Post-operative rehabilitation following multi-ligament knee reconstruction

Twin Cities Orthopedics Virtual Grand Rounds

Jill Monson, PT, OCS

Twin Cities Orthopedics (TCO)

Training HAUS

Eagan, MN | Edina, MN

Thank you

- Karie Nash
- TCO team members contributing to virtual grand rounds
- Dr. LaPrade and our multi-specialty complex knee team
- Our patients

AASPT 2021

Inaugural
Annual Meeting &
Scientific Conference

Overview

- Epidemiology of multi-ligament knee injury (MLKI)
- Scientific foundations for post-operative precautions
  - Biology, biomechanics, confounders
- Early post-operative rehabilitations priorities
  - Recovery → Transition phase emphasis
  - Understanding how to make progressions

Language/Abbreviations

Cruciates:

- ACL: anterior cruciate ligament
- PCL: Posterior cruciate ligament

Medial/Posteromedial Knee:

- MCL: medial collateral ligament
  - dMCL: deep MCL
  - sMCL: superficial MCL
- PMC: posteromedial corner
- POL: posterior oblique ligament

Lateral/Posterolateral Knee:

- ALL: anterolateral ligament
- BF: Biceps femoris
- ITB: iliotibial band
- FCL: fibular collateral ligament
- PLC: Posterolateral corner
- PFL: Popliteofibular ligament
- PT: Popliteus tendon

Other:

- CPN: common peroneal nerve
- MLKI: multi-ligament knee injury
- PF: Patellofemoral

MLKI EPIDEMIOLOGY

Multi-Ligament Knee Injury (MLKI)

- **MLKI** = Tear of ≥2 of the 4 major knee ligaments (ACL, PCL, MCL/PMC, FCL/PLC)
  - Incidence: <0.02% of all orthopaedic injuries
    - Rihn JA. J Am Acad Orthop Surg. 2004; Kaitlin M. Harv Orthop J. 2013

- **Knee Dislocation** = rupture of both cruciates with or without additional grade III medial or lateral side injury
  - Incidence: 0.001% to 0.013% per year
  - Likely higher d/t spontaneous reduction
    - Hoover N. Surg Clin North Am. 1961; Meyers M. J Bone Joint Surg Am. 1971; Shields L. J Trauma. 1969

Status Post:

1) Revision PCLr,
2) Revision FCLr/PTFJr with hamstring autograft
3) Revision MM root repair
4) Biceps femoris repair
5) Peroneal Nerve Neurolysis

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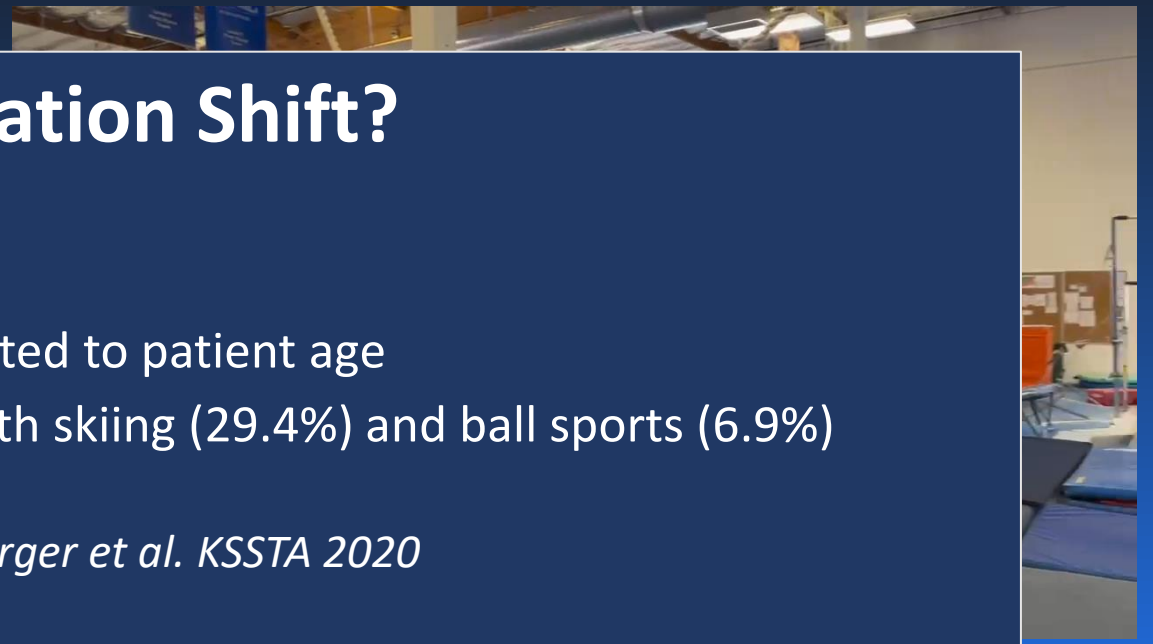
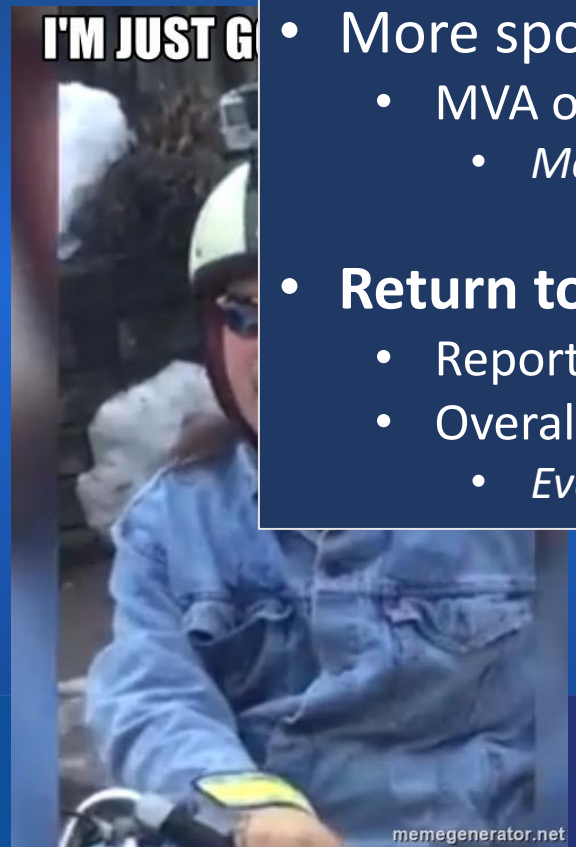
Jill Slide



Demographic Shift = Expectation Shift?

