2	3	4
f. Squatting.	0	1	2	3	4
g. Lifting an object, like a bag of groceries from the floor.	0	1	2	3	4
h. Performing light activities around your home.	0	1	2	3	4
i. Performing heavy activities around your home.	0	1	2	3	4
j. Getting into or out of a car.	0	1	2	3	4
k. Walking 2 blocks.	0	1	2	3	4
l. Walking a mile.	0	1	2	3	4
m. Going up or down 10 stairs (about 1 flight of stairs).	0	1	2	3	4
n. Standing for 1 hour.	0	1	2	3	4
o. Sitting for 1 hour.	0	1	2	3	4
p. Running on even ground.	0	1	2	3	4
q. Running on uneven ground.	0	1	2	3	4
r. Making sharp turns while running fast.	0	1	2	3	4
s. Hopping.	0	1	2	3	4
t. Rolling over in bed.	0	1	2	3	4
Column Totals:					

SCORE: _____/80

Knee Questionnaire Indices.*

Indices	Indication	MCD	Comment
Western Ontario and McMaster Universities Osteoarthritis Index	Osteoarthritis Total Knee Arthroplasty	Pain subscale: 22.39 Stiffness subscale: 29.12 PF subscale: 13.11 Other: 14	Strong for pain, stiffness, and physical function in osteoarthritis
International Knee Documentation Committee Questionnaire	Knee ligament injury	11.5	Not sensitive for sports-related function May overestimate the disability of an injury
Lysholm Knee Score	Ligament and meniscal injuries	10 points	Evidence for usefulness in inconclusive
Cincinnati Knee Rating System	Nonspecific knee	Pain 2.45 Swelling 2.86 Partial Giving way 2.82 Full giving way 2.30	Responsive for changes in pain, swelling, giving way, symptoms, sports function and overall rating
Knee Outcome Survey	Nonspecific knee	8.87	Responsive for functional limits for a variety of impairments
Lower Extremity Function Scale	All lower-extremity conditions	9	Useful with patients following arthroplasty and lower extremity conditions of musculoskeletal origin

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Swelling and Diagnosis

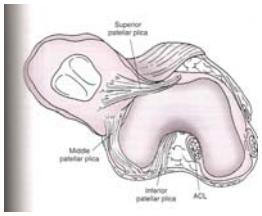
- < 2 hr ? Fracture
- Immediate- tense
  - ? PFJ Dislocation
- 2-12 hours
  - Intraarticular ligament
- 12-24 hours
  - Synovial swelling
  - ?meniscus
- Chronic
  - Meniscus or DJD

First Order Classification

- Patellofemoral
- Anterior Knee Pain
- Pain with Prolonged Sitting
- Pain with Stairs
- Impairments
- Tibiofemoral
- Absence of complaints related to PFJ
- Impairments
- Disability

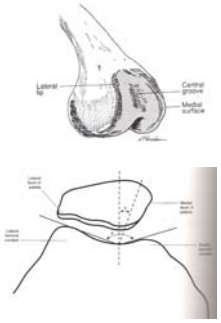
Tibiofemoral Joint

- Bi- convex Femoral Condyles
- Lateral condyle is larger A-P
- Medial condyle larger articulating surface with tibia
- Intercondylar notch



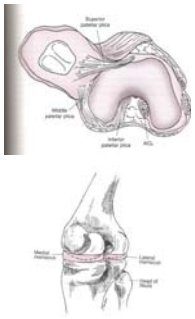
Trochlear Groove

- Higher Lateral Side
- Axial x-ray (Merchant)
  - Knee flexed to 45º
  - Sulcus angle
    - Groove depth
    - Shallow may increase risk
  - Congruence angle
    - Position of patella in groove
    - Lateral tilt may risk



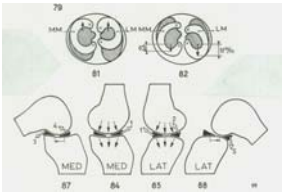
Tibial Plateaus

- Medial longer than lateral
- Flat plateau
  - Lack bony congruency
- Rely on meniscus to add stability
  - 70% load bearing
  - Thick centers
  - Thin Edges



Menisci

- Lateral Meniscus
  - Circular
  - Loose attachment to tibial plateau and lateral capsule
  - Lower incidence injury
- Medial Meniscus
  - "C" shaped
  - Firm attachment to tibial plateau and med capsule
  - Increased incidence injury
- Horns
  - End of circular shapes

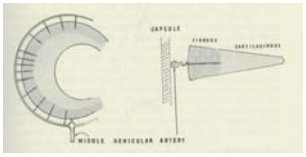


Motion of Menisci

- Extension
  - Femoral condyles cause menisci to move forward
  - Pull via menisco-patellar ligaments
- Flexion
  - Menisci move posterior
  - Semimembranosis link to medial meniscus
  - Lateral meniscus moves with action of popliteus
- External Rotation
  - Medial meniscus moves anteriorly
  - Lateral meniscus moves posteriorly
- Internal Rotation
  - Medial meniscus moves posteriorly
  - Lateral meniscus moves anteriorly
  - Lateral moves most (less injury)

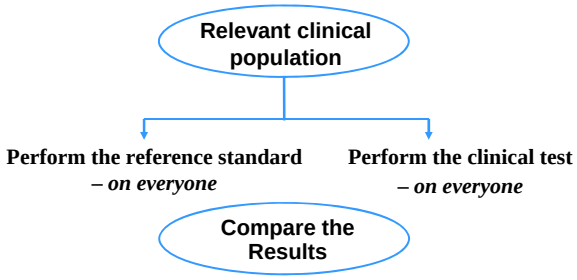
Meniscus Vascular Supply

- Red Zone
  - Outer 1/3 supplied by med geniculate artery
  - Good potential to heal
  - Meniscal repair
- White Zone
  - Low to Avascular
  - Low potential to heal
  - Menisectomy or fibrin clot



Good Test/ Measure

- A test must be reliable with and between raters and give the same results at different times
- How does the test compare with the truth?



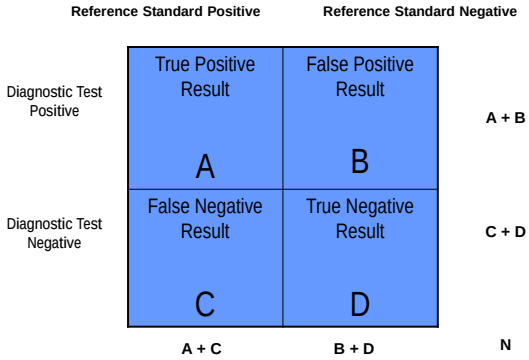
"The optimal design for assessing the accuracy of a test is a prospective blind comparison of the test with a reference or gold standard in a consecutive series of patients from a relevant clinical population"

(Lijmer et al, 1999)

SnNouts and SpPins

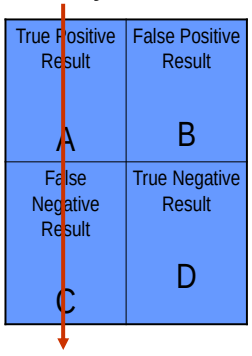
- Mnemonics to remember the most useful aspects of tests with moderate to high sensitivity and specificity
  - SnNout: A test with a high sensitivity value (Sn) that, when negative (N), helps to rule out a disease (out)
  - SpPin: A test with a high specificity value (Sp) that, when positive (P) helps to rule in a disease (in)

Contingency Table



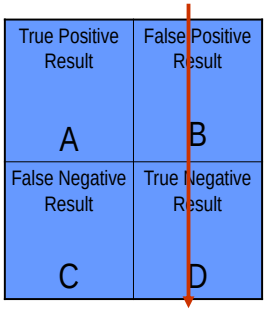
Definition: Sensitivity

- Sensitivity
  - Test's ability to obtain a positive test when the target condition is really present
  - Based on the True Positives
  - Calculated as:
    - A/(A + C)



Definition: Specificity

- Specificity
  - Test's ability to obtain a negative test when the target condition is really absent
  - Based on the True Negatives
  - Calculated as:
    - D/(B + D)



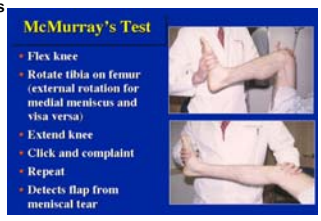
What are likelihood ratios?

- Positive likelihood ratio (LR+)
  - reflects the odds that a person who tests positive actually DOES have the disorder
- Negative likelihood ratio (LR–)
  - reflects the odds that a person who tests negative actually DOES NOT have the disorder

+LR	-LR	Interpretation
> 10	< .1	Large and conclusive shifts in probability
5-10	.1-.2	Moderate shifts in probability
2-5	.2-.5	Small shifts in probability
~~1-2~~	~~.5-1~~	~~Rarely alters probability to an important degree~~

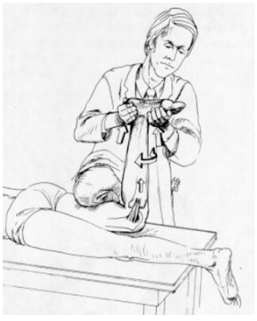
McMurray's Test

- Tests for meniscal injuries
  - Tibia IR
    - **Indicates lateral meniscus injury**
  - Tibia ER
    - **Indicates medial meniscus injury**
- (+) test is popping, clicking or locking of knee;
- pain or reproduction of symptoms
- Sens 58%, Spec 94%



Positive finding more meaningful than negative finding

Apley's Distraction Test



- Tests for meniscal or ligamentous lesions
- Distraction plus IR and ER
- Repeated with compression and IR/ER
- (+) test is pain that is eliminated (meniscal injury), or pain that is increased (ligamentous)

Meniscal Diagnosis

- Joint Line Tenderness
  - Medial joint line tenderness
    - Sens 45% spec 35%
  - Lateral joint line tenderness
    - Sens 57% spec 49%
- Cluster of Tests Outperforms any single test
- McMurray
- Apley
- Joint Line Tenderness
- Sens 78.8%
- Spec 79.3%

Meniscus

Meniscal Pathology Composite Score

- Hx Catching/Locking
- Joint line tenderness
- Pain with forced hyperextension
- Pain with maximal knee flexion
- Pain or audible click with McMurray

When 5 of 5 present
92.3% positive predictive value
Of meniscal tear
3 positive- 75%

- Thessaly test
- Locking or catching over medial or lateral joint line in unilateral stance at 5° of knee flexion and IR/ER active twist 3 reps
- Repeated at 20 °

Increased sensitivity at 20 ° for medial tear
59-89% Medial, 67-92% laterally
Specificity: 83-97% Med and 95-96% Lat
Positive pred value 69-92% med 35-85% Lat

Table 4. Special Tests

Structure to be assessed	Initial Test	Most Specific Test	Results and Indications
Medial collateral ligament (MCL)	Valgus stress full extension >5mm; check PCL and ACL	Valgus stress at 30º flexion > 5mm	Valgus stress at 30º flexion > 10 mm; check ACL
Lateral collateral ligament (LCL)	Varus stress full extension; check LCL, PCL, and ACL	Varus stress at 30º flexion isolates LCL	If laxity exists, LCL is injured; extent of injury dependent on excursion and end feel
Posterior cruciate ligament (PCL)	Posterior drawer	Posterior saf; quadriceps activation shows anterior translation of tibia	If laxity increases with posterior drawer in external rotation, evaluate posterolateral corner
Anterior cruciate ligament (ACL)	Anterior drawer > 6 mm	Lachman test with empty end feel	Pivot shift; arthrometer difference >3mm side-to-side
Posterolateral corner	Posterior drawer increased at 30º and normal at 90º	Posterolateral drawer	Prone external rotation test increased at 30º, not at 90º; l both, check PCL
Meniscus	Meniscal Pathology Composite Score Thessaly Test	History of catching or locking, joint line tenderness, pain with forced hyperextension, pain with maximal knee passive flexion, and pain or audible click with McMurray	If 5/5 present, 92.3% of positive meniscal tear; 75% if 3/5 are positive

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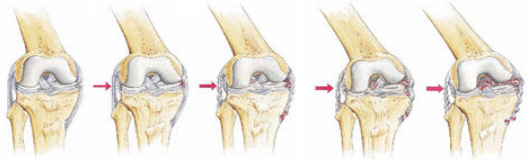
Structural Measures

- Relationship between tibia and femur
  - Genu varum < 175º
    - Medial compression
  - Genu valgum > 185º
    - Lateral compression

Medial Collateral Ligament

- Medial femoral condyle anteriorly to medial tibia 2 inches below jt line (IR slack)
- Deep fibers attached firmly to medial meniscus
- Resists valgus
  - 57% at 5º flexion
  - 78% at 25º flexion
  - More slack in flexion
    - Implication for immob

MCL Sprains



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- Typically due to valgus forces in CKC
  - Foot typically in neutral or externally rotated
- Most frequently injured ligament in the knee
- Usually no joint effusion unless deep portion affected since primarily located outside the joint capsule

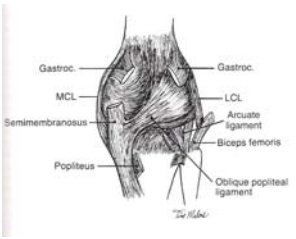
Valgus Stress Test

- Assesses medial instability
- Must be tested in 0° and 30°
- (+) Test in 0°
  - MCL
  - > 5 mm check ACL/PCL
- (+) Test in 30°
  - MCL primary restraint
  - > 10 mm check ACL
- Grading Sprains
  - Compared to opp side
  - Grade 1+ 3-5 mm end feel pain
  - Grade 2+ 6-10 mm laxity- end
  - Grade 3+ > 10mm laxity- no end

Sens 86-96%, Spec: Unknown

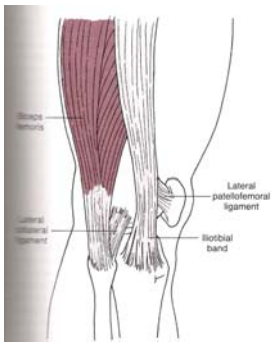
Posterior Medial Corner

- Posterior Oblique Lig
  - Thickening of posteriomedial capsule
  - Resists anteriormedial rotation
  - Resists valgus near full extension

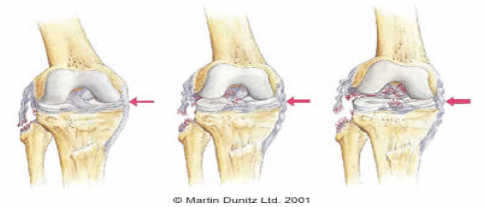


Lateral Collateral Ligament

- Lateral femoral condyle posterior to head of fibula
- With MCL restrain ER
  - Think IR to protect
- Resists varus stress



LCL Sprains



- Typically due to varus forces, especially in CKC position with leg adducted and tibia internally rotated
- Usually occur during contact sports
- Typically has limited joint effusion since it is located outside of the joint capsule

Varus Stress Test

- Assesses lateral instability
- Tested in 0° and 30° flexion
- (+) Test in 0°
  - LCL
  - PCL/ACL
- (+) Test in 30°
  - LCL

Sens: .25- Spec Unknown

Anterior Cruciate Ligament

- Anterior lateral tibial plateau
- Runs post and laterally to posterior medial wall of lateral femoral condyle
- Anteriormed bundle
  - Taut in flexion
  - Small
- Postlat bundle
  - Taut in ext
  - Large

Lachman's Test

- Best acute ACL test
- Best on field test
- (+) test is a "mushy" or "empty" end-feel
- False (-) if tibia is IR or femur is not properly stabilized

Sens 96% and Spec 100%

Anterior Drawer Test

- (+) Test is increased anterior tibial translation over 6 mm with empty end feel
  - 76% sensitivity
  - 86% specificity
- Add IR to tighten PCL and excursion will decrease
  - If increase excursion PCL
- Add ER if increased may include MCL, POL and med capsule
- False (+) if there is a posterior sag positional fault before test

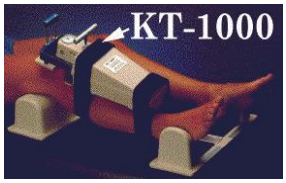
Pivot Shift Maneuver

- Tests for ACL
- (+) test is the tibia reduces on the femur at 30 to 40 degrees of flexion, subluxation of the tibia on extension
- Difficult to relax, flexion contracture, hamstring guarding- Best data under anesthesia

Sens 24% Spec 98%

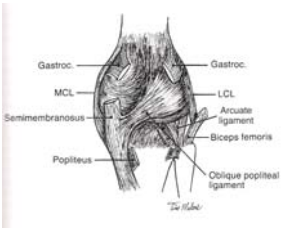
KT 1000 Testing

- Clinical Uses
- Bilateral Comparison (>3 degrees)
- Adjunct to Overall Assessment
- Patient Position
- Sensitivity 96%
- Specificity 92%



Posterior Lateral Corner

- Arcuate Ligament
- "Y" ligament from head of fibula to popliteus and tibia and to lateral head of gastroc and lateral epicondyle of femur
- With LCL, popliteal tendon and lateral gastroc is lateral corner



Posterior Cruciate Ligament

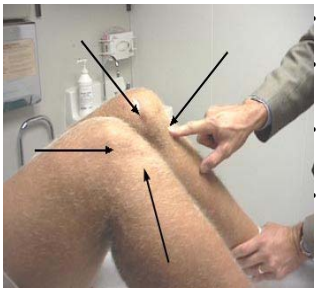
- Posterior tibia to lateral wall of medial femoral condyle
- Anteriorlat bundle (95%)
  - Taut in flexion
- Posterior med bundle (5%)
  - Taut in ext
- Restrains post translation of tibia on femur
  - 93% load in full ext
  - Greatest translation at 70-90º

Posterior Drawer Test

- Tests for posterior instability at 90º flexion
- Make sure that there is no anterior translation prior to performing test
- (+) Test indicates:
  - PCL
- Add ER to tighten PCL
  - No change = PCL
  - Increase with ER consider Post lateral corner
- (-) 90º but (+) 30º think Posteriorlateral corner

Sens 89.5 Spec 98.2

Posterior Sag Test



- Tests for posterior tibial translation
- Tibia "drops back" or sags back on the femur
- Medial tibial plateau typically extends 1 cm anteriorly
- (+) test is when "step" is lost Sens 79% spec 100%
- Quad Activating
  - Contract quad and see migration anteriorly
  - Sens 98% spec 100%

Dial Test- Prone ER Test

- Tests for posterolateral rotary instability
- Prone Stabilize femur & ER foot with knee flexed to 30 degrees
- (+) test is increased external tibial rotation greater than 10º compared to opp side
- (+) test indicates:
  - Posterolateral corner
  - If (+) at 90º too look at PCL

Motion Summary

- Primary Restraint
  - Primarily Responsible for restraining a particular motion
- Secondary Restraint
  - Assist primary
- Injury
  - If secondary ok- may be little change
  - Over time secondary can stretch out
- Restraint to IR
  - ACL
  - PCL
  - Meniscofem Ligs
    - Post Horn Lateral to PCL
- Restraint to ER
  - MCL
  - LCL

Motion

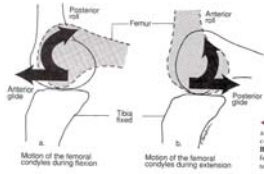
- Ant Displacement of Tibia on Femur
  - ACL 85%
  - Secondary
    - MCL, LCL
    - Middle Med and Lat capsule
    - ITB
- Post Displacement of Tibia on Femur
  - PCL 95%
  - Secondary
    - Meniscofem Ligs
      - Post Horn Lateral to PCL
    - LCL, MCL
    - Post Med and Lat Cap
    - Popliteus

Motion

- Valgus at 30º
  - MCL 78%
  - ACL/PCL 13%
  - Medial Capsule
- Valgus at 0º
  - MCL 57%
  - ACL/PCL 15%
  - Post Med Capsule 18%
  - Ant- Middle Capsule
- Varus at 30º
  - LCL 70%
  - ACL/PCL 12%
  - Lateral capsule, ITB, popliteus 18%
- Varus at 0º
  - LCL 55%
  - ACL/PCL 22%
  - Capsule, ITB, popliteus 23%

Tibiofemoral Mechanics

- Knee Flexion
  - Femur Roll Posterior
  - Femur Anterior Glide
  - Tibial Plateau rolls and glides posteriorly
- Knee Extension
  - Femur Roll Anterior
  - Femur Posterior Glide
  - Tibial Plateau rolls and glides anteriorly

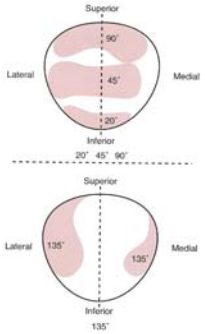


Patellofemoral Joint

- Patella increases moment arm of extensor mechanism- increases force of quad
- Medial and Lateral Facet
- Odd facet on med edge
  - >135º of motion
- Full Extension is position of least bony congruency
- Patella Alta
- Patella Baja
- Motion
  - Glide Superior/Inferior
  - Glide Medial/Lateral
  - Tilt Med/Lateral
  - Rotates Med/Lateral

Patellar Contact Area

- 20º Inferior med and lateral facets
- 45º middle patella
- 90º superior 1/3 is in contact
- Beyond 90º odd and lateral facets are contacted
- Full extension compression is lower and contact area is small



Patellar Instability

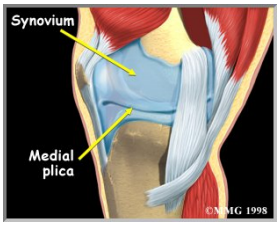
- Shallow groove
- Trochlear dysplasia
  - Lateral femoral condlye is less prominent
- Patellofemoral soft tissue tethers are lax
- Medial PF ligament can control 60% lateral migration

Apprehension Test

- Tests for patellar subluxation or dislocation
- (+) test is verbal or facial apprehension from the athlete, OR an attempt to contract the quadriceps to avoid dislocation

Plica

- Synovial membrane
- Inferior plica
  - Ligamentum mucosum
  - Inf pole patella to intercondylar fossa
- Medial plica
  - 30% knees
- Lateral plica
  - Less common



Hughston's Plica Test

- Tests for medial plica's
- (+) test is pain and/or popping of the plical band under the clinician's fingers on the medial aspect of the knee

Joint Restriction

- PROM directed at angular motions
- Joint mobilization targets translations

Joint Mobilization

- Osteokinematic motion
  - Physiologic motion
  - Motion of a joint when muscle or gravity acts on it
  - Superior-Inferior
  - Medial Lateral
  - Rotation about and axis
- Arthrokinematic
  - Joint play
  - Motion between 2 articulating surfaces without regard for forces applied to the joint

Assessment: PROM

- Is there a restriction?
- Where is the restriction?
- Pain with the restriction?
  - End Feel

Mobilization

- Passive movement by the therapist
- Patient is relaxed
- Slow: patient can stop the movement if needed
- Oscillatory or Sustained
- To decrease pain and/or increase mobility

Effects of Joint Mobilization

- Joint mechanoreceptors are stimulated to inhibit nociceptive stimulation and can cause muscle relaxation.
- Improved synovial fluid movement can improve nutrition to the joint.
- Stretch of the capsule can cause plastic deformation of collagen to improve motion.

These concepts help us compartmentalize

- Importance of treating accessory movements vs. simply using physiological movements to maintain/improve ROM

Treatment Variables

- Position of Joint
- Direction of mobilization
- Type- sustained or oscillatory
- Grade of mobilization
- Length of mobilization

Position of Joint

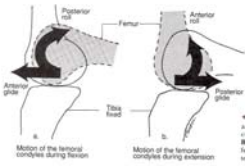
- Place joint in the resting position
  - To be more aggressive: move to more closed positions

Guidelines for Application

- Assessment is controlled (avoid injury/dislocation)
- Assess patients signs and symptoms during treatment and after treatment
- Re-assess after each intervention and between interventions
  - Provide feedback on quality of application
  - Justify continued treatment
  - Provide information on effectiveness

Tibiofemoral Joint

- Flexion is coupled with
  - IR of tibia
  - ADD of tibia
- Extension is coupled with
  - ER of tibia (last 30º)
  - ABD of tibia



Patellofemoral Joint

- Convex patella on concave femur
- Glides in same direction as being restored even though is convex
  - Ventral surface of patella tilts in the opposite direction of the restriction when the patella is glided in the direction of the restriction
- Extension
  - Moves 5-7 cm superiorly
- Flexion
  - Positioned more laterally

Tibiofemoral Joint Motion

- Distraction
  - Overall ROM
  - Grasp tibia and move distally

Tibiofemoral Joint

- Dorsal Glide
  - Inc knee flexion
  - Stabilize femur
  - Glide tibia posteriorly

- Ventral Glide
  - Inc knee extension
  - Glide tibia ventral

Tibiofemoral Joint

- Ventral Glide of Tibia on Femur
  - Increase ext

  - Prone

Tibiofemoral Joint

- Medial Glide
  - Overall ROM
  - Stabilize femur
  - Glide proximal tibia medially

- Lateral Glide
  - Overall ROM
  - Stabilize femur
  - Glide proximal tibia laterally

Patellofemoral Joint

- Superior Glide
  - Inc. Extension
- Inferior Glide
  - Inc. Flexion

- Medial Glide
  - Inc Flexion
- Lateral Glide
  - Inc Flexion

Evaluation and Treatment Approach

- Impairment Approach
  - Identify Impairments
  - Generate Objective measure of the deficit
  - Continual Reassessment
- Functional Limitations
  - Objective measures of limitations
  - Reassessment and milestones

How Much PT does the Patient Need

Significant "Hands On Time"

Visits/wk	Reason
4-5	Swelling &/or pain control Joint Mobilization
3	ROM, Pain control, Strengthening/early phase
2	Strengthening / late phase Functional advancement

Use the Gym if that's all they need

Is relieving pain THE impairment you are treating?

- Pain is only one measure of improvement
  - IF pain is the same
  - BUT
    - Function increased
      - FUNCTIONAL QUESTIONNAIRES
    - Strength improved
    - ROM increases
    - Stopped pain meds

THEN YOU HAVE BEEN SUCCESSFUL!!!!!

Provocative Testing

- Comparable Sign
- Identify cause of a limitation and treat directly
- Reassess problem after treatment to confirm contribution

What does swelling indicate?

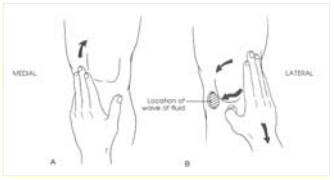
- Early (bloody) it is expected
- >2 weeks post-op
  - Infection
  - Too much weight-bearing activity
  - Not enough motion
- NORMAL to continue to swell for up to six weeks after chondroplasty or meniscal repair

Background

- Knee Swelling
  - Extracapsular vs Intracapsular (effusion)
  - Indicative of inflammation/irritation
- Monitoring for clinical decision making
  - patient prognosis
  - program progression

Stroke Test

- Stroke upward from medial joint line 2-3X
- Observe for spontaneous fluid flow downward
  - If not present then
- Stroke distal lateral thigh downward
- Observe medial knee for fluid return with lateral stroke



Effusion Grading Scale

(Michael J Axe, MD)

Zero	No wave produced on downstroke
Trace	Small wave on medial side with downstroke
1+	Larger bulge on medial side with downstroke
2+	Effusion spontaneously returns to medial side after upstroke (no downstroke necessary)
3+	So much fluid that it is not possible to move the effusion out of the medial aspect of the knee

Effusion Grade 1+

Effusion Grade 2+

Effusion Grade 3+

Results

	Zero	Trace	1+	2+	3+
Zero	3				
Trace		6	2	2	
1+	1	4	24	2	
2+		2	4	15	1
3+				3	6

- 5/75 (6%) had a disagreement of 2 grades
  - In 4 paired tests, one rater graded trace, other graded 2+
    - 2 of the 4 involved the same pair of graders
    - In 1 paired test, one grader gave the effusion a 1+, other zero
- No disagreements of more than 2 grades

Discussion

- Effusion scale = means of communicating about status of knee joint
- Effusion scale can be a factor in clinical decision-making

Application of Decision Rules

- 94% of the rating pairs would have resulted in the same clinical decision regarding patient status &/or progression according to the effusion grading system

Conclusion

- 70/75 of the paired tests resulted in effusion grades that would result in the same clinical decisions being made by different PT's
- Further research is necessary to establish validity of this measure and the clinical decision making rules associated with it

Effusion Grades

- Trace: small fluid wave with superior pouch compression
- 1+: larger fluid wave with superior pouch compression
- 2+: fluid wave spontaneously returns
- 3+: too much to milk out of pouch

If 3+ and Restricting

- Get the fluid out
- Get the situation under control
  - Compression/cold
  - Restrict weight-bearing
  - Gentle AROM

How much is too much?

- Early
  - 3+
  - Uncontrolled Pressure Pain
  - Unable to initiate SLR (Quad lag)

Knee Aspiration

- Restricts critical ROM
- < 90 degrees flexion
- > 5 degrees lack of full extension

18 gauge Needle; 50 cc syringe

Prevention is the key

- Compression cold therapy put on in the OR
- Early controlled active ROM
  - Wall slides
- Dynamometer as CPM
  - Can't "cheat"

How much is too much later?

- Late
  - 2+ with anti inflammatory meds OR
  - Any increase in swelling

Swelling Returns in Response to PT

- Cannot tolerate increase in activity
  - Therapist must BACK OFF
  - ? Aspirate and SLOW DOWN

Effusion Guidelines

- Pain and Swelling

  ≥ 2+ = No Activity Increase

  3+ = ↓ Activity level

Range of Motion

- Range of Motion
  - Identify cause of motion loss
    - Joint Hypomobility
    - Effusion
    - Stiffness
    - Weakness
  - Reassessment after intervention to determine results

Strength

- **Functional Strength**
  - Instrumented strength testing for large muscle groups like the quadriceps muscle
    - Isometrics/ Slow speed isokinetics
    - One Rep Max
  - Side to side comparisons
  - Aged matched norms
  - Criteria for progression
    - 70% walk without a limp
    - 80% Treadmill running
    - 90-95% Return to play

Designing a Strength Program

What are your patient's goals and aspirations

- Increasing motivation
- Exercise Selection
- Determining Intensity
- Recovery times

Open Chain -When would you need to isolate?

- Those pesky 'trouble' areas

- Activities or muscles that patients seem to want to substitute other muscle or movements

Isolate Target Muscles

- One time strength test from other clinics
  - 20+ visits of only closed chain exercise and strength is only 60% of uninvolved leg
- Compliant with exercise programs
  - All exercises are bilateral
    - ISOLATE then integrate!
- Evaluate functional activity
  - Identify substitution patterns

Exercise program should be research based when possible

- Prospective, matched follow-up study
  - Closed chain alone or combined closed and open chain for quadriceps strengthening and return to sport (Mikkelsen et al. 2000)
- Prospective, randomized trial
  - Effects of open vs closed kinetic chain on knee laxity (Morrissey et al. 2000)
- Combination of 0pen and Closed chain exercise is more effective than their use in isolation

Open Kinetic Chain

- PFJR force increases and then decreases (Peak PFJR force occurs at 36 degrees of knee flexion)
- patellofemoral contact area decreases

Closed Kinetic Chain

- occurs when distal segment of leg is fixed
- simultaneous motion at ankle, knee and hip
- flexion of knee accompanied by dorsiflexion of ankle and flexion of hip
- results in co-contraction of muscles throughout lower extremity

Closed Kinetic Chain

- patellofemoral contact stress/area increases as knee flexion increases.
- flexion moment arm increases
- quad and patellar tendon tension increases
- patellofemoral contact area increases
- PFJR force increases
- squatting with lower leg perpendicular results in greater quad force than squatting allowing lower leg to shift forward

PF Contact force Open vs Closed

- comparison of open chain knee extension against 9kg weight boot and closed chain exercise (I.e. squatting) under body weight
- open chain> closed chain in range from 0 - 53 degrees
- closed chain > open chain flexed more than 53 degrees
- similar results found by Steinkamp (1993)

PFJ Forces with Function

- PFJR force during level walking is .5 times body weight
- PFJR force when climbing stairs is 3 to 4 times body weight
- PFJR force during deep knee bends is 7 to 8 times body weight

Translation with Open Chain

- anterior translation produced at 60, 45 and 30º of flexion
- posterior translation produced at 90º of flexion
- quadriceps neutral angle (QNA) = angle of knee flexion at which contraction of the quadriceps produces no net A/P translation (~75º of flexion)

Strain during Open Chain

- ACL strain during passive open chain motion:
- 0% strain defined as strain on ACL with the knee in full extension.
- ACL strain decreases and reaches minimum at 30 to 45o of flexion.
- continued flexion results in increased ACL strain
- ACL strain during open chain quadriceps exercise:
  - strain increases from 60o of flexion to almost full extension
- ACL strain during open chain hamstring exercise:
  - hamstring contraction reduces ACL strain throughout the range of motion

PCL Strain Passive Open Chain

- 0% percent strain defined as strain on PCL with knee in full extension.
- Strain on posterior fibers of PCL decreased from 0 to 20o flexion then increased to maximum strain at full flexion
- posterior fibers of PCL are most lax from 15 to 30o of flexion
- the anterior fibers of the PCL are lax from 0 to 10 degrees
- strain rapidly increases on the anterior fibers beginning at 10o of flexion
- max strain on anterior fibers of the PCL at full flexion

PCL Strain with Hamstring

- hamstring contraction produces increased strain on the PCL compared to the strain on the PCL during passive motion at 45 and 75o of knee flexion

Intensity and progression

- Be PROGRESSIVE not aggressive

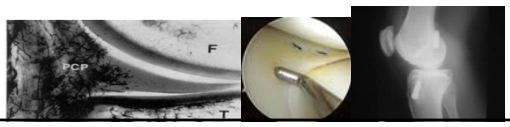
Overtraining

- Bury the patient in exercises
- Difficult to identify the offending exercise
- How do you know if what you did really worked??