- Males>Females
- Younger (Mean age 37 ± 15 years)
  - Rate of knee dislocation inversely related to patient age
- More sporting injuries - MLKI rates with skiing (29.4%) and ball sports (6.9%)
  - MVA only 19.2% in same study
    - *Moatshe et al. OJSM 2017; Schlumberger et al. KSSTA 2020*

- **Return to Sport:**
  - Reporting inconsistent
  - Overall RTS 53%, competitive athletes 22%
    - *Everhart et al. Arthroscopy 2018*



4) Biceps femoris repair
5) Peroneal Nerve Neurolysis

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Mechanism of Injury

- High energy trauma (MVA, fall from height) or low energy trauma (sports)
  - 50.3-51% high energy trauma
  - 47-49.3% low energy trauma
    - Engebretsen et al. KSSTA 2009; Moatshe et al. Arthroscopy 2017
- Often knee hyperextension + varus or valgus force
- Typically a contact injury
- Concomitant “trauma” injuries

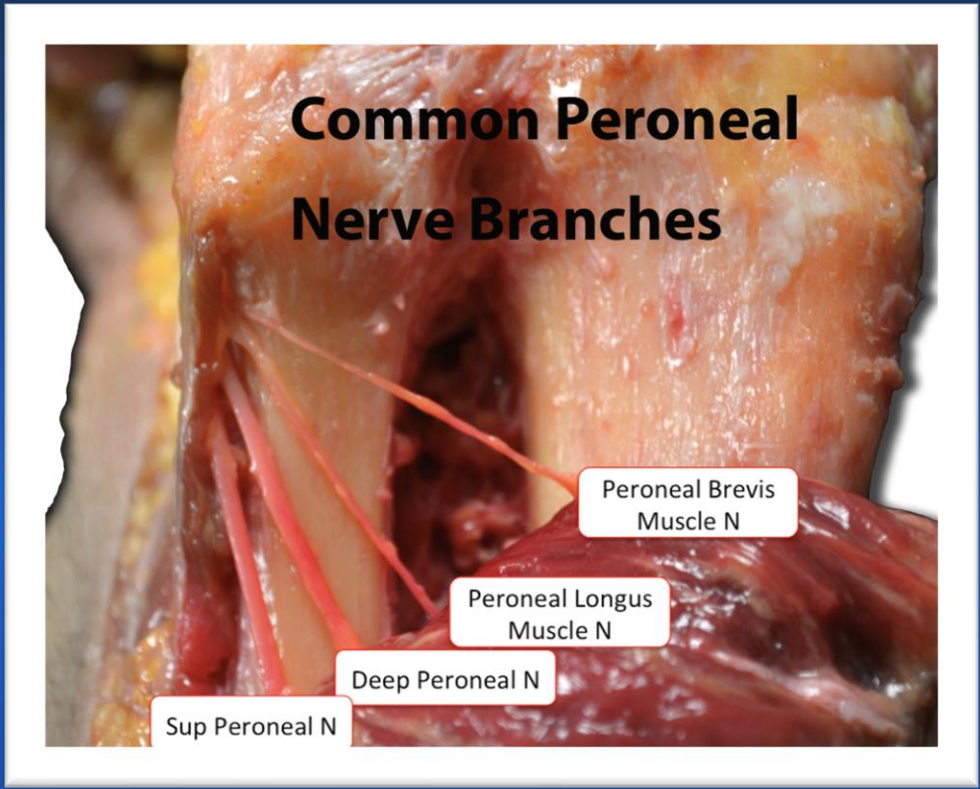
Injury Grading: Schenk's Classification

Table 1 Explaining Schenck's knee dislocation classification

KD I	**Injury to single cruciate + collaterals**
KD II	Injury to ACL and PCL with intact collaterals
KD III M	Injury to ACL, PCL, MCL
KD III L	Injury to ACL, PCL, FCL
KD IV	Injury to ACL, PCL, MCL, FCL
KD V	Dislocation + fracture

Additional caps of "C" and "N" are utilized for associated injuries. "C" indicates an arterial injury. "N" indicates a neural injury, such as the tibial or, more commonly, the peroneal nerve. ACL, anterior cruciate ligament; FCL, fibular collateral ligament; KD, Knee Dislocation Classification I–V; MCL, media collateral ligament.