Rehabilitation Progressions

Understanding soft tissue healing & fixation techniques

Rehab Modified Surgery
Surgeon attempts Rigid Fixation
Screws rarely Stitches
Fixation: Race between healing vs. fixation failure



Surgery Modified Rehabilitation

Understanding soft tissue healing & fixation techniques

Surgery Modified Rehab
Unless Rigid Fixation is achieved
Rehab is slowed

Know the pathology (surgery)!

- Fixation – reconstruction, repair, tendonitis, or tendonosis
- What was cut for visualization?
- Rehab is limited by the weakest structure or the slowest healing time

What slows and speeds healing?

- Is it a revision?
  - Take caution with exercise and progression
- Age
- Nutrition
- Medications
  - Steroids
  - NSAIDs
- Co-morbidities
  - Diabetes

Patients that don't hurt but have to respect biological healing

- Examples
  - Revision ACL
    - Can you trust symptoms?

Phases of Rehabilitation

- Acute Phase
- Intermediate Phase
- Functional Progression Phase
- Return to Sport/Work Phase
- These phase are strongly driven by phases of healing!!

Stages of healing?

- Inflammatory or acute (2-5 days)
  - Let the body lay down the ground work
  - Control signs & symptoms make patient comfortable
- Proliferation and Repair and Fibroplasia (5-25 days)
  - Motion and exercise to assist in scar formation
- Remodeling and Maturation (21 days – 2 years)
  - Apply stress to take advantage of Wolf's law

Acute Phase- Goals

- Decrease inflammation and pain,
  - Control Inflammation
  - Use Effusion guidelines
- Increase ROM and prevent muscle atrophy
- Minimize the effects of immobilization
- Don't overstress tissues

Limitations

- NWB, PWB or WBAT
- The exercises prescribed in acute phase depend on
  - available knee ROM
  - weight-bearing status
- When would you go back to crutches??

Subacute Phase

- effusion is minimal
- ROM is restored
- Goals
  - Increase muscular strength

  - improve proprioception/neuromuscular control
  - ready the patient for sport-specific exercise performed in the Functional Progression Phase

Consider the Role of Proximal stability

- Hip rotational control for knee function
- Lumbar paraspinals (transverse abdominals, multifidi, QL) stabilizing hypermobility in a skater to perform jumps

Key Points of Progression

- Think anatomically
- Think biomechanically
- Think functionally

Functional Progression

- Speed: slow → fast
- Planes of movement: Single plane → multiplane
- Controlled → less controlled
- Force: light → heavy
- Volume: short → long

Example progressions

- Quad sets
- SLR
- Full AROM
- Short arc quads
- Long arc quads

↔

- Total gym squat
- Minisquats
- Full squat or leg press
- Full squat with weight
- Unilateral squats
- Lunges
- Multiplane lunge or lunge with weight

↕

- Vertical jump
- Multiplane jump
- Vertical hop
- Multiplane hop
- Cutting & ladder drills

Ways to Progress Intensity of Exercise

- Plane of exercise
- Lever arm length
- Effect of Gravity
- Amount of resistance
- Postural stability demands

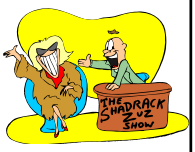
SAID Principle

- Specific Adaptations to Imposed Demands
- Assumes that you understand the demands of the patient's desired activities

Daily Reassessment

- How did my treatment effect…
  - Swelling
  - Pain
  - Function
  - Fatigue
  - Instability
  - Range of motion

How much and how long?



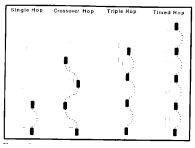
  - These are the questions that are answered at the beginning of each session!
    - Usually comprise most of your subjective in a note

Return to Sport/Work Phase

- Criteria to Enter?
- Goals?

A word of caution

- Do not play – **Name that Tune!!**
  - I can name that tune (treat that Dx) in only 7 visits?
- Increased confidence in patient and PT when completing a functional progression



What is Functional Testing?

- Functional Testing is used to determine whether or not an athlete is ready to begin functional progression for return to play.
- This is determined by using a test that assesses lower extremity muscular strength and their ability to perform tasks that challenge knee stability.

When do you use Functional Testing?

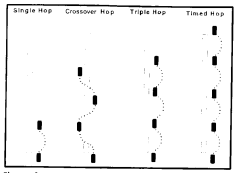
- After injury
  - Is the athlete ready to return to activity?
- Pre-operatively
  - Does the athlete truly need surgery?
- Post-operatively
  - Is the athlete prepared to return to play?

Why do we use Functional Testing?

- Want the least possible risk to the athlete
- Want to know if they are fully rehabilitated
  - Do you trust all athletes subjective responses

Functional Testing

- Single Leg Hop Series (Frank Noyes)
  - Uninvolved leg tested first
  - 2 practice hops
  - 2 recorded and averaged trials
  - % side/side difference
    - Single leg Hop
    - 3 cross-over hops
    - 3 hop for distance
    - Timed 6 M hop

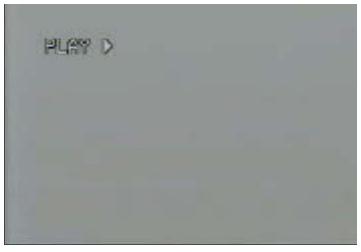


The Hop Test

- Begin on uninvolved side
  - One practice trial
  - Two real trials
- Switch to involved side
  - One practice trial
  - Two real trials

The Hop Test

- Single Hop
  - For distance



The Hop Test

- Cross Over Hop
  - 3 hops for distance

The Hop Test

- Triple Hop
  - 3 hops for distance

The Hop Test

- Timed Hop
  - 6 meter hop for time

Interpretation

- Single Hop, Cross Over Hop & Triple Hop
  - The longer the better
  - Divide the Involved by the uninvolved
- Timed Hop
  - The faster the better (ie. shorter)
  - Divide the uninvolved by the involved

Functional Testing

Lower Extremity

- **ACL**
- **Lower Extremity Problems**

- **Assess at Eval**
- **Reassess during Treatment**
- **> 90% strength of the opposite side for Return to Play**

Functional Self-Report Questionnaires

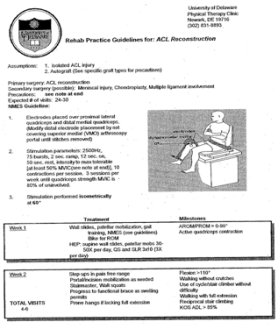
- Knee Outcome Survey (KOS)-Activities of Daily Living scale

	I Do Not Have the Symptom	I Have the Symptom But It Does Not Affect My Activity	The Symptom Affects My Activity Slightly	The Symptom Affects My Activity Moderately	The Symptom Affects My Activity Severely	The Symptom Prevents Me From All Daily Activities
Pain	☐	☐	☐	☐	☐	☐
Stiffness	☐	☐	☐	☐	☐	☐
Swelling	☐	☐	☐	☐	☐	☐
Giving Way, Buckling or Shifting of Knee	☐	☐	☐	☐	☐	☐
Weakness	☐	☐	☐	☐	☐	☐
Limping	☐	☐	☐	☐	☐	☐

- Global Rating of Knee Function

Diagnosis Driven Programs

– Protocols: A Good Start



– Programs
- Functional
  - Simulates the activity
- Practical - < 60 minutes
- Progressive

Functional Progression

- Activity Specific Progression towards return to activity
- Successive steps are completed to progress towards full, return to work/play

Functional Progression

- Control of parameters to move towards sport like circumstances
  - Easy to Hard
  - Slow to Fast
  - Unidirectional to Triplanar Movements

Objective Criteria for Progression

- Don't forget Healing Principles
  - Swelling under control (THIS MEANS DECREASING!!)
- Soreness Rules
  - No KNEE soreness

Soreness rules – Curwin & Stanish

1. No pain
2. Pain with extreme exertion that stops with rest
3. Pain with extreme exertion that lasts for 2 hours
4. ***Pain with extreme exertion that alters function and lasts 4-6 hours***
5. Pain with onset of activity, prevents activity
6. Pain with ADLs, unable to participate in PT or sport

Objective Criteria for Progression

SORENESS RULES

Criterion	Action
1. Soreness during warm-up that continues	2 days off, Drop down 1 level
2. Soreness during warm-up that goes away	Stay at level that led to soreness

Objective Criteria for Progression

SORENESS RULES

3. Soreness during warm-up that goes away but redevelops during session	2 days off, drop down level of program
4. Soreness the day after exercise(Not muscle soreness)	1 day off, do not advance program
5. No Soreness	Advance as instructed by healthcare professional (i.e. 1 step per week)

When can I ...

- drive?
- run?
- return to sports?

Drive?

- What do the data say?
- Hau R Journal of Knee Surgery, Sports Traumatology, Arthroscopy. 2000
- Gotlin and colleagues (*Arch Phys Med Rehabil 2000, Arthroscopy 2000)*
  - Brake reaction time normal 4-6 weeks after right ACL
- Nguyen T and colleagues (Knee Surg Sports Traumatol Arthrosc 2000)
  - Reaction time normal 6 weeks after right ACL
  - Sit-to-stand 6 in 10 sec

Seated Step Test

- Procedure: Patient is seated with both knees and hips at 90°. An oblong box measuring 2.5x2.5x30 cm is placed along side the patient's right foot. The patient has to then step across either side of the box without touching it. Each step is counted with firm contact of the heel (no tiptoeing allowed). The test is performed in 10 seconds.
- Results: Patient must perform 13 steps to pass the test.

Nguyen T 2000

Drive after ACL?

- left leg operated
  - problem with clutch
  - 2 weeks
- right leg operated
  - 4-6 weeks

Example – When to Run?

- Treadmill walking
- Treadmill walk/run
- Treadmill running
- Track: run straight, walk turns
- Track: Full run
- Off-track (road/field)

Example – When to Run?

- Treadmill walking
- Treadmill walk/run
- Treadmill running
- Track: run straight, walk turns
- Track: Full run
- Off-track (road/field)

- Progress when 2 miles without effusion or pain
- One day off in between
- Consider limiting no more than 2 levels per week

Example – After ACLR?

- If 6-8 week milestones are met
  - Normal gait pattern
  - Full ROM
  - Quadriceps strength >80% of uninvolved
- 2 miles, no swelling
- Can takes 2-3 months to progress
- May discharge to self management at this point

Return to play?

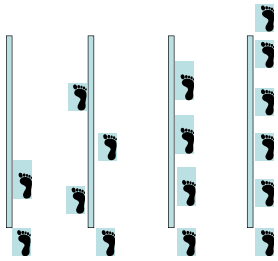
- Conventionally
  - time-based
  - "knee feels ready"
  - cross your fingers
  - go!

Return to sports?

- Need a tested return to activity test battery
  - strength testing is not enough
  - laxity testing is not helpful here

UD program -Week 12 - Return to Activity Screening

- Strength test 90%
- Hop tests (Noyes) >90%
- KOS ADLS >90%
- Global >90%



Passing screening exam and running progression

beginning to **practice**, not direct return to preinjury level and intensity

Office call for Variance

- Inconsistent Findings
  - Red Flags
  - Yellow Flags
- Medical Status Change–
  - Temp increase with an angry wound
- Failure to Progress –
  - Re-evaluation
  - Subspecialty consultation
  - Injections

Curve Balls

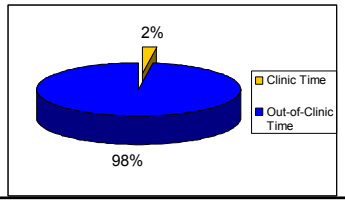
- Severe pain – RSD
- Multiple ligament injury
- Severe Effusion
  - Knee
- Severe Inhibition
  - Quadriceps
- Significant Instability
  - PFJ, tibiofemoral,

Challenge to Clinical Care

One hour clinic time

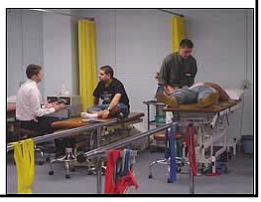
VS

47 hours or more between treatments



HEP can't be underestimated

- An educated patient is an adherent patient
  - Know what problem is, extent of problem, how the treatment will work, why this is important



Home Programs

Home Exercise Program

- Patient Understanding

  1 – 60%

  2 – 80%

  3 – 90%

- Patient Compliance
  - Feels Better - ↓ compliance

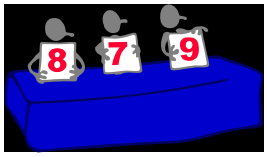
Good Rehabilitation

Discharge Criteria & Outcomes

- **DC criteria should be International**
  - **Region specific questionnaires**
    - Proven objective

Outcomes

- Did the Treatment Work?
- Effective Return to Play
- No Re-injury



Safe Return to Activity

Accurate Diagnosis
Reliable Surgical Procedure
Good rehabilitation
Objective Progressive Criteria
Balance between healing and ability

The Patellofemoral Joint Strategies of Management

Tara Jo Manal PT, OCS, SCS
Director of Clinical Services
Orthopedic Residency Director
Physical Therapy Department
University of Delaware, USA

Incidence

- 25-40% of Knee Problems in Sports Medicine in US
- Multifactoral

Differential Diagnosis PFJ vs Tibiofemoral

- Anterior Knee Pain
- Pain with Prolonged Knee Flexion(movie)
- Pain with Forceful Knee Extension (stairs)
- Complaints of Pseudobuckling
- Patellar Subluxation

Reilly and Martens 1972

Differential Diagnosis

- Referred Pain from the Hip
  - Slipped Femoral Capital Epiphysis
- Referred Pain from the Back
  - L4 distribution
- Old PCL/ACL injury
  - History MVA
- Ankle/Foot Dysfunction
- RSD/OCD

PFJ Diagnosis

- Impairments
  - Inflammation
  - Limited Mobility
  - Limited Muscle Function
- Functional Limitations and Disability
  - Activities of Daily Living
  - Sports Recreation

Pain Sources

- Osgood-Schlatter's (tib tubercle)
- Sinding-Larson-Johansson (inf pole patella)
- Plica
- Lateral Patellofemoral ligament
- Quad Tendon
- Infrapatellar Tendon

Patellar Special Tests

- Resisted Knee Extension
- Step Test
  - +/- for pain
  - Angle or reps to pain onset
- Reproduction of Pain Complaints
  - Provocative Testing

Anterior Knee Pain Factors

- Quadriceps Weakness
- Muscle Hypomobility
- Soft Tissue Hypomobility
- Skeletal Alignment
  - Dynamic
  - Static
- Tissue Irritation
- Arthritis

Hypothesis

- Patellar malalignment
- Patellar maltracking
- Increased PFJ compressive and shear forces during activity
- Subsequent articular cartilage wear

Muscular Weakness

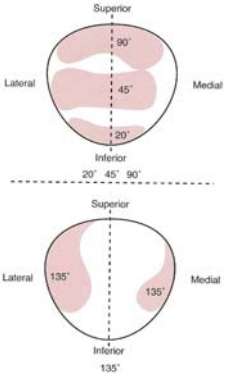
- Quadriceps
  - Decreased strength and EMG
  - No VMO Differentiation ?