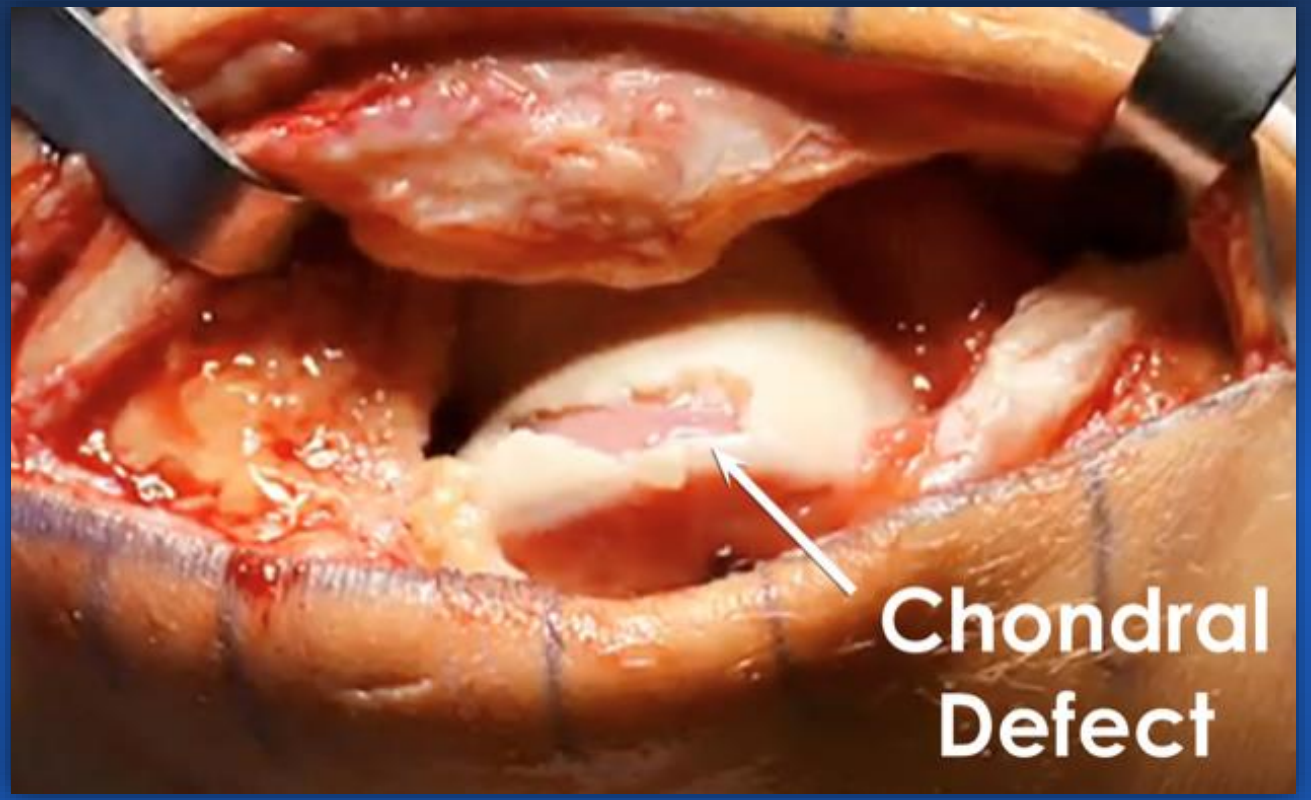
Neurovascular (NV) Injury



- Higher risk when both cruciates are involved
- With knee dislocation (compared to MLKI alone):
  - Common Peroneal Nerve (CPN) Injury: 38% (14% MLKI)
  - Popliteal artery injury: 18% (4% MLKI)
    - Kahan et al JBJS 2021
- PLC injury = 42 times higher odds of CPN injury, 9.2 times higher odds of popliteal a. injury
    - Moatshe G. et al. Arthroscopy 2017

Concomitant Joint Injury

- In presence of MLKI:
  - Meniscal injury: 37.3-55%
  - Cartilage injury: 28.3-48%
    - Moatshe G. et al. Arthroscopy 2017
    - Krych A. et al. KSSTA 2015



SCIENTIFIC FOUNDATION FOR POST-OP PRECAUTIONS

Foundations for Post-Op Precautions

Biology	• Tissue-specific healing timeframes & considerations
Biomechanics	• Joint biomechanics • Structure-specific considerations • Movement/exercise-specific considerations
Confounders	• Intrinsic & extrinsic factors • Modifiable & non-modifiable

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Early Recovery

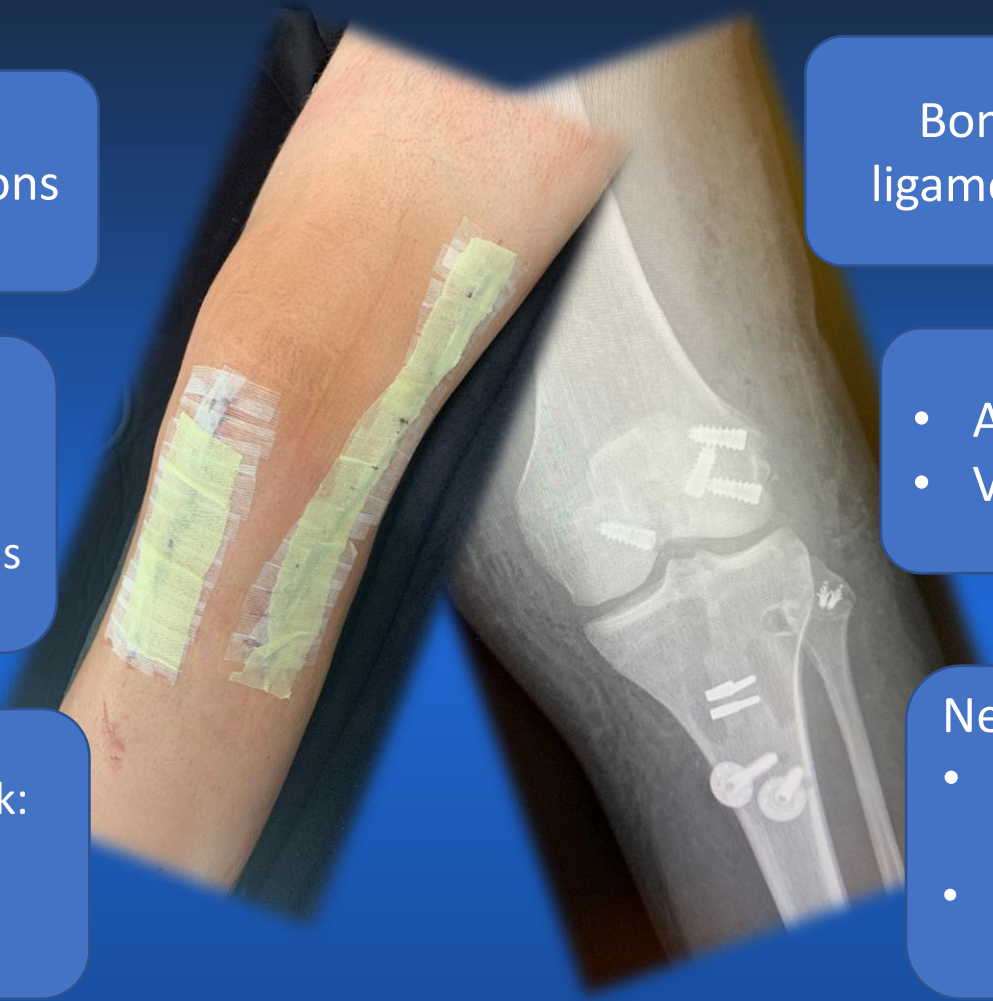
Multiple, large soft tissue incisions

Concomitant extra-articular work (soft tissue repair):

- Biceps femoris tenson, IT band, lateral capsule, lateral gastrocnemius tendon

Concomitant intra-articular work:

- Meniscus repair
- Fracture fixation



Bone tunnels at multiple ligament reconstruction sites

- Autograft and allograft tissue
- Various fixation methods

Neurovascular Issues:

- Nerve injury (Common peroneal nerve)
- Vascular injury/bypass (Popliteal artery)

Biology: Overview of Healing

Hemostasis & Inflammation (immediately through day 3)

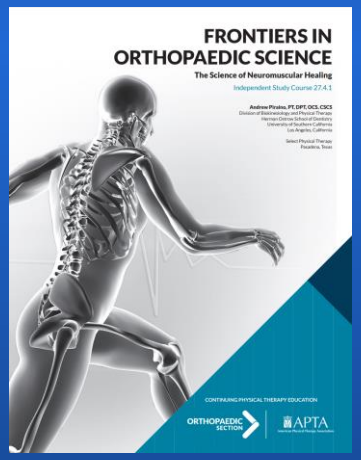
- Hematoma
- Inflammatory mediators released
- Macrophages clear wound site
- Growth factors & cytokines released
- VEGF (vascular endothelial growth factor) stimulates angiogenesis

Proliferation (3 days to 14 days)

- Scaffold of specific tissue type is built (type III collagen, bone callus, etc.)
- Ground substance
- Scarring
- Ongoing angiogenesis

Remodeling/Maturation (14+ days)

- Mature tissue type fills in scaffold (Type 1 collagen. Bone, etc.)
- Collagen fibers align, diameter increases, cross-links form
- Tissue adapts, strengthens (influenced by mechanical stress)



Piraino A. Frontiers in Orthopaedic Science: The Science of Neuromuscular Healing. 2017 Orthopaedic Section, APTA, Inc.)

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Biology: Structure Specific Considerations

Ligament Graft

- Graft material (auto, allo) *harvest site morbidity
- Bone tunnels w/hardware fixation
- Extra-articular suture fixation
- Ligament healing, maturation process (up to 24 mos)

Tendon/Soft Tissue Repair

- Location of injury & repair
- Tissue quality, chronicity of injury
- Fixation technique, security of fixation
- Post-injury tissue strength ~ 80% of pre-injury strength

Nerve Injury

- Injury severity, location (<7cm favorable)
- Patient age (<25 y/o favorable)
- Initial recovery: 3-6 mos
  Late stage: up to 2 yrs
- Secondary surgery

Bone/Fracture Healing

- Hardware fixation required?
- Soft tissue impact of external fixator (quad)
- Alignment restored?
- Bone density loss

Peskun CJ. CORR 2012; Niall DM. JBJS(Br) 2005;
Woo J. Biomechanics 2006; Piraino 2017; Nagelli Sports Med 2017

Foundations for Post-Op Precautions

Biology	Tissue-specific healing timeframes & considerations
Biomechanics	• Joint biomechanics • Structure-specific considerations • Movement/exercise-specific considerations
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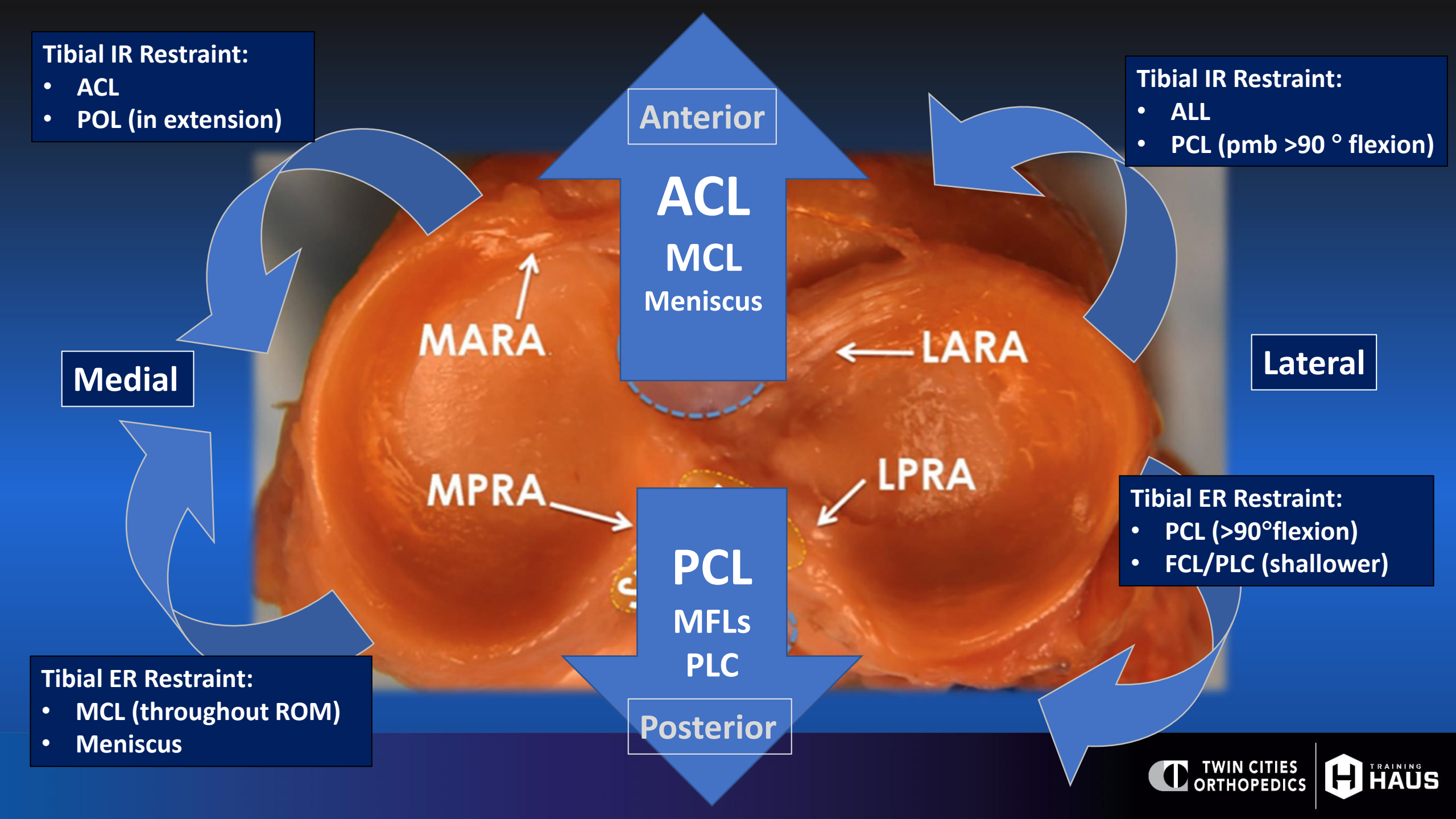
ANATOMY & BIOMECHANICS