Positive Response to:

- Weight bearing
- Non Weight bearing
- Eccentric Exercise
- Hip Abduction
  - Unclear how common

Werner 1995, Thomee 1997 , Witvrouw 2000

Considerations with Strengthening



Muscular Flexibility

- ITB
- Quadriceps*
- Hamstring *
- Hip Flexor
- Gastroc/Soleus *
- Hip IR/ER

- Not Universal among PFJ patients

PIVA 2005

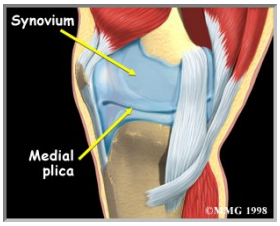
Soft Tissue Hypomobility

- Mobility
  - Glide :Superior, Inferior, Medial, Lateral
  - Tilt : Lateral PF Compression
    - Hypomobile lateral retinaculum
- Position
  - Alta, Baja
- Tracking
  - With Quadriceps Contraction

Kolwich AJSM 1990, Docuette AJSM 1992
Maitland 1991 and Kaltenborn 1985

Plica

- A synovial fold which is not completely resorbed, and persists into adulthood.
- Locations:
  - Infrapatellar
  - Suprapatellar
  - Mediopatellar



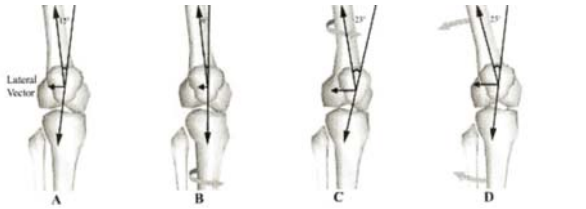
Plica

- Can become irritated from continuous rubbing over the medial femoral condyle

Overuse

Influence of Lower Extremity Biomechanics

- Abnormal motion of tibia and femur in the transverse and frontal plane can impact the PFJ



A Normal

B Tibial Internal Rotation Decreases Q angle

C Femoral Internal Rotation Increases Q Angle

D Knee Valgus increases The Q Angle

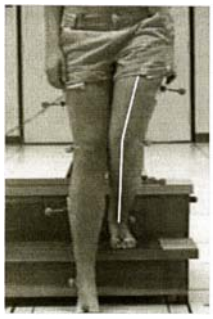
Movement between Patella and Femur

MRI with knee flexed

MRI with knee extended

Powers CM 2000

Dynamic Alignment Excessive Knee Valgus



Contributing Factors to Valgus

- Hip Abduction Weakness *
- Femoral Internal Rotation
- Knee Valgus
- Tibial Internal Rotation
- Foot Pronation

PIVA 2005

Gotz-Neumann 2002

Foot Orthosis

Eng et al 1993

- Females with pronation
- Forefoot varus or calcaneal valgus of > 6°

Eng 1993

- Likely success in patients with pronation
- Arch Taping for Trial

Patellar Taping

- Patellar Taping and Bracing
- No Positional Change
  - No change after exercise
- Significant symptom control
  - >50% - 75% Improvement

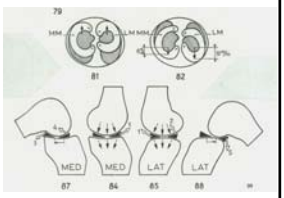
Finestone 1993 , Fitzgerald 1995, Kowall1996, Miller 1997
Powers 1997, Pfeiffer 2004, Clark 2000

Patellofemoral Classification

- Assess Flexibility
  - Stretching
- Assess Muscle Strength
  - Strengthening Exercises
- Assess Static and Dynamic Skeletal Alignment
  - Strengthening and Foot Orthotics
- Assess Pain
  - Taping and Modalities
- Assess Patellar Mobility
  - Patellar Mobilization

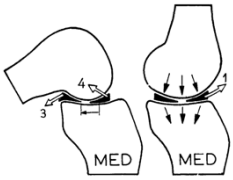
Meniscal Motion

- Menisci translate on tibia with femur
- Translate anteriorly with extension & posteriorly with flexion:
  - joint geometry
  - meniscopatellar ligaments
  - semimembranosis & popliteus



Meniscal Motion

- Flexion under weight bearing produces increased shear loads on meniscus



Partial Menisectomy

- Rehabilitation progression
  - Easy to rehab, but long term concerns
  - Strict adherence to the soreness and effusion rules

Criterion	Action
• Soreness during warm-up that continues	• 2 days off, drop down 1 step
• Soreness during warm-up that goes away	• Stay at step that led to soreness
• Soreness during warm-up that goes away but redevelops during session	• 2 days off, drop down 1 step
• Soreness the day after lifting (Not muscle soreness)	• 1 day off, do not advance program to the next step
• No soreness	• Advance 1 step per week or as instructed by healthcare professional

Rehabilitation Progression

- Effusion Rules
  - Do not progress exercise if effusion is more than a 1+
  - When patients are holding anything above 2+, contact MD
  - Any drastic change of 2 grades or appearance of effusion when absent, decrease activity

Rehab Practice Guidelines for: *Meniscal Repair*

- Assumptions: Isolated meniscal repair
- Primary surgery: Meniscal repair
  - arthroscopically assisted open repair or all inside repair
- Secondary surgery (possible)
  - ACL reconstruction
  - PCL reconstruction
  - Chondroplasty
  - High Tibial Osteotomy
- Precautions: No loaded knee flexion beyond 45^0 for 4 weeks
- No loaded knee flexion beyond 90^0 for 8 weeks

- Cooper et al., *Clin Sports Med 1991*
- McAndrews & Arnoczky, *Clin Sports Med 1996*

Post-operative Rehabilitation

- Manage secondary impairments:
  - Pain/swelling
  - Loss of motion
  - Quadriceps weakness

Week 1-2 (1-3 visits)

INTERVENTION

- Immobilizer for ambulation or brace locked at 0^0 extension
- Crutches as needed (WB per surgeon)
- OKC AROM and PROM exercises
- Patellar mobilization
- NMES for quadriceps
  - *Snyder-Makler, 1995*
- modalities as needed

MILESTONES

- Full knee extension
- AROM knee flexion to 90^0
- Superior patellar glide with QS
- AROM hip/ankle WNL
- SLR without quad lag

Weeks 3-4 (1-3 visits/week)

INTERVENTION

- Immobilizer for ambulation or brace locked at 0° extension
- Crutches with WB per surgeon
- OKC AROM and PROM exercises
- OKC PREs hip, knee, ankle
- Multi angle isometric knee extension
- NMES for quadriceps
- Gait training (WB per surgeon) week 4
- CKC to 45 degrees knee flexion week 4

MILESTONES

- Full scar mobility
- AROM knee flexion within 10 degrees
- Full patella mobility
- Zero to Trace effusion

Weeks 5-7 (0-2 visits/week)

INTERVENTION

- Immobilizer d/c per surgeon
- Progress PREs for hip, knee, ankle
- Begin to progress WB flexion 45-90°
- Begin proprioceptive training
- Endurance training via bike/stairmaster

MILESTONES

- Full AROM
- Normal gait
- MVIC>60%
- No effusion

Weeks 8-11 (0-2 visits/week)

INTERVENTION

- Progress PREs
- Begin loaded flexion beyond 90° at 8 weeks

MILESTONES

- MVIC > 80%

Weeks 12-14 (visits prn)

INTERVENTIONS and TESTS

- Functional hop test if MVIC > 80%
- When MVIC > 80% initiate:
  - running progression
  - sports specific drills
  - agility drills
  - PREs at fitness facility
- Follow up Functional testing at 6 month and 1 year post-op
  - Progression of strengthening in gym
  - Emphasize plyometrics, jumping, cutting

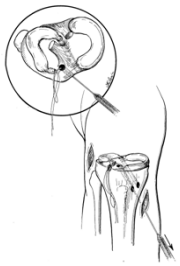
MILESTONES

- Restore function & reduce disability

Meniscal Transplant

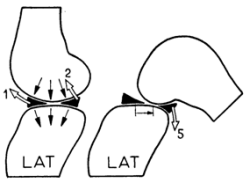
Rehabilitation Considerations:

- Compartment
- Healing of periphery of meniscus to capsule
- Healing of bone block or plugs in tunnels



Post-operative Rehabilitation

- Protect repair/graft:
  - Avoid end range flexion
  - Avoid weight-bearing flexion
  - Avoid resisted hamstring exercises



Post-operative Rehabilitation

Rehabilitation Brace:

- Locked in extension for 1 week
- Unlock several times daily for ROM
- After 1 week unlock brace for gait training
- Discontinue use of brace after 4 weeks

Post-operative Rehabilitation

Weightbearing Status:

- PWB immediately after surgery with brace locked in extension
- Progress to WBAT after 1 week with brace unlocked
- Discontinue use of crutches 4 - 6 weeks after surgery if:
  - Full knee extension without lag
  - >100^0 knee flexion
  - No/minimal swelling
  - Able to walk without bent knee gait

Post-operative Rehabilitation

ROM:

- 0 to 90^0 in brace for 4 weeks
- Gradually increase beyond 90^0 of flexion after 4 weeks
- Do not stretch into flexion until 6 weeks

Post-operative Rehabilitation

ROM Milestones:

- Full extension within 1 week
- 90^0 flexion by 6 weeks for transplant
- Flexion within 10^0 of opposite side by 8 to 10 weeks

Post-operative Rehabilitation

Quadriceps Exercise:

- Quad sets
- SLR
- Open chain knee extension exercises dependent on concomitant surgery & status of P-F joint:
  - 90 to 60^0
  - 20 to 0^0

Post-operative Rehabilitation

Quadriceps Exercise:

- Lag with SLR greater than 5^0 at 1 week:
  - High intensity electrical stimulation
    - Snyder-Mackler, 1995
  - Biofeedback

Post-operative Rehabilitation

Closed Chain Exercises:

- 0 to 45^0 at 6 weeks for transplant
- Gradually progress range up to 75^0 with resistance as tolerated after 6 to 8 weeks

Meniscal Transplant

Clinical Experience – 1993 to 1996:

- Patient-reported outcomes:
  - ADLS – 86 (11)
  - SAS – 78 (16)
  - Lysholm – 84 (14)
  - No difference by compartment, ACL status or chondrosis

  Yoldas et al 2003
- Function:
  - 11 normal
  - 19 nearly normal
  - 1 abnormal
  - 0 severely abnormal
- Activity level:
  - 16 normal
  - 15 nearly normal
  - 1 abnormal
  - 0 severely abnormal

Meniscal Transplant

Clinical Experience – 1993 to 1996:

- Patients' overall global rating:
  - 22 were greatly improved
  - 8 were somewhat improved
  - 1 reported no change
  - None were worse
- Range of motion:
  - 3^0 loss of extension (3^0 greater to 12^0 less than non-involved side)
  - 9^0 loss of flexion (range 0 to 25^0)
- Functional strength:
  - One-legged hop & vertical jump were 85% of non-involved leg

Yoldas et al 2003

Post-operative Rehabilitation

Return to Sports:

- Low impact aerobic activities (walking, cycling, swimming)
  - Meniscal Repair 8 weeks
  - Meniscal Transplant 10 weeks
- Running
  - Meniscal Repair 3 to 4 months
  - Meniscal Transplant 4 to 5 months
- Return to sports
  - 4 to 6 months
  - 6 to 9 months if criteria met for light to moderate sports
    - Return to strenuous sports not recommended!!!

Criterion Based Progression of Functional Activity

Running:

- Criteria for walking met and
- At least 80% quad strength compared to uninvolved side

Criterion Based Progression of Functional Activity

Agility & Sport Specific Drills:

- Running without symptoms
- Quad index at least 80%
- Begin at half effort and progress to full effort as tolerated

Criterion Based Progression of Functional Activity

Return to Sport:

- Tolerating full effort agility and sport specific drills
- Quad index, Hop tests, KOS/GRS $\geq$ 90%
- Begin with return to practice, followed by limited competition, with eventual return to full activity

ACL Injury

- Common athletic injury
  - 100-200,000 ACL injuries per year
- Patients typically cannot return to pre-injury activities while ACL deficient
  - Functional Knee Instability

Conservative Management

- Many patients want to delay surgery
  - Athlete competing for scholarship
  - Seasonal worker
- Does everyone need surgery?
- Who can safely return to sports without surgery?

Patient Classifications

- Non-Coper: individuals who have knee instability with activities of daily living and/or are unable to return to pre-injury activity levels
- Coper: individuals who have no symptoms of knee instability with pre-injury activity levels
  - Must be a potential-coper for at least one year
  - Including sports
  - Rare
- Potential-Coper: individuals identified by screening who have potential—with training—to develop dynamic knee stability and return to pre-injury activity levels

Non-Copers

- Majority of patients
- Unable to return to pre-injury activities after ACL injury
  - Quadriceps weakness
  - Diminished neuromuscular control
  - Altered knee mechanics

Copers

- Rare (5-7%)
- Return to all pre-injury activities at least 1 year without experiencing knee instability
- Muscle activity and neuromuscular coordination compensate for absent ACL

How Do We Prospectively Identify Those With The Potential To Return To Sports After ACL Injury?

Evaluation

- ROM
- Effusion Rating
- Pain Ratings
- Manual Muscle Testing
- Patella Mobility
- Special Tests
  - Lachman
  - Anterior Drawer
  - Pivot Shift
- KT 1000 Arthrometer
- Rule out other ligaments and corners
  - PCL, MCL, LCL, POL
- Seek MRI findings
- Burst Superimposition Testing

KT 1000 Arthrometer

- Measures laxity
  - ≥3 mm = ACL tear

Screening Examination

- Battery of clinical tests developed to prospectively identify individuals who may safely attempt return to activity
  - Potential Copers

Screening Candidate

- Regular participants in Level I and II activities (cutting, jumping sports) without:
  - Concomitant ligamentous injury
  - Bilateral involvement
  - Repairable meniscal tear
  - Full-thickness articular cartilage defect

Criteria to be Screened

- Full ROM
- No effusion
- No concomitant ligament instability
- No repairable meniscal tear
- No full thickness articular cartilage damage

Pre-Screening Rehabilitation

- Resolve Joint Effusion
  - RICE
  - Massage
  - Aspiration
  - Pain
- Restore Full Passive Knee Motion
  - Patellar Mobilization
  - Wall Slides
- Restore Full Active Knee Extension

Pre-Screening Rehabilitation

- Hop on Injured Limb without Pain
  - Bilateral Mini Tramp
  - Involved leg on Mini Tramp
  - Bilateral Floor
  - Involved leg on the Floor
- If pain- continue treatment and reassess

Quadriceps Strength Testing

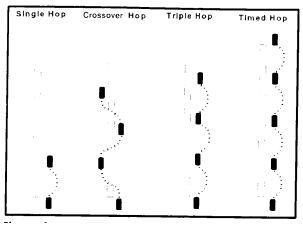
- Quadriceps Strength Testing
  - Isometric Contraction
  - Target Maximal Force
  - Low Speed Isokinetics
- No Hop Testing if MVC is < 70%

Screening Examination

- Single Leg Hop Series
  - All patients are BRACED
  - Uninvolved leg tested first
  - 2 practice hops
  - 2 recorded and averaged trials
  - % side/side difference calculated (involved avg./uninvolved avg. *100)

Screening Examination

- Single Leg Hop Series
  - Single Hop for Distance
  - Triple Crossover Hop
  - Triple Hop for Distance
  - 6 Meter Timed Hop



Noyes 1991

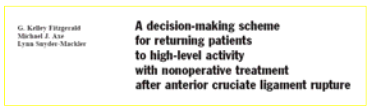
ACL SCREENING

- Hop testing (in brace)
  - Single hop
  - Triple cross-over hop
  - Triple hop
  - Timed hop (≥ 80%)
- KOS (≥ 80%)
- Global rating (≥ 60%)
- Number of giving way episodes (≤ 1)
  - » *Fitzgerald, Axe, Snyder-Mackler JOSPT 2000*

Failure to meet *any* of the criteria = Non-Coper

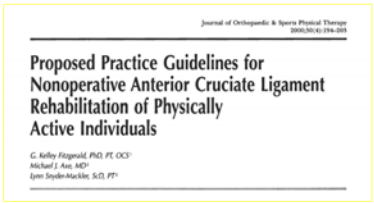
Does It Work???

- Potential copers had a 79% success rate for short-term return-to-sport without giving way (50% long-term)
  - Without screen, 75% of patients experience giving way when returning to sports



Fitzgerald, Axe, Snyder-Mackler, 2000

University of Delaware Perturbation Enhanced Rehabilitation Program



- Perturbation training
- Strength training
- Agility training

Soreness Rules

- Criterion
  - Soreness during warm up that continues:
  - Soreness during warm up that goes away:
  - Soreness during warm up that goes away but redevelops during session:
  - Soreness the day after lifting (not mm)
  - No soreness
- Action
  - 2 days off, drop down 1 step
  - Stay at step that led to the soreness
  - 2 days off, drop down 1 step
  - 1 day off, do not advance program to next step
  - Advance 1 step per week or as instructed by healthcare professional

Perturbation Variables

- Predictability
- Direction
- Speed
- Amplitude
- Force
- Feed forward / Feedback

Training Program Dosage

- 10 treatments, administered bi-weekly to as frequently as daily
- Number of session per week and program progression are dependent on
  - the ability of the patient to appropriately perform the techniques
  - the response of the patient's knee joint
  - time constraints, including the amount of time left in the competitive season

Perturbation Training

Tiltboard

Rollerboard

Rollerboard + Platform

Themes in Perturbation Training

- Changing aspects of the perturbation training to challenge neuromuscular system
  - Speed, magnitude, direction
  - May affect clinical presentation
- Goals of training
  - Break up rigid co-contraction
  - Promote rapid, selective muscle responses

Task Performance

- Eyes straight ahead
- Knees soft
- Let me move you, then respond to match my force
- Keep trunk still
- Assess
  - Where responses are coming from (hip, trunk, ankle, knee)
  - Speed of response
  - Specificity of response

Early Phase

- Sessions 1-4
  - Expose patient to perturbations in all directions
  - Elicit an appropriate muscular response to perturbations
    - (no co-contraction)
  - Minimize verbal cues

Early Phase

- 2 → 1 foot
- Feedforward → Feedback
- Block → Random directions
  - A-P
  - M-L
  - Diagonals
  - Rotations

Tiltboard


-3 sets for 1 minute each: anterior-posterior, medial-lateral

-Verbal cues: let me move the board, then bring it back level

Rollerboard

-Do not induce fall (beyond LOS)

-3 sets for 30 seconds each

Rollerboard + Block

-Verbal cues: Meet my force, don't beat my force; stay relaxed in between

-3 sets for one minute with rollerboard under each leg (total 6 sets)

-Board should not move > 1-2 inches

Middle Phase

- Sessions 5-7
  - Add light sport-specific activity during perturbation drills
  - Limited practice after session 7 in brace
  - Improve patient accuracy in matching muscle responses to perturbation intensity, direction, and speed



Late Phase

- Sessions 8-10
  - Increase difficulty of perturbations by using sport specific stances
  - Obtain accurate, selective muscular responses to perturbations in any direction of any intensity, magnitude, or speed

Agility Drills

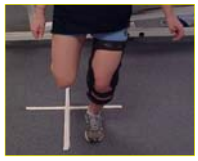
- "Functional Progression"
- Facilitate carry-over into more sport-specific movement
- Performed in brace

Agility Drills

- Shuffles
- Shuttle running
- Cariocas
- 45º and 90º cuts and direction changes on command
- Plyometrics

Progression

- Sequentially add more difficult drills
  - Straight → cutting directions
  - Sport specific
  - Increase intensity
- Re-assess for implementation of "Soreness Rules"



Strength Training

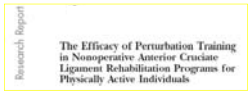
- NMES if quadriceps strength < 80%
- Progressive strengthening program that addresses entire lower extremity

Training Discharge

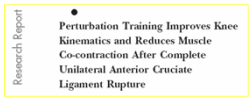
- Patients are discharged to full competition by the 10th treatment
  - Successful passing of all RTP criteria
    - 90% quadriceps strength
    - 90% on all hop tests
    - 90% on KOS
    - 90% on global rating

Training Effectiveness

- Perturbation group: 11/12 return to sports
- Standard group: 7/14 return to sports
  - » Fitzgerald et al., 2000
- Training resulted in increased knee flexion excursion and decreased muscle co-contraction
  - » Chmielewski et al., 2005


Research Report

The Efficacy of Perturbation Training in Nonoperative Anterior Cruciate Ligament Rehabilitation Programs for Physically Active Individuals


Research Report

Perturbation Training Improves Knee Kinematics and Reduces Muscle Co-contraction After Complete Unilateral Anterior Cruciate Ligament Rupture

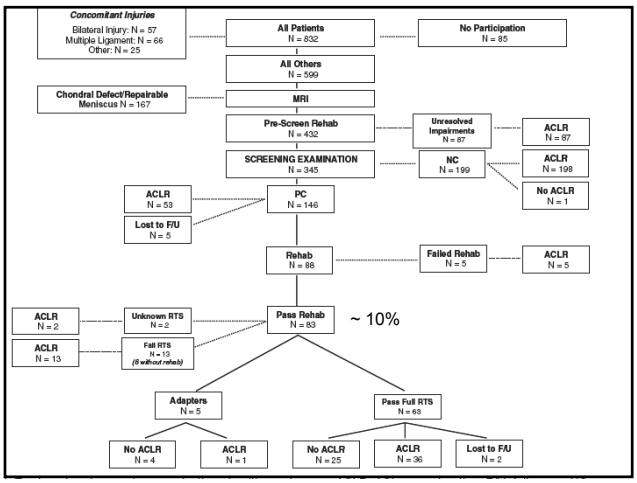
Results: Frequency Data

- $X^2 = 5.27$ Critical $X^2 = 3.84$
- more failures in standard group.
- ($p < .05$)
- Positive Likelihood Ratio - 4.88 times more likely to succeed if receiving perturbation training

	Success	Fail
Perturbation Group	11	1
Standard Group	7	7
Total	18	8

Comparison to Shelton, et al, 1997. *Am J Sports Med.*

- Shelton: 39% (12/31) Returned To Competition Without Giving Way
- Fitzgerald: 86% (24/28) Returned To Competition Without Giving Way
- Fitzgerald: 100% Participated Without Extending Damage To Knee



Does the screening discriminate?

[RESEARCH REPORT]

Individuals With an Anterior Cruciate Ligament-Deficient Knee Classified as Noncopers May Be Candidates for Nonsurgical Rehabilitation

- 125 Patients with ACL injury
- Level I and II sports
- No MRI or MVC
- Symptomatic meniscal tears excluded
- To record data and classify as non coper or potential coper and then assess the results

TABLE 2 SUBJECT CHARACTERISTICS AT SCREENING EXAMINATION*

Measures	Potential Copers (n = 46)	Potential Noncopers (n = 79)	P Value
Age (y)	27.9 ± 10.3	26.8 ± 7.6	.52
Time from injury (d)	80.2 ± 33.4	82.9 ± 40.1	.91
Physical therapy sessions	5.9 ± 3.4	5.7 ± 3.8	.84
KT-1000 (mm difference)	6.5 ± 3.5	7.5 ± 3.3	.31
Activity level (level I and II)	35 and 11†	50 and 29†	

* Data are mean ± SD.
† Number of subjects at each level

TABLE 3 PERFORMANCE AND OUTCOME MEASURES AT SCREENING EXAMINATION*

Measures	Potential Copers (n = 46)	Potential Noncopers (n = 79)	P Value
Single-hop for distance (% of uninjured)	90.3 ± 9.0	82.5 ± 14.8	<.01
Triple-hop for distance (% of uninjured)	92.3 ± 7.8	83.6 ± 12.5	<.001
Crossover hop for distance (% of uninjured)	91.7 ± 9.4	84.5 ± 13.3	<.001
Timed 6-meter hop test (% of injured)	95.6 ± 6.5	87.4 ± 12.5	<.001
KOS-ADLS	94.3 ± 3.7	81.5 ± 13.3	<.001
Global rating of knee function (VAS, 0-100)	77.7 ± 9.3	47.6 ± 20.1	<.001
Episodes of giving way	0 (0-1)	1 (0-6)	<.001
IKDC2000	78.5 ± 8.2	61.9 ± 14.0	<.001

Abbreviations: IKDC2000, International Knee Documentation Committee Subjective Knee Form; KOS-ADLS, Knee Outcome Survey activities of daily living scale; VAS, visual analogue scale.
* Data are mean ± SD, except for episodes of giving way, which were median (minimum-maximum).

Screening for Classification

- Then given 6 months PT unless the physician recommended surgery before that date
- Muscle strength
- Agility drills
- Neuromuscular training
- Until the MD decided for surgery- based on episodes of giving way, age, patients choice, level of activity and screening data

What happened?

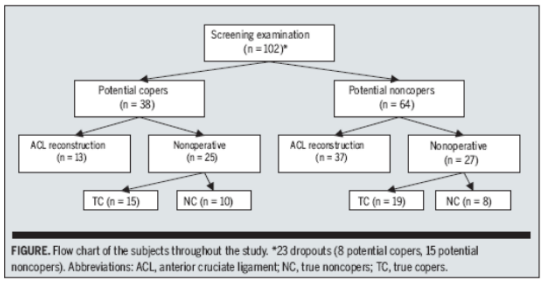


FIGURE. Flow chart of the subjects throughout the study. *23 dropouts (8 potential copers, 15 potential noncopers). Abbreviations: ACL, anterior cruciate ligament; NC, true noncopers; TC, true copers.

How did the screening perform?

TABLE 4 Classification of Subjects at Screening and 1-Year Follow-up After Nonoperative Treatment

	True Coper at 1-Year Follow-up		
Potential Coper at Screening Examination	Yes	No	Total
Yes	15	10	25
No	19	8	27
Total	34	18	52

TABLE 5 Prognostic Accuracy Profile of the Screening Examination

Measures	Accuracy	95% Confidence Interval
Sensitivity	44.1%	28.9%-60.6%
Specificity	44.4%	24.6%-66.3%
Positive predictive value	60.0%	40.7%-77.6%
Negative predictive value	29.6%	15.9%-48.5%
Positive likelihood ratio	0.79	0.45-1.39
Negative likelihood ratio	1.26	0.69-2.28

Value of the screening

- Non operated knees at 1 year
  - 65% copers
  - 35% non copers
- 60% positive predictive value to identify who would be a coper at 1 year
- 30% negative predictive value of who would be a non coper at 1 year

Patients after surgical management

- 24% had medial meniscal damage
  - 75% had partial menisectomy
  - 25% no treatment at time of surgery
- 30% with lateral meniscal damage
  - ~50% had partial menisectomy or no tx.
- 20% had cartilage damage- no tx
- (UD 28% MRI dx repairable meniscus/chondral damage- excluded from study)

Data

- 65% of subjects were copers at 1 year follow up
- In Fitzgerald only 25% were given a chance to try and 79% succeeded
- More patients may succeed if given a chance but it takes TIME…….

KEY POINTS

FINDINGS: The majority (70%) of subjects with ACL injury classified as potential noncopers were true copers after 1 year following nonoperative treatment. The prognostic accuracy of the screening examination was poor.

IMPLICATION: Subjects classified as potential noncopers and potential copers from the screening examination should be equally regarded as rehabilitation candidates. Orthopaedic surgeons and physical therapists should be cautious when advising treatment options to subjects with an ACL injury, based on the screening examination.

CAUTION: The results presented in this paper were obtained from subjects regularly performing level I and II sports; no professional athletes were included in the study.

What's Next?

- How many potential copers turn into copers?
- Do they need tune-ups?
- Can non-copers turn into potential copers?
- Who really needs surgery?

Potential Coper vs. Non Coper

- ≥ 80% on the Timed Hop Test
- >80% on the KOS ADL score
- > 60% on the Global Rating score
- Greater than 1 incidence of giving way

Post Operative Functional Testing

- 12 weeks post operation
- MVIC ≥80%
- KOS & Global Rating 80%
- Effusion: trace or less
- Full ROM
- Wear functional brace (per M.D.)

POST OPERATIVE REHAB

- ACL
- PCL
- MCL

Arthrofibrosis: Management of the “Stiff Knee”

Arthrofibrosis doesn't only happen after surgery

- Patient examples

TKA

Patellar Fracture

RSD

MCL Sprain

Arthrofibrosis

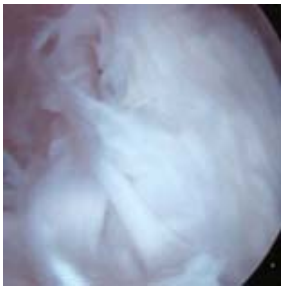
- **Local**
  - **Increased tissue volume in anterior compartment**
  - **Cyclops**
  - **Roof impingment**
  - **Stenosis of notch**
- **Global**
  - **Diffuse involvement of the knee**
  - **Suprapatellar pouch**
  - **Peripatellar soft tissue**
  - **Infrapatellar soft tissue**
  - **Capsular tightness**

Aglietti 1995

Arthrofibrosis

- Diffuse scar tissue/ fibrous adhesions within the joint
  - Loss of flexion and extension

Petsche *JAAOS* 1999



Arthrofibrosis

- **Loss of knee extension of >10° from neutral and flexion < 125°**

Cosgarea *AJSM* 1995

- **Symptomatic loss of knee flexion or extension compared to the opposite knee**

	Description
Type 1	≤ 10° extension loss and normal flexion
Type 2	>10° extension loss and normal flexion
Type 3	>10° extension loss and > 25° flexion loss with decreased medial and lateral movement of the patella (patellar tightness)
Type 4	>10° extension loss and ≥ 30° of flexion loss and patella infera with marked patellar tightness

Complications of Arthrofibrosis

- **Loss of knee extension**
  - **Contractures of 5° associated with PFJ pain** Sachs *AJSM* 1989
  - **Contractures cause gait alterations**
  - **More disabling than the pre-op instability in ACL deficient patients**

  Jackson *Arthroscopy* 1990
- **Loss of knee flexion**
  - **Flexion loss of 10°**
    - **related to loss of running speed in athletes**
  - **Overall, changes in knee kinematics and kinetics can lead to degenerative changes**

  Paulos *AJSM* 1987
  Fisher *AJSM* 1993

Risk Factors

- Pre-operative loss of motion
  - Extension < 10°
- Surgical timing
  - Early inflamed knee
- Post-operative prolonged immobilization
  - 20% reduction with early extension
- Excessive scar formation
- Concomitant injuries
- Additional surgeries

Cosgarea et al 1995, Fisher *AJSM* 1993, Harner *AJSM* 1992, Mohtadi *AJSM* 1991, Shelbourne *AJSM* 1991, Strum *Clin Op* 1990

Prevention of Arthrofibrosis

- **ROM**
  - **Maximize pre-op ROM**
  - **Early full extension after ACL surgery**
  - **Progress flexion**
  - **Restore patellar mobility**
  - **Resolution of joint effusion**
- **Red Flags**
  - **Stiffness with ROM not resolving**
  - **Firm or rubbery end-feel**

Prevention

- **Quadriceps weakness**
  - **Early weight-bearing to encourage quadriceps recovery and extensor mechanism superior motion**
  - **Progress quadriceps with open and closed chain exercises**
- **Red Flags**
  - **No dissociation of knee movement with activity**
  - **Anterior knee pain limiting strength gains**

Prevention

- **Cosgarea et al. *AJSM* 1995**
  - **Reduced incidence of arthrofibrosis following ACLR from 23% to 3%**
  - **Delaying surgery for 3 weeks**
  - **Maximize pre-operative knee ROM**
  - **Perform less extra-articular surgery**
  - **Bracing patients post-op in full extension**
  - **Emphasis on post-op ROM, quadriceps recovery, patellar mobility and early weight-bearing**

Prevention

- **Irrgang et al *J Sport Rehab* 1997**
  - **Reduced incidence of limited extension following ACL surgery from 11.1% to 1.7%**
  - **Delay surgery for 4 weeks**
  - **Achieve full pre-op knee ROM**
  - **Resolve acute inflammatory response**
  - **Less MCL and medial capsule repairs**
  - **Full extension immediately after surgery**

What the physician can do …

- Resolve flexion contracture pre-op
- Refer to PT post-reconstruction early
  - Days not weeks

What to do when it goes bad?

- **Team Approach**
  - **Surgeon:** **Medical Management**
    Surgical options
    Drop out Cast/dynamic splints
    NSAIDs/pain meds
  - **PT/ATC:** **Resolve impairments**
  - **Patient:** **Consistency**
    Compliance

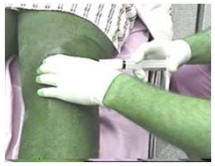
Medical Management

Problem category #1
Full Flexion & Full Extension
But Painful Superficially

- Pathology – Portals

Injection / Mobilization

- Use collagen softening side effect of steroid
- Deposit corticosteroid
  - **2 cc of Depomedrol / portal**
  - Long acting anaesthetic (amounts)
    - **5 cc marcaine / portal**
    - **Lasts 4 hours**
    - **(travel time + PT waiting room + treatment)**
      - **Allows immediate scar mobilization**
- Once / week for 3 weeks

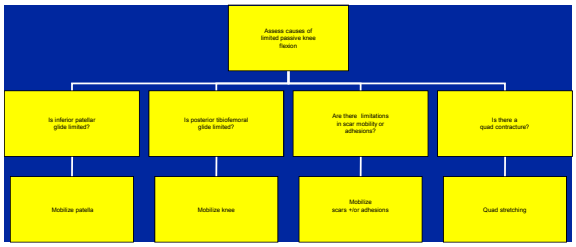


Patellar Mobility

- Straight plane
- Corners

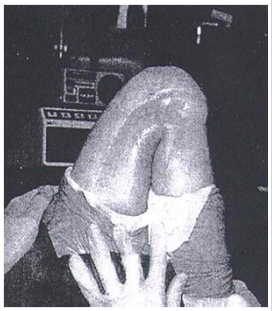
- Inferior mobilizations at end range with a stretch

Problem Category #2
Full Active and Passive Extension but Limited Flexion



Failure to progress – Flexion ROM

- Manipulation can be successful in this case
- Manipulation is a team effort



Indications

- Manipulation is indicated < 5°/week for 2 weeks

AND

- < 90° after 4 weeks of supervised PT

MUA - Flexion

- Mobilize patella and scars
- Slow sustained mobilization of tibiofemoral joint

Other Factors

- Intra-operative photographs are an excellent documentation tool as well as a motivational tool
- Immediate post-operative ROM exercises should not be performed in the prone position
  - Quadriceps soreness and spasm will likely preclude therapeutic levels of stretch

Post - MUA

- PT within 4 hours
- Treat quad spasm
- Stationary bike
- CPM mode

Tibiofemoral Joint Mobility

- IR / ER
- Anterior glide
- Posterior glide

Rectus Femoris Stretching

- Prone knee flexion
  - Towel in posterior knee
  - May assist with joint distraction during stretch
  - More comfortable

#3 Full Passive Ext but Limited Active Ext and Limited Flexion

- Pathology: Superior pouch
- Treatment: Manipulation, patellar mobilizations
- Second procedure (failed first attempt)
  - Manipulation and arthroscopic debridement

#3 Continued

- Pathology: Superior pouch
- Treatment:
  - Manipulation with Inferior patellar mobs
  - Flex to full and hold

#4 Lack Full Ext actively and Passively But No Loss of Flexion

- Pathology: **NOTCH CRUD**
  - Possibly posterior capsule
- Treatment: Arthroscopically assisted debridement (with limited open)
- Criteria – 10^{o} flexion contracture criteria

More Surgery

- THEN patellar mobs and manipulation
- THEN possible medial and posterior capsular release from the femur
- THEN dropout cast

#5 Lack Full Ext Actively and Passively and Lacks Flexion as well

- Pathology
  - SUPERIOR NOTCH CRUD, superior pouch, possibly posterior capsule
- May need to stage
  - Debridement 1st with drop out followed by MUA later for flexion
- Treatment: Dropout cast
- Epidural with 2 day stay in hospital
  - Max flex 3/day because it DOESN'T HURT!