Tibial IR Restraint:
• ACL
• POL (in extension)
Anterior
ACL
MCL
Meniscus
Tibial IR Restraint:
• ALL
• PCL (pmb >90 ° flexion)
MARA
LARA
Medial
Lateral
MPRA
LPRA
Tibial ER Restraint:
• PCL (>90°flexion)
• FCL/PLC (shallower)
PCL
MFLs
PLC
Tibial ER Restraint:
• MCL (throughout ROM)
• Meniscus
Posterior
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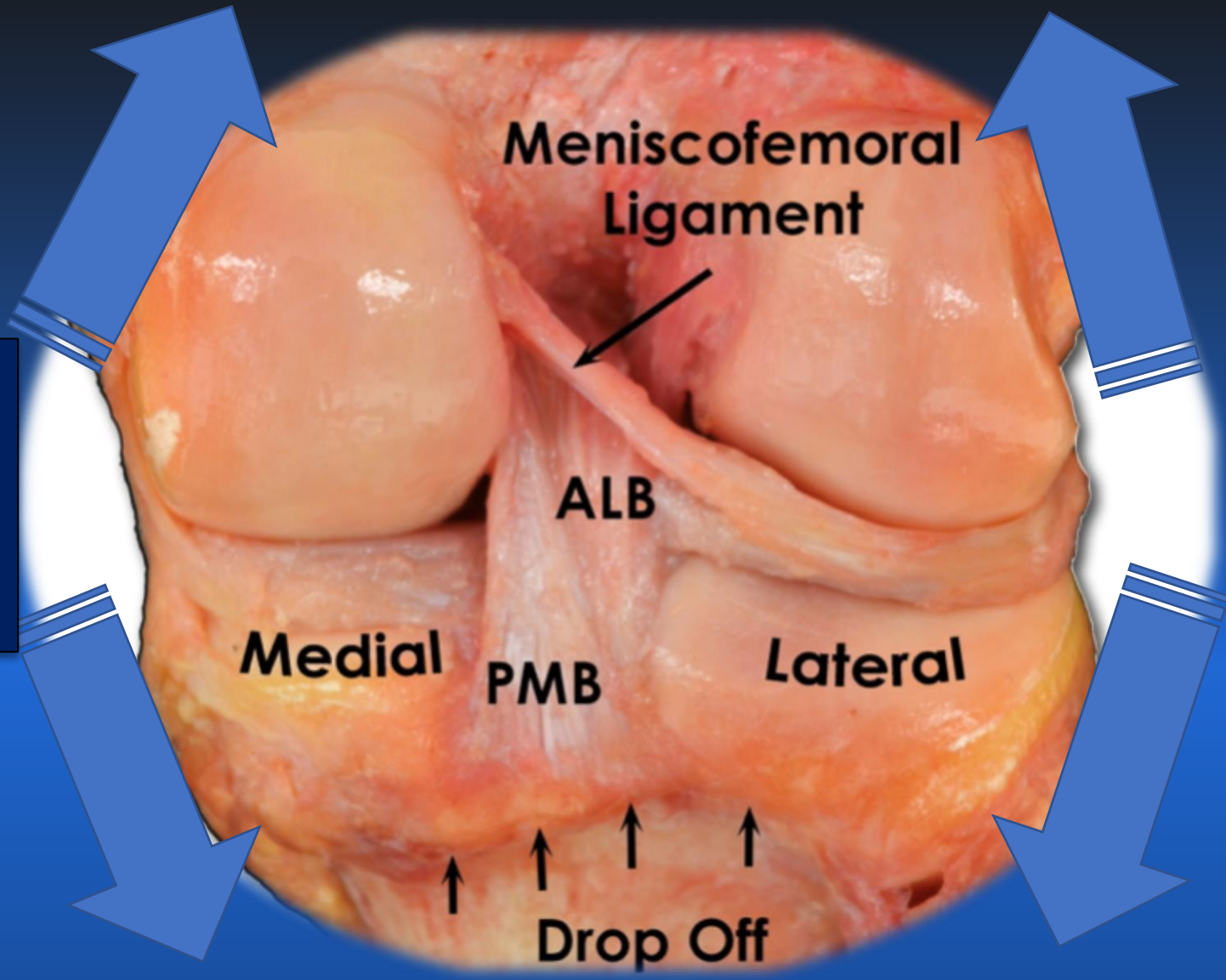
Medial