Criteria for #4 and #5

- Extension
  - Persistent 10° flexion contracture
- Flexion
  - Manipulation is indicted < 5°/week for 2 weeks

AND / OR

  - < 90° after 4 weeks of supervised PT

Posterior Capsule Release

- Inpatient
- Stay for 2 days on continuous epidural anesthesia

Drop Out Cast

- Valium 10 mg when they are outpatients
  - Will need a driver!
- May need serial casting
- **PAD** the heel
- Felt doughnut around the patella if not cutting until later

Drop Out Cast

Padding

- Stocking
- Padding
  - Extra
    - Thigh
    - Ankle

Cylinder Cast

Cutting the Cast

Bisect Padding and Stockinette

Distal Length of Cast

- One finger width above malleolus

Remove the Cast

Completing the Thigh

- Pad the edges

Patient Independence with the Cast

Wear Schedule

- **24 hours a day / 7 days a week**
- **Cast removed 4-5 times**
  - **Flexion exercises**
- **Initiate PT Rx 5 days/wk for 2-3 weeks**
- **Progress cast to night only**
  - **loss of extension - resume wearing the drop out cast**

Physical Therapy after Drop-Out Casting

- 5 times / week for 2-3 weeks
- ROM
- Patellar mobility
- Quadriceps strengthening
- Isolation of knee movement

Physical Therapy Impairments

- **Swelling**
- **ROM Loss**
- **Joint Hypomobility**
  - **patellofemoral**
  - **tibiofemoral**
- **Gait Deviations**
- **Lack of Isolated Knee Motion**
- **Quadriceps Weakness**

Swelling

- **Ice**
- **Elevation**
- **NSAID's**
- **Standing time**

Patellar Mobility

- **Straight plane**

- **Corners**
- **Inferior mobs at end range flexion or with a stretch**

Tibiofemoral Joint Mobility

- **IR / ER**
- **Anterior glide**
- **Posterior glide**

ROM

- **Maximize joint mobility**
  - **Prolonged stretching > 20 minutes**
    Kottke 1966
  - **Adequate stretching requires moving the joint beyond the point of pain to increase range of motion**
    Krusen 1971

Knee Flexion and Extension Stretch

- **Supine wall slides**
  - **Flexion**
    - **Assist with other leg**
    - **Hold**
    - **Assist with other leg**
  - **Extension**
    - **Let quadriceps extend knee when able**
    - **Straighten fully**

Knee Extension Stretching

- **Manual Stretching**
  - **Patient needs to relax**
  - **Foot is relaxed in plantarflexion**
    - **decrease resistance to stretch**
  - **If apprehensive place the distal hand in the popliteal fossa**
  - **Contract-relax: patient attempts to raise the knee**
  - **Anterior knee pain**
    - **add superior mobilization of the patella in combination**

Knee Extension Stretching

- **Sitting Extension**
  - **Leg in neutral**
  - **Foot plantarflexed**
  - **Low load stretch**

- **Ankle dorsiflexion strategy**
  - **gastrocnemius can resist the stretch with greater ease**

Knee Extension Stretching

- **Prone hangs**
  - **Weight**
  - **Leg in neutral**
  - **Hips secured**
  - **Knee off table**
  - **When completed caution taking weight off**

Stretching for Knee Flexion

- **Supine Knee Flexion**
  - **Rectus on slack - capsular stretching**
  - **Towel in posterior knee - joint distraction**
- **Contract/Relax for knee flexion**
  - **Use towel or sheet to help increase leverage**
  - **Note plantarflexed foot to minimize co-contraction**

Flexion

- **Isokinetic device in CPM Mode**
  - **30°/sec or slower**
  - **Maximal tolerable stretch**
  - **Increase range as tolerated (2-3 min)**
- **Flexion**
  - **knee axis anterior to dynamometer axis**

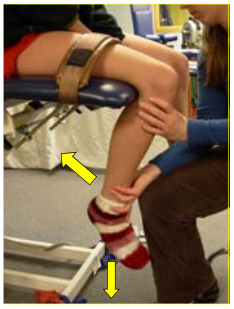
Extension

- **Extension**
  - **knee axis inferior to dynamometer axis**
  - **stabilize thigh**

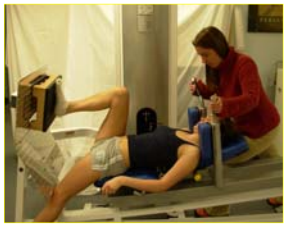
Through Range Stretching

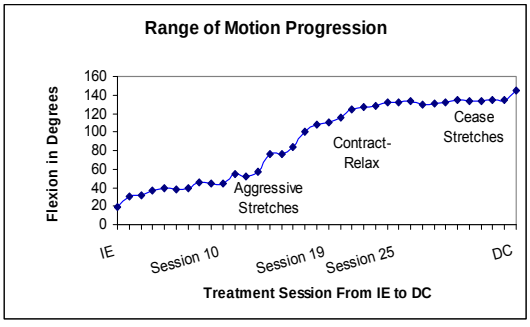
- **Progress to working both ends of the range**

Stretching for Knee Flexion



Stretching for Knee Flexion





Rectus Femoris Stretching

- **Prone knee flexion**
  - **Goal is rectus femoris stretch only**
  - **Caution with speed/force in patients with previous bad experiences**

Bike for Knee Flexion Stretching

- **Patient pushes into flexion range and then retreats to go directly into flexion again**
- **Repeat until they can complete a revolution**
- **Lower seat and repeat**

Stretching for Knee Flexion

- **Body-weight to assist**
- **Foot on chair and sit back to stretch**
- **Modify with tibial IR/ER**
  - **Promotes tibiofemoral stretching**

Through Range Stretching

- **Facilitate movement through the available range of motion**
- **Resist loss in one direction in favor of gains in the opposite direction**
- **Incorporate motion into activity**

Gait

- **Not utilizing full extension with stride**
- **Maintains stiffened knee flexion range during swing phase**

Gait

- **Full extension is being utilized but stiff in knee flexion on swing**
- **Cue, step on a bent knee and then push back as you put weight on that limb**

Isolation of Knee Motion

- **Open chain exercises encourages isolated knee movement**
- **Prevents substitution seen with closed chain exercises**

Isolation of Knee Motion

- **Low weights**
- **Eccentric control**
- **No substitution of agonist muscles**
- **No pain**

Free Knee Motion

- **Educate on practice to allow knee to move freely**
- **Un-weighted knee flexion/extension swings**

Common Substitutions for Knee Motion

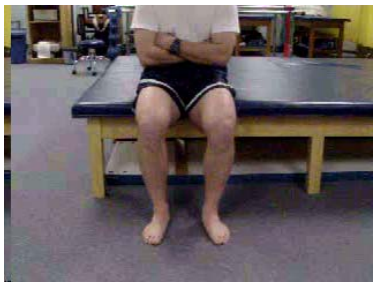
- **Bike**
  - **Elevated hip**
  - **Plantar flexed foot**

Common Substitutions for Knee Motion

- **Stairmaster**
  - **Locking knee in flexion**
  - **Weight shifting to depress step**

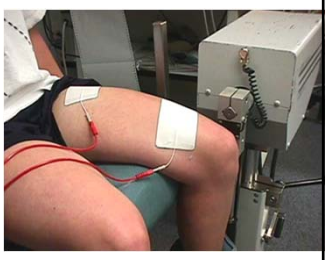
Use of Knee Motion in ADL's

- **Identify substitution patterns in ADL's**
- **Sit to stand**
- **Relaxed standing with flexed knee**



Assessment of Strength

- **Quadriceps maximal isometric contraction**
  - **Stabilized in knee flexion**
  - **Burst superimposition technique**
  - **Calculate % side to side difference (inv. max./uninv. max *100)**



Assessment of Strength

- **Quadriceps strength testing**
  - **Isometric contraction**
  - **Target maximal force**
  - **Low speed isokinetics**

Electrical Stimulation for Strength

- **Snyder-Mackler et al, *JBJS* 1995**
  - **Conclusion: For quadriceps weakness, high-level NMES with volitional exercise is more successful than volitional exercise alone**

Parameters of Electrical Stimulation

- **2500 Hz**
- **Variable wave form**
  - **triangle, sine, square**
- **75 bursts/second**
- **2 second ramp**
- **12 seconds on time**
- **50 second rest time**
- **10-15 contractions**

NMES For Quadriceps Strengthening

- **Amplitude to minimum of 50% MVIC**
  - **Patient encouraged to increase the intensity to maximum tolerated**
  - **Dose-response curve demonstrates greater intensities lead to greater strength gains**

(Snyder-Mackler et al., 1994)

Quadriceps Set

- **Bad**
  - **Hip elevation for knee extension**
  - **Little to no quadriceps activity**
  - **Primarily glut. Exercise**
- **Good**
  - **Patella migrates superiorly**
  - **Quadriceps is recruited**
  - **Knee extension stretch occurs**

Straight Leg Raise

- **Bad**
  - **Quad Lag Present**
  - **Hip externally rotated**
  - **No effort on concentric or eccentric phase**
  - **Leg drops to bed**

Good SLR

- **Full extension prior to lift**
- **Extension maintained throughout lift**
- **Slow decent with full extension until reaching the table**

Standing Terminal Knee Extensions

- **Bad**
  - **Heel elevation for knee flexion**
  - **Substitution of hip extensors for knee extension**
  - **Little or no quadriceps activity**
  - **No eccentric quad activity during knee flexion**
  - **Bilateral knee flexion**

Standing Terminal Knee Extensions

- **Good**
  - **No hip substitution**
  - **Both eccentric and concentric phase of quadriceps contraction**
  - **Patella is lifted superiorly**
  - **Even weight distribution**

Step Down

- **Bad**
  - **Hip Drop to reach floor in place of knee flexion**
  - **Poor eccentric control of the knee**
  - **Poor balance on decent**
  - **Often drop off involved leg onto heel of opposite foot**

Step Down

- Good
  - **Hips remain level**
  - **Slow controlled decent of involved quadriceps**
  - **Gentle heel touch and return**
  - **May begin with only 2” step progressing to 6” over months**

Wall Squat

- **Bad**
  - **Unweight involved side**
  - **Knee does not go over 2nd toe**
  - **Back comes off wall with return to standing**
  - **Little to no quadriceps activity**

Wall Squat

- **Good**
  - **Equal weight-bearing bilaterally**
  - **Knees directly over middle of foot**
  - **Knee does not move anterior to ankle**
  - **Can be made more difficult by placing uninvolved leg on unstable surface**

Patellofemoral Pain

- **Patellar Taping**
  - **Bracing**
- **Stretching**
  - **ITB**
  - **Hip/Ankle ROM**
- **Modalities for Pain Control**

Portal Pain

- **Elastomer**
  - **Incision and portal site**
  - **Nightly wearing schedule**
- **Mobilizations in neutral and flexion**
- **Ice massage**
- **Modalities for pain**

Elastomer

- **Putty Elastomer**
- **Part A and B**
- **Contact**
  - **North Coast Medical, Inc**
  - **408-283-1900**

Arthrofibrosis Summary

- **Prevention is the KEY**
  - **Drop out cast can be used early**
  - **Adequate supervision in PT**
- **Management is COSTLY**
  - **Multiple procedures**
  - **Average PT Visits 30-50 or more**
  - **Emotionally draining**
  - **Time intensive within treatments**

Arthrofibrosis Summary

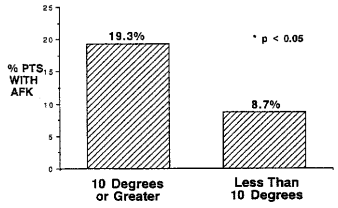
- **Team Approach is ESSENTIAL**
  - **Patient**
  - **Family**
  - **Co-workers/Classmates**
  - **Surgeon**
  - **Physical Therapist**

Pre-operative ROM

- **Loss of ROM pre-op is associated with an increased risk of postoperative arthrofibrosis**
  - **Pre-operative extension should be <10°**

Cosgarea et al 1995

Pre-Operative ROM



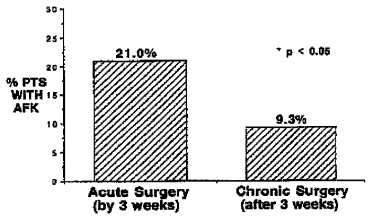
- **Incidence of arthrofibrosis by preoperative extension deficit** **Cosgarea *AJSM* 1995**

Surgical Timing

- **Acute reconstruction has been identified as a risk factor**
  - **Between 2-4 weeks post injury**

Fisher *AJSM* 1993 **Shelbourne *AJSM* 1991**
Harner *AJSM* 1992 **Strum *Clin Op* 1990**
Mohtadi *AJSM* 1991

Surgical Timing



- **Increased risk for 3 weeks post injury in the presence of inflammatory response**

Surgical Timing

- **185 patients self-selected surgical timing for ACL reconstruction**
  - **Within 48 hours**
  - **3-7 days**
  - **1-3 weeks**
  - **> 3 weeks**

Hunter R, et al, 1996

Results

- **Extension and flexion ROM**
  - **no statistical difference among any of the groups for either**
- **Classified ROM**
  - **0 - 5°**
  - **5°- 10°**
  - **> 10°**

Results

- **By 4 weeks post-op**

Time to sx	5°-10° or greater
48hrs	3
3-7 days	0
1-3 weeks	9
> 3 weeks	0

**** Rest of patients had between 0°-5° ****

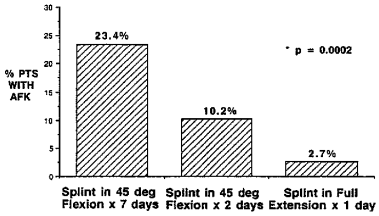
Results

- **Physical Therapy intervention**
  - **Began day of surgery**
  - **Daily for 2 weeks focus on full ROM**
  - **Hinged full motion brace for 2 weeks**
- **Results possibly skewed because**
  - **Skiing population**
  - **Prospective study that was patient driven**

Results

- **Trend towards more complications with surgery in the first 3 weeks but not statistically significant**
- **Restoration of early full ROM had no compromise on KT-1000 measured joint laxity**

Post-operative Immobilization



- **Least incidence of arthrofibrosis in group with ROM beginning on the first day and splint in full extension**

Cosgarea *AJSM* 1995

Impingement

- **Insufficient notchplasty**
- **Non-anatomic graft placement**
- **Development of scar tissue / cyclops lesion**

The continuum of Osteoarthritis..from pain and disability through rehabilitation following Total Knee Arthroplasty- Can we Improve Outcomes?

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University of East London

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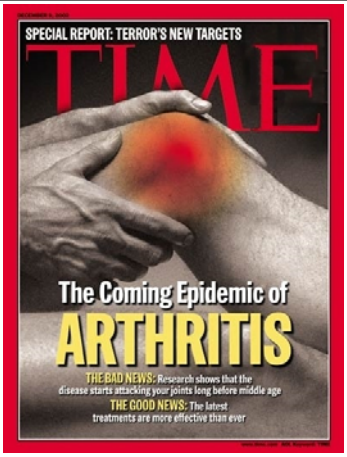
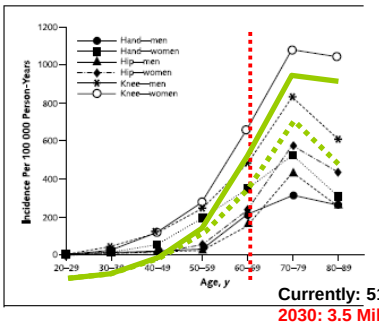
Eastern Washington University



Prevalence Rates

Figure 1. **Incidence of osteoarthritis of the hand, hip, and knee in members of the Fallon Community Health Plan, 1991–1992, by age and sex.**



Currently: 510,000 TKAs
2030: 3.5 Million TKAs

Disease Characteristics

- Pain with weight bearing activities
- Osteophyte formation
- Joint space narrowing
- Subchondral bone sclerosis

Stiffness or Laxity?

Debilitating Signs & Symptoms

- Pain
- Stiffness
- Restricted joint mobility
- Laxity and instability
- Joint malalignment
- Muscle weakness
  (Quadriceps Femoris Group)

Pharmacological Tx

Most Common

- Acetaminophen
- NSAIDs
- Topical NSAIDs (capsaicin)
- Opioids
- Glucosamine sulfate
- Corticosteriod Injections
- Intra-articular hyaluronate

Data

- Superior to Placebo 4mg/day but minimal (liver toxicity- monitor)
- More effective than Acetaminophen- GI issues
- Mild effect on pain limited side effects
- When others not effective- strong meds only when severe pain- consider sx.
- ?benefit try for 6 months
- ? Short term(2-3 wks) little long term benefit
- Slow acting but can last 2-3 months ? Cost/benefit

Bade M, et al Joint Arthroplasty: Advances in Surgical Mgmt APTA Ortho Section Independent Home Study Course 2010

NonPharm Conservative Mgmt

- Weight Loss
  - Loss of 6.1 kg is associated with sig and moderate improvements in pain and disability
- Exercise
  - Guidelines: 5 days/wk 30 min session Moderate to vigorous intensity and low impact
  - High load: 60-80% 1 RM
  - Low load: 10-30% 1 RM
  - Walking, cycling, water jogging, Tai Chi
  - Consider proprioception training as well

Physical Activity Guidelines Advisory Committee Report

Non Pharm Conservative Mgmt

- Knee Braces
  - Knee Sleeve
  - Unloading Brace
  - + change pain not fnct
  - Moderate improvement pain and function
  - Medial compartment braces show positive impact but compliance long term is poor
  - Difficult to fit in obese population

Non Pharm Conservative Mgmt

- Patellar Taping
  - Reduces pain in patient's with knee OA
  - Mechanism in unknown
  - Consider a trial and D/C if no benefit
- Footwear
  - Supportive shoe with shock protection
  - Rear foot or full length lateral wedge may help with pain (esp. trial)

Non Pharm Conservative Mgmt

- Modalities
  - Heat
  - Ice
- TENS
- Assistive Device
- Little evidence for use especially long term benefits
- Evidence for short term use for pain
- Effective way to reduce weight bearing forces and fall protection

The Delaware Osteoarthritis Profile

- Self-reported pain and function
  - KOOS, KOS-ADLS, VAS for pain, SF-36
- Performance-based measures of mobility and balance
  - TUG, SCT, 6MW, UBT
- Clinical and Anthropometric Measures
  - Age, Sex, Height, Weight, BMI, ROM, Quadriceps strength with burst superimposition

TUG

(Functional Assessment)

SCT

(Functional Assessment)

6MW

(Functional Assessment)

Surgical Management

- High Tibial Osteotomy
  - Opening Wedge versus Closing Wedge
    - Tibial vs Supracondylar
  - Unicompartmental OA
  - Varus or valgus alignment
  - Younger in age (<60 years old)
  - Can be used to delay need for TKA
    - Corrects malignment to unload injured compartment
    - Failure rate is 25%
    - Risk: non-union, intra-articular fx, compartment syndrome, hardware failure…

Surgical Management

- Unicompartmental Knee Arthroplasty
  - Option for OA of one compartment
  - Surgery is technically demanding
    - Danger of overcorrecting and undercorrecting
  - Indications; non-inflammatory OA, low impact sports, jobs without squatting, intact cruciates, non-obese, able to correct malalignment without major soft tissue release, deformity less than 15degrees
  - Faster short term recovery, better propioception and ROM- 85%+ 10-yr data

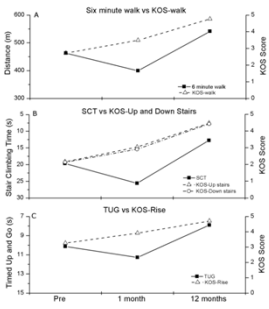
Surgical Management

- Knee Arthrodesis/ Fusion
  - Indications: Failed TKA from infection, poor skin or soft tissue coverage, gross instability, extreme quad weakness or those unwilling to undergo a TKA revision
  - Gait compensations
    - Pelvic tilt, hip abduction, increased ankle dorsiflexion
  - Contraindicated with advanced DJD of spine, ankle or hip

Knee Osteoarthritis

What we look like before TKA?

Performance Does Not Equal Perception

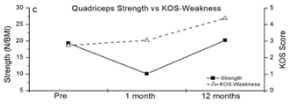


1 month after TKA walking distance and speed decreases, but walking ability reportedly improved

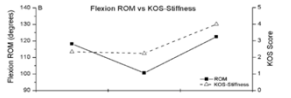
1 month after TKA patients take longer to go up and down stairs and more people require a handrail, but stair climbing ability reportedly improved

1 month after TKA patients take longer to get up and out of a chair, but ability to rise from a chair reportedly improved

Performance Does Not Equal Perception



>50% reduction in strength, but patients report same or increased strength



20° loss of flexion, but patients report same amount of stiffness during knee flexion

Outcomes Below than Age-Matched Controls

"TKA reliably reduces pain and improves functional ability. However patients do not return to the standard of age-matched controls without knee pathology"

Table 2. Patient characteristics 2 years post-op

	OA (n=106)	Control (n=31)
KOS-ADLS (%)	84.6 (12.7)*‡	94.9 (8.1)†
TUG (s)	8.2 (2.6)*‡	6.8 (1.5)
SCT (s)	12.8 (4.5)*‡	10.1 (2.1)†
Quad Strength (Non-op) (N/BMI)	20.8 (9.2)‡	23.7 (8.9)‡
Quad Strength (Op) (N/BMI)	20.4 (8.1)	23.7 (8.9)‡

Handrail use after TKA

OA (n=105)		Controls (n=64)
Baseline	Follow-up	Baseline
60%	57%	30%

"Younger, **stronger patients** who do not use a handrail prior to unilateral total knee arthroplasty can expect the best outcomes in terms of ascending and descending stairs following surgery"

-- Zeni et al. JBJS 2010

Impairments 1 year after TKA
Walking speed: 17% lower
Stair-climbing speed: 50% lower
Quadriceps strength: 39% weaker

-- Walsh et al. PTJ 1998

The Importance of Quadriceps Strength

Improved Function From Progressive Strengthening Interventions After Total Knee Arthroplasty: A Randomized Clinical Trial With an Imbedded Prospective Cohort

STEPHANIE C. PETTERSON,† RYAN L. MIZNER,† JENNIFER E. STEVENS,† LEO RADNIS,† ALEX BOBENSTAB,† WILLIAM NEWCOMB,† and LYNN SNYDER-MACKLER†

Post-operative rehabilitation requires aggressive quadriceps strengthening

Preoperative Quadriceps Strength Predicts Functional Ability One Year After Total Knee Arthroplasty

RYAN L. MIZNER, STEPHANIE C. PETTERSON, JENNIFER E. STEVENS, MICHAEL J. AXE, and LYNN SNYDER-MACKLER

The stronger the patient is before surgery, the better the outcomes after surgery

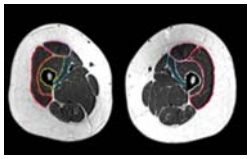
Quadriceps Strength and the Time Course of Functional Recovery After Total Knee Arthroplasty

Ryan L. Mizner, MPT, PhD*
Stephanie C. Petterson, MPT*
Lynn Snyder-Mackler, PT, Sc.D. SCS, ATC, FAPTA*

Quadriceps strength is highly correlated with functional ability after TKA

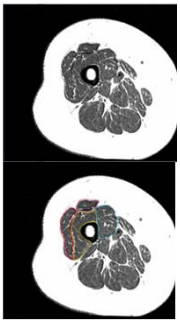
Contributions to Strength Loss

Reported deficits 8-25%
(Berth 2002; Hurley & Newham 1993; Lewek 2004; Stevens 2003)

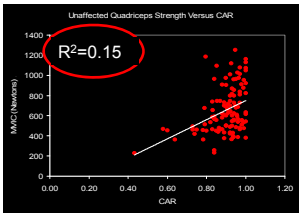


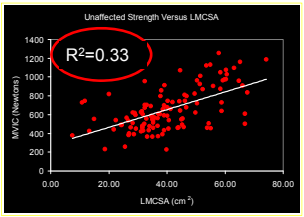
- Arokoski (2002) → hip OA

Quadriceps Lean Muscle Cross-Sectional Area *(LMCSA)*

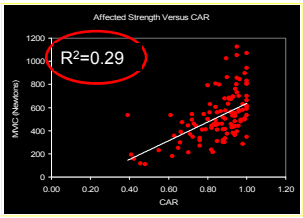


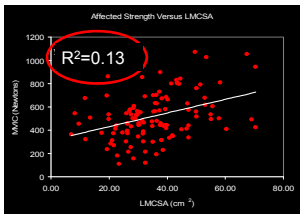
LMCSA Explains 33% of the Variability of the *Asymptomatic* Limb's Quadriceps Strength





Activation Explains 29% of the Variability of the *Symptomatic* Limb's Quadriceps Strength

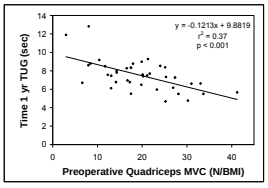


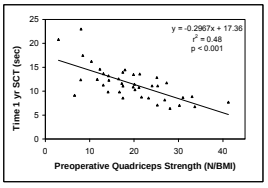


Why does it matter…

Clinical Importance

Preoperative strength predicts long-term postoperative strength & function (Mizner et al 2005)





Deep Vein Thrombosis

- Epidemiology
  - 2 million Americans affected each year
  - 50 - 60 thousand people die each year
  - 3rd leading cause of cardiovascular death
  - 10% of all hospital deaths are related to DVT/PE
  - 2/3 of all the deaths that occur from PE occur rapidly

Aldrich and Hunt, *Phys Ther* 2004

- Total knee arthroplasty
- Treated with prophylaxis

DVT 31% of the time!

Signs and Symptoms

- Swelling
- Warmth
- Blue/red/brown discoloration
- Dependent edema
- Prominence of superficial veins
- Pain or tenderness
- Fever
- Chills
- Malaise
- Cyanosis of the affected extremity
- > 50% are clinically silent

Clinical Signs/Symptoms

	DVT present	No DVT
Pain	48 - 90%	23 - 97%
Tenderness	43 - 84%	35 - 89%
Edema	42 - 78%	26 - 67%
Homan's Sign	11 - 56%	11 - 61%

O'Donnell *Surg Gynecol Obster* 1980
Haeger *Angiology* 1969
Molloy *Ir Med J* 1982

Clinical Decision Rule

Figure 2 – Simplified Clinical Model (reprinted from Anand et al., *JAMA* 279:1094-99, 1998).

Clinical Parameter	Score
Active cancer (treatment ongoing or within previous 6 months or palliative)	1
Paralysis, paresis, or recent plaster immobilization of the lower extremities	1
Recently bedridden >3 days and/or major surgery within 4 weeks	1
Localized tenderness along the distribution of the deep venous system	1
Entire leg swelling	1
Calf swelling 3 cm > symptomless side (measured 10 cm below tibial tuberosisty) [v]	1
Pitting edema; symptomatic leg only	1
Collateral superficial veins (non-varicose)	1
Alternative diagnosis as likely or greater than that of DVT	−2

Scoring method: high probability if score is ≥3; moderate if score is 1 or 2; and low is score is ≤0.
[v] In patients with symptoms in both legs, the more symptomatic leg was used.

Anand, Wells et al. *JAMA* 1998

Conclusion

- When utilized correctly, the DVT CDR developed by Wells can help identify those patients who are at greater risk for developing a DVT

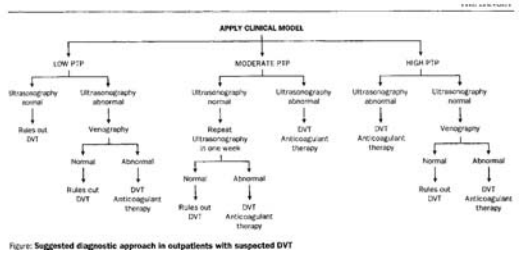


Figure: **Suggested diagnostic approach in outpatients with suspected DVT**

The Success of TKA

1. Reduces knee pain
   (Gill 2003; Duffy 1998; Konig 2000; Huang 1996)
2. Corrects deformity
3. Improves range of knee motion
   (Beaupre 2001; Kramer 2003; Mizner 2005)
4. Improves functional performance
   (Gill 2003, Huang 1996, Walsh 2001)

Outcomes with TKA

- Good outcomes for pain reduction and return to functional activities
  (Lorentzen *et al.* 1999)
- ROM at 1 year
  - Flexion: 110-124° (Walsh 1999; Yoshida et al)
  - Extension:-1-0° (Walsh 1999; Yoshida et al)

Outcomes with TKA

- 20-30% slower walking speeds
  (Walsh *Phys Ther* 1998)
- 50% slower stair climbing speeds
  (Walsh *Phys Ther* 1998)
- 52% have some limitations with functional activities, compared to 22% without knee problems (Noble *Clin Orthop Relat Res* 2005)
- Long term Impairments
  - 6 mo – 1 yr after TKA
    - 30 - 40% deficit in quadriceps strength (Lorentzen 1999, Walsh 1998)

Outcomes with TKA

- ¾ of patients with TKA report difficulty negotiating stairs (Noble *Clin Orthop Relat Res* 2005)
- Following a peak in functional recovery 2-3 years after TKA, there is an accelerated decline in function relative to age-related decrements (Ritter *JBJS* 2004)

Is TKA Successful?

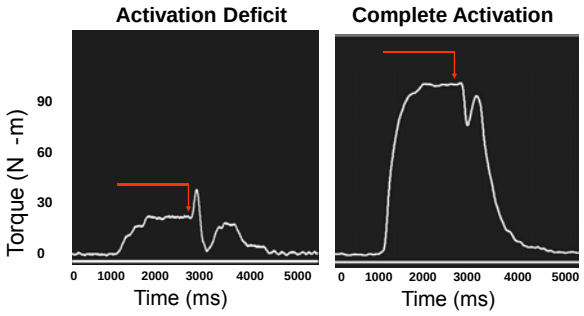
YES

- Reduced pain
  (Gill 2003; Duffy 1998; Konig 2000; Huang 1996)
- Increased knee ROM
  (Beaupre 2001; Kramer 2003; Mizner 2005)
- Increased function
  (Walsh 2001)
- Self-report
  (Ethgen 2004; Finch 1998; Gill 2003)

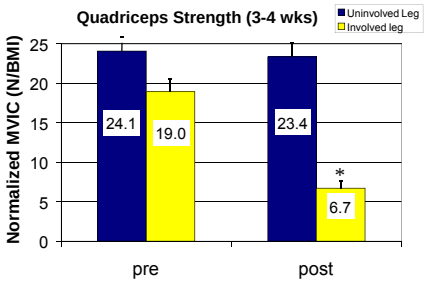
NO

- Quadriceps Weakness
- Functional Limitations

Muscle Activation

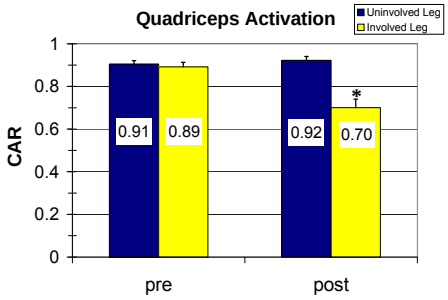


Quadriceps Force Decreased 60% From Pre-operative Levels



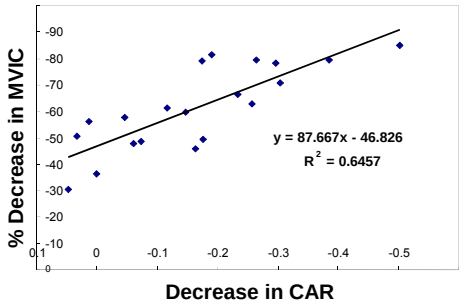
Mizner *et al. JBJS*, 2005.

Quadriceps Activation Decreased 21%

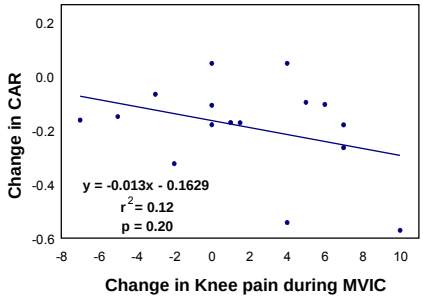


Mizner *et al. JBJS*, 2005.

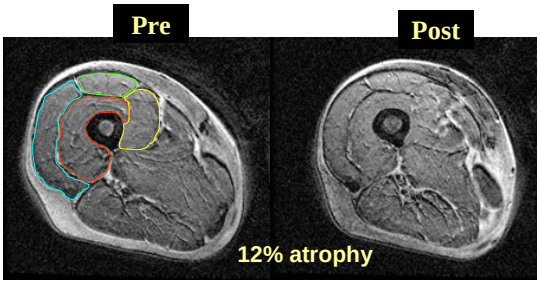
Large Amount of Quadriceps Force Loss Accounted for by Decrease in Activation



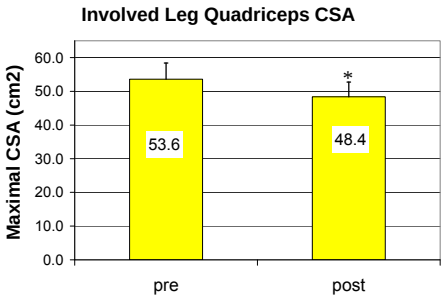
Change in pain did not account for significant decrease in activation.