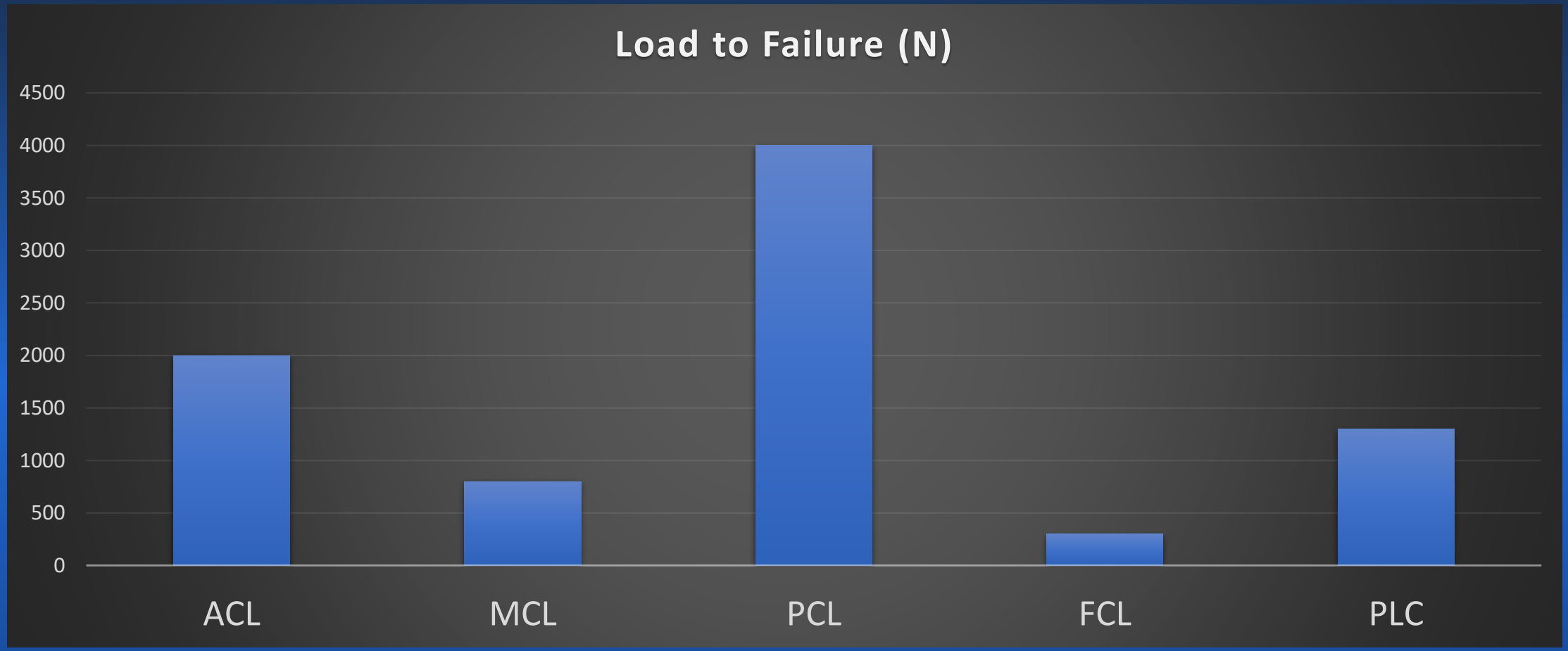
Valgus Restraint:
- **MCL**
- **POL**
- **ACL**