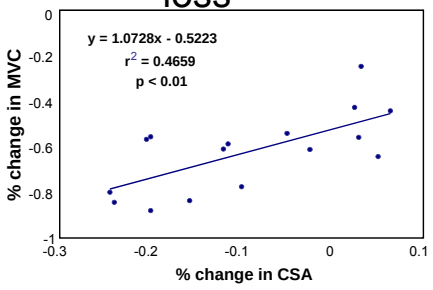
Changes in CSA before and after TKA



Quadriceps Cross Sectional Area decreased by 10%



Change in CSA accounted for significant amount of force loss



Collectively, changes in activation and changes in muscle CSA explained **86%** of variance in loss of quadriceps force

(R^2=0.86, p<0.01).

Clinical Implications

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

Clinical Implications

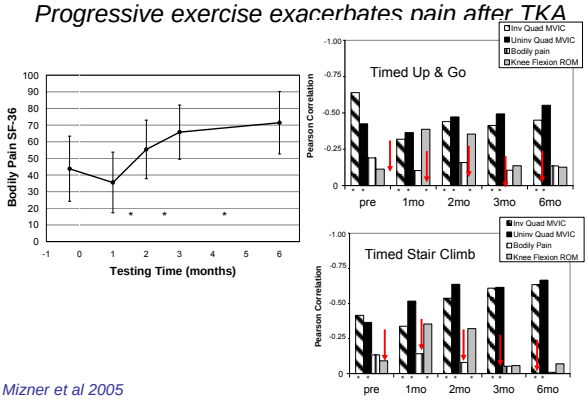
- Quadriceps strengthening after TKA relies on volitional exercise alone in paradigms designed to counteract disuse atrophy.
- Patients with large muscle activation deficits have negligible improvements in force even after intensive rehabilitation. (Hurley et al. 1993)
- Failing to address activation deficits may help explain long-term quadriceps weakness.

- Alternatives to traditional voluntary exercise paradigms
  - Neuromuscular electrical stimulation
  - Biofeedback
  - Cryotherapy

Rehabilitation after TKA

Myth

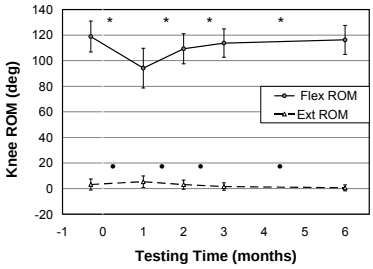
Progressive exercise exacerbates pain after TKA



Mizner et al 2005

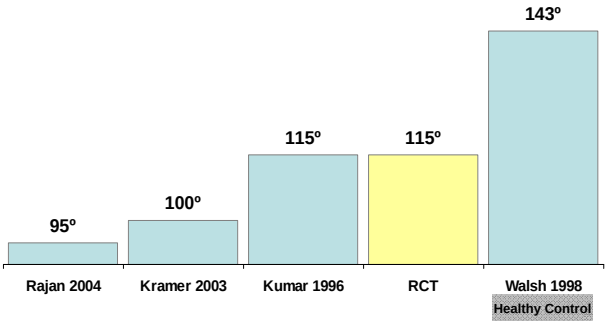
Myth

Progressive exercise limits range of motion recoverv



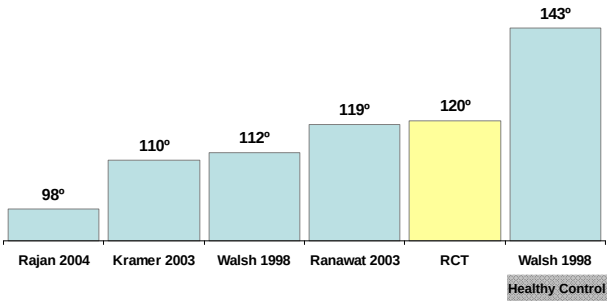
Mizner et al 2005

Improved Knee Flexion – 3 Months



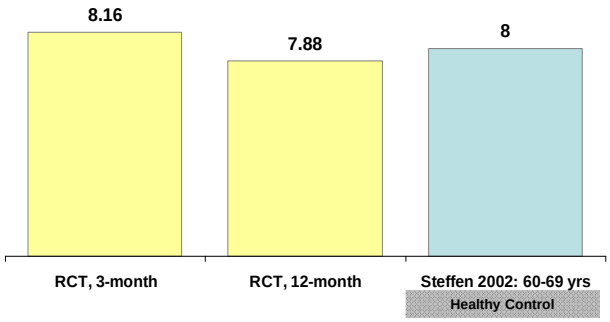
Unpublished data

Improved Knee Flexion – 12 Months



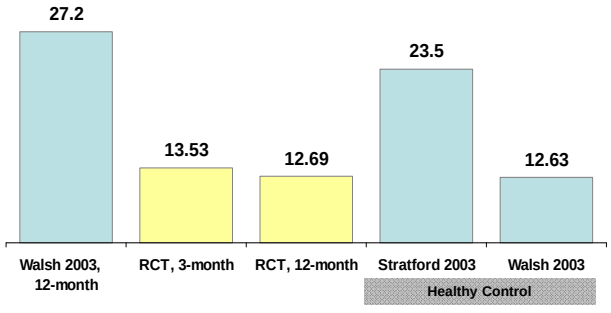
Unpublished data

Improved Timed Up and Go (seconds)



Unpublished data

Improved Stair Climb (seconds)



Unpublished data

Improved Six-Minute Walk (meters)

3-Months

Enright 1998: 320 m
Moffet 2004: 380 m
RCT: 535 m

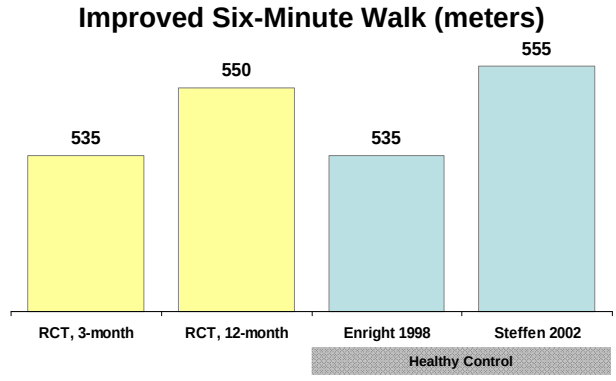
53% better

12-Months

Enright 1998: 400 m
Moffet 2004: 405 m
RCT: 550 m

40% better

Unpublished data



Optimizing exercise prescription

- Neuromuscular electrical stimulation (NMES)
- Exercise selection
  - Strength training: dosage
- Movement substitutions
  - Suggestions to improve form and efficacy

Why NMES following TKA?

- Profound strength deficits after TKA (Stevens et al 2003)
  - 60% decrease in MVIC
  - 17% decrease in CAR
- Impaired ability to perform ADL's (Wolfson et al 1995)

Goals of NMES

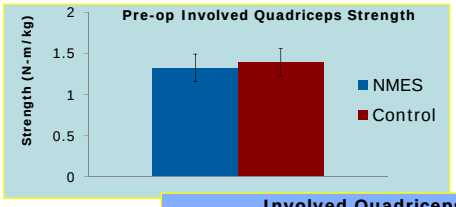
- Quality
  - Muscle Reeducation
- Quantity
  - Selective recruitment (Cabric et al 1988)
- Ultimate goal: greatest *tolerable* force output

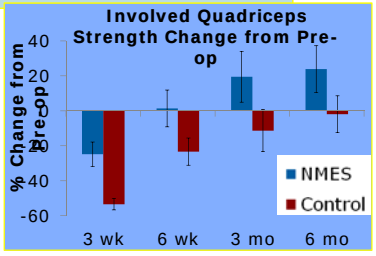
NMES treatment parameters (Mintken et al 2007)

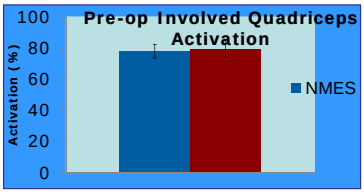
- Electrodes at VM and RF
- 2500Hz carrier freq
  - 250 μsec wavelength
- 50Hz burst freq
  - Sine wave
- 3-sec ramp up
- 12-sec on
- 45-sec off
- Maximum tolerated intensity
- 15 repetitions
- Frequency of treatment
  - Twice daily for 6 weeks
  - Postop day 2

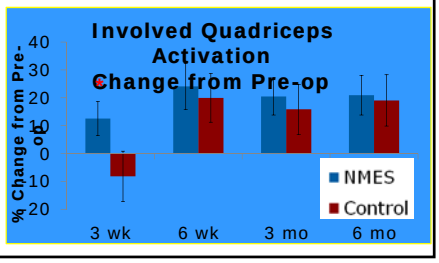
NMES treatment parameters
(Mintken et al 2007)

- Electrodes at VM and RF
- 250 μsec pulse duration
- 50Hz freq
- 2-3 sec ramp up
- 12-sec on;45-sec off
- Maximum tolerated intensity
- 15 repetitions
- Frequency of treatment
  - Twice daily for 6 weeks
  - Starting postop day 2

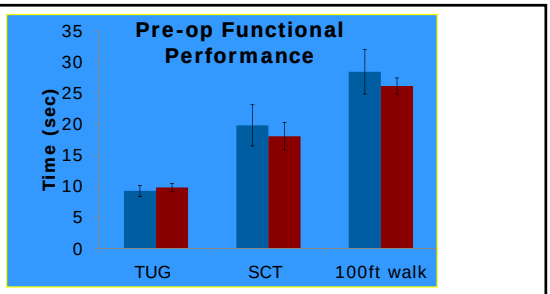


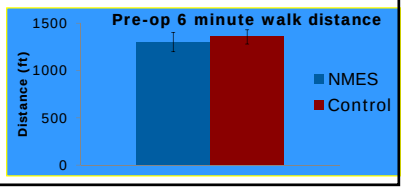


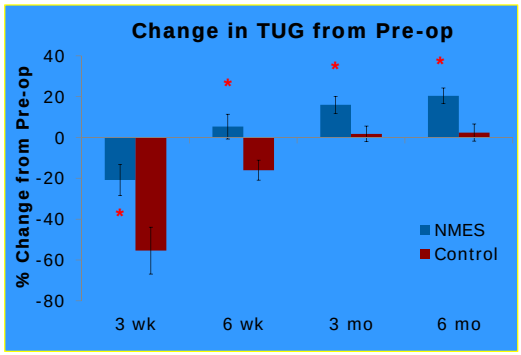




* p<0.05







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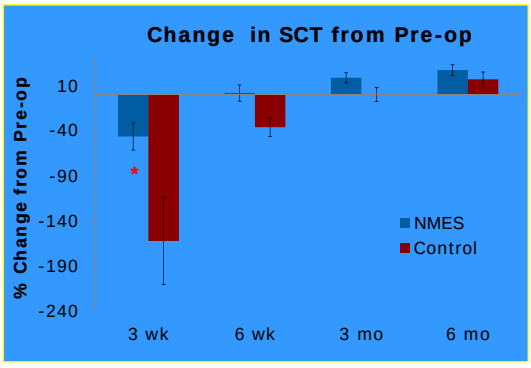

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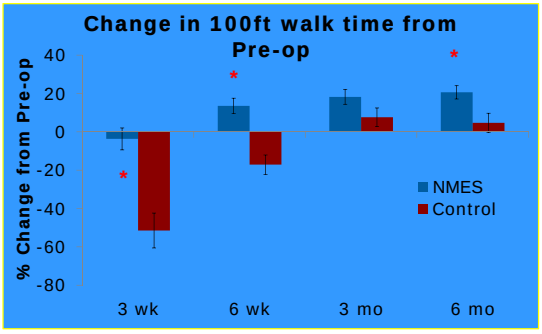

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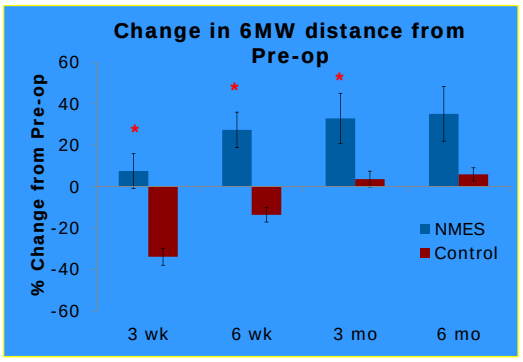


* p<0.05

Goal of NMES

- Quality muscle contraction
- Quantity sufficient enough to produce strength gains
- Strength gains reflect intensity tolerated
- Therefore …
- Ultimate goal is to generate the greatest tolerable force output

Total Joint Arthroplasty

- **Amplitude targeted at a minimum of 30% MVIC (Snyder-Mackler et al., 1994)**
- **Ramp time, frequency adjusted to increase comfort and tolerance for higher intensity stimulation**

MVIC 178N NMES 107N

Patient Tolerance

Early postoperative strengthening

Late phase strengthe

Late phase strengthening

Strength training dose

- Stevens et al 2004
  - 1 to 3 sets of 8-15 repetitions
  - Progression criteria
    - Exercise through full ROM
    - Proper technique
    - No pain
    - Minimal fatigue
- Moffet et al 2004
  - No progression criteria
  - Intensity: 60-80% predicted heart rate
    - Endurance exercises 5-20 minutes

Weight shifting

Gait Deviations

Cues for Gait

- Avoid Heel Toe Cue
- Encourage landing on flexed knee with “push through” to emphasize knee extension
- Push Back

Encourage Push Back

Pre-Gait Push Back

Add Arm Swing

Pain

- Identify pain location
- Modified activity level

Pain

- Medications
  - Analgesics
  - Anti-inflammatories
    - NSAIDs
    - COX-2 inhibitors
- Use of NSAID's and COX-2 inhibitors
  - Risk/benefit
  - Case by case

Pain - Modalities

Swelling

- Ice
- Elevation
- Monitor activity level
- NSAID's
- Compression socks
  - Brown *J Am Osteopath Assoc 1995*

Limited ROM

- Interventions can be performed in a number of ways
  - –Passive
  - –Active – Assistive
  - –Active

Limited ROM

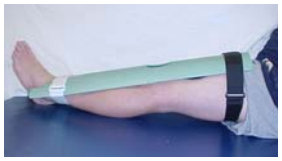
- Supine wall slides
  - Flexion (AA or P)
    - Assist of other leg
    - Hold
    - Assist of other leg
  - Extension (AA or A)
    - Let quadriceps extend knee when able
    - Straighten fully

Limited ROM

- Passive
- Foot position is critical

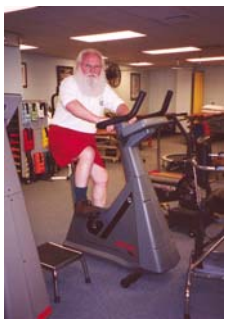
Extension Stretching Options



Limited ROM

- Active Assist
- Substitution patterns can be used in order to obtain greater ROM gains



Bike for ROM

- Substitutions
  - Hip hiking
  - Weight shift
  - Plantarflex ankle

Self Flexion Stretches



Limited Patellar Mobility

- **Passive** joint mobilizations
- **Active**
  - Quad set
  - Patella migrates superiorly
  - Quadriceps is recruited
  - Knee extension stretch occurs

Quad Set

Cues to Facilitate Quad Set

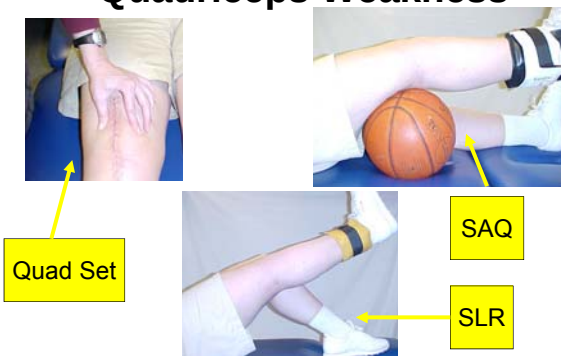
Quad Set

- Isolated quadriceps firing
- Pull the patella superiorly

Strengthening Dose

- 3 sets of 8-15 reps at maximal effort
- Proper technique
- No pain
- Follow up to next visit

Quadriceps Weakness



SLR

STKE

Therapeutic Exercises

- Hip abduction
- Hip extension
- Knee flexion
- Ankle plantarflexion

Hip ABD Strength

- Compensations
  - Leg forward
  - Pelvis backward

Hip and Knee Weakness

Long Arc

Wall Sit

Step Down

Step Downs

- Technique
  - Hips level
  - Knee over toe
- Modifications
  - Concentric / eccentric
  - Concentric only

Lower Extremity Strength

Leg Press

Leg Curls

Home Program

- Stretching Program
- Strengthening Program
- Swelling / pain management
- Compliance Notebook
  - Checked every treatment
- Daily notes has “Changes in HEP” section

Stretching

- Frequency
  - 3-5 times per day
- Duration
  - Sets/reps versus sustained stretch
  - Balance between feeling a stretch and pain
- Technique

Strength Dosage

- Frequency
  - 1-2 times / day
- Intensity
  - 2-3 sets of 8-15 repetitions
- Technique

Swelling / Pain Management

- Ice and elevation
  - Use their ice machines for 10-15 minutes
  - 4-5 times a day
  - To offset increases in activity level as the patient progresses

Compensation Strategies

- Shifting weight in standing to uninvolved leg

Compensation Strategies

- Unweighting involved leg for sit to stand

THANK-YOU!!!!!