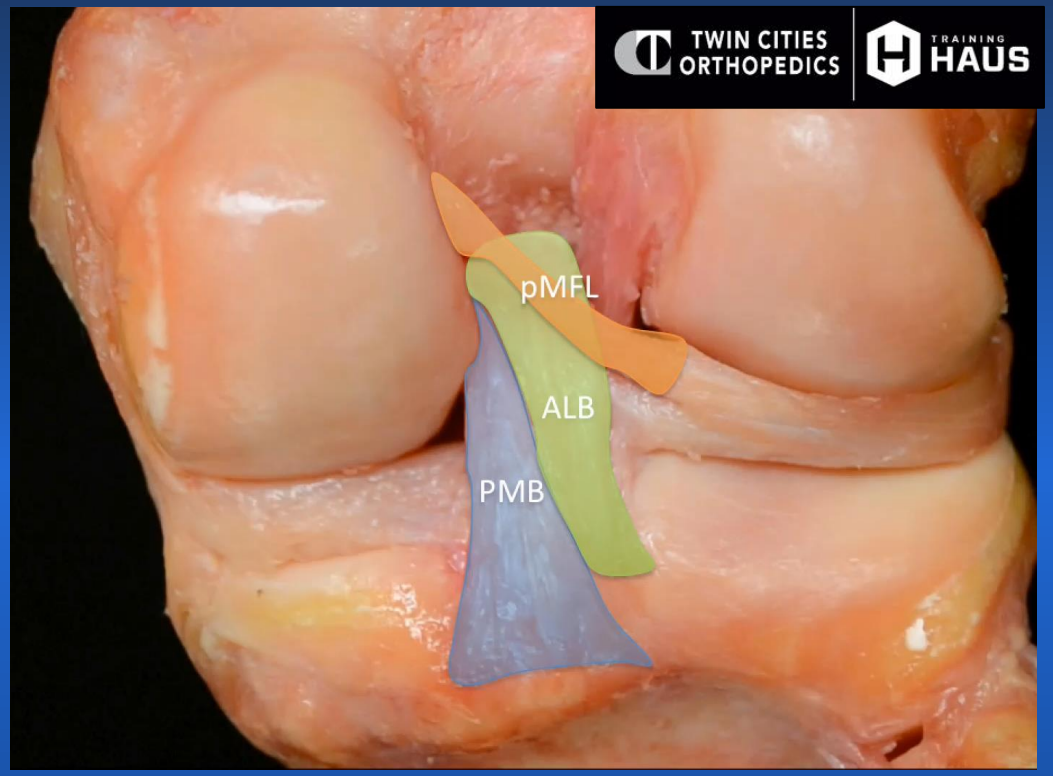
Lateral

Varus Restraint:
- **FCL (PLC)**
- **Cruciates**

Load to Failure



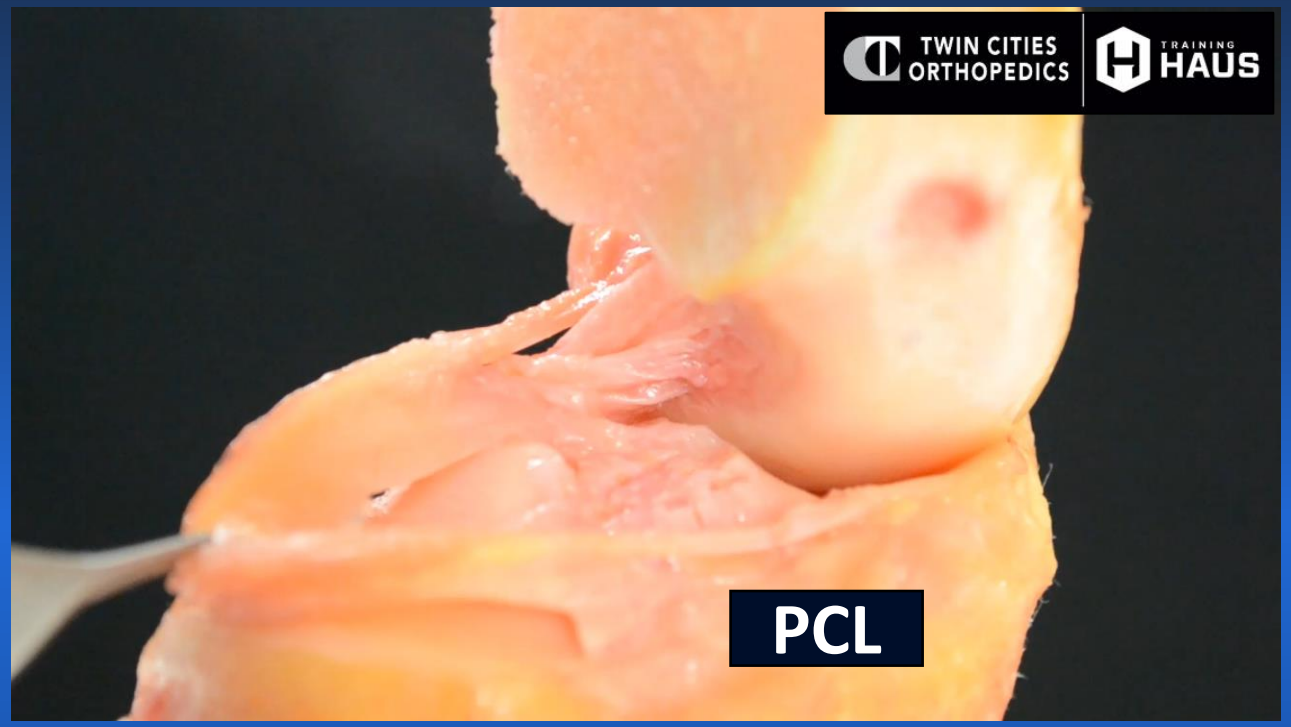
Posterior Cruciate Ligament (PCL) Anatomy



- 2 distinct PCL bundles:
  - Anterolateral bundle (strongest)
  - Posteromedial bundle
- Codominant contributions to knee stability (between the bundles)
  - Resists **Posterior tibial translation** → Tibial rotation (ER & IR)
- Meniscofemoral ligaments
  - Anterior (Ligament of Humphrey)
  - Posterior (Ligament of Wrisberg)

Kennedy NI et al. AJSM. 2013 Dec;41(12):2828-38.

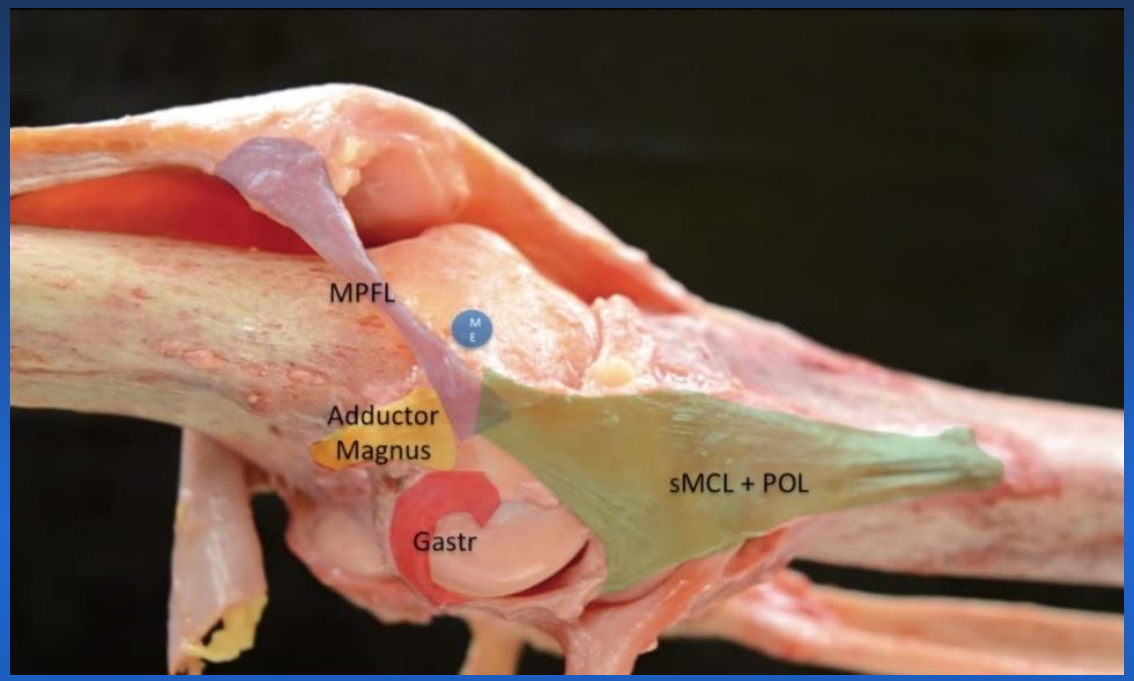
PCL Biomechanics



- **AL bundle**:
  - Lengthens with knee **flexion**
  - AL bundle resists PTT through most of **flexion** (90°)
- **PM bundle**:
  - Lengthens with knee **extension**
  - Resists PTT near full **extension** & resists **hyperextension**
  - PM bundle can resist PTT again in deep, end range **flexion**
- Both provide rotational stability throughout the range
  - More pronounced near 90°

Hosseini Nasab SH et al. PloS one. 2016

Medial Knee Anatomy



- **sMCL**: (superficial MCL)
  - Long, primary stabilizer
  - Proximal & distal tibial attachments
  - Highest load to failure & stiffness
- **dMCL:** (deep MCL aka "mid-third medial capsular ligament")
  - Short, secondary stabilizer
  - Meniscotibial and meniscofemoral attachments
  - Lowest load to failure & stiffness
- **POL**: (Posterior oblique ligament)
  - Consists of 3 fascial expansion off distal semimembranosus tendon
  - Merges with posteromedial capsule

LaPrade MD, Kennedy MI, Wijdicks CA, LaPrade RF. SMAR 2015

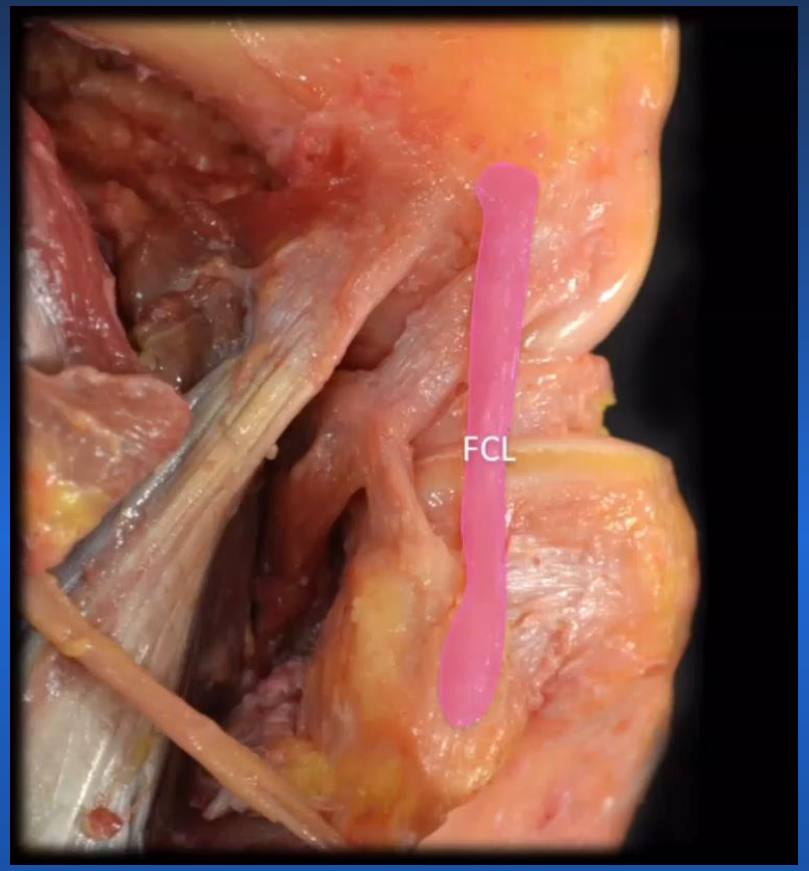
Medial Knee Biomechanics

- **Anterior** bundles elongate with **flexion**
- **Posterior** bundles elongate with **extension**

- **sMCL**:
  - Resists valgus (proximal) and tibial rotation (distal) **throughout ROM**
- **dMCL**:
  - Secondary restraint to valgus & rotation
- **POL**:
  - Tensions at posteromedial knee in **extension**
  - Resists IR→valgus→ER

LaPrade MD, Kennedy MI, Wijdicks CA, LaPrade RF. SMAR 2015
Hosseini A, Qi W, Tsai TY, Liu Y, Rubash H, Li G. KSSTA

Lateral Knee Anatomy



<u>Posterolateral Corner (PLC):</u>

- 3 primary structures:
  - Fibulocollateral ligament (**FCL** or LCL)
  - Popliteus Tendon (PT)
  - Popliteofibular ligament (PFL, aka “arcuate ligament”)

- Popliteus Tendon is the strongest structure
  - PT (700N) → PFL (298 N) → FCL (295N)

LaPrade RF, et al. AJSM 2005 Sep;33(9):1386-91.

Lateral Knee Biomechanics

- **PLC:**
  - Resists hyperextension, varus, tibial ER
    - More pronounced near **extension**
  - Resists PTT near full **extension**

- **FCL**:
  - Resists varus **throughout range**
  - Resists tibial ER near full **extension**

LaPrade RF et al AJSM 2005 Sep;33(9):1386-91.

ROM Precautions:

Knee flexion ROM limit

90°x 2 weeks post-op

(Prone PROM for PCLs)

***Some structures will have a hyperextension (HE) precaution**

(PCL, PLC, FCL, POL)

0-0-90° to honor ↑ ligament/graft length/tension with HE or deeper flexion angles

2 weeks = early collagen proliferation has occurred

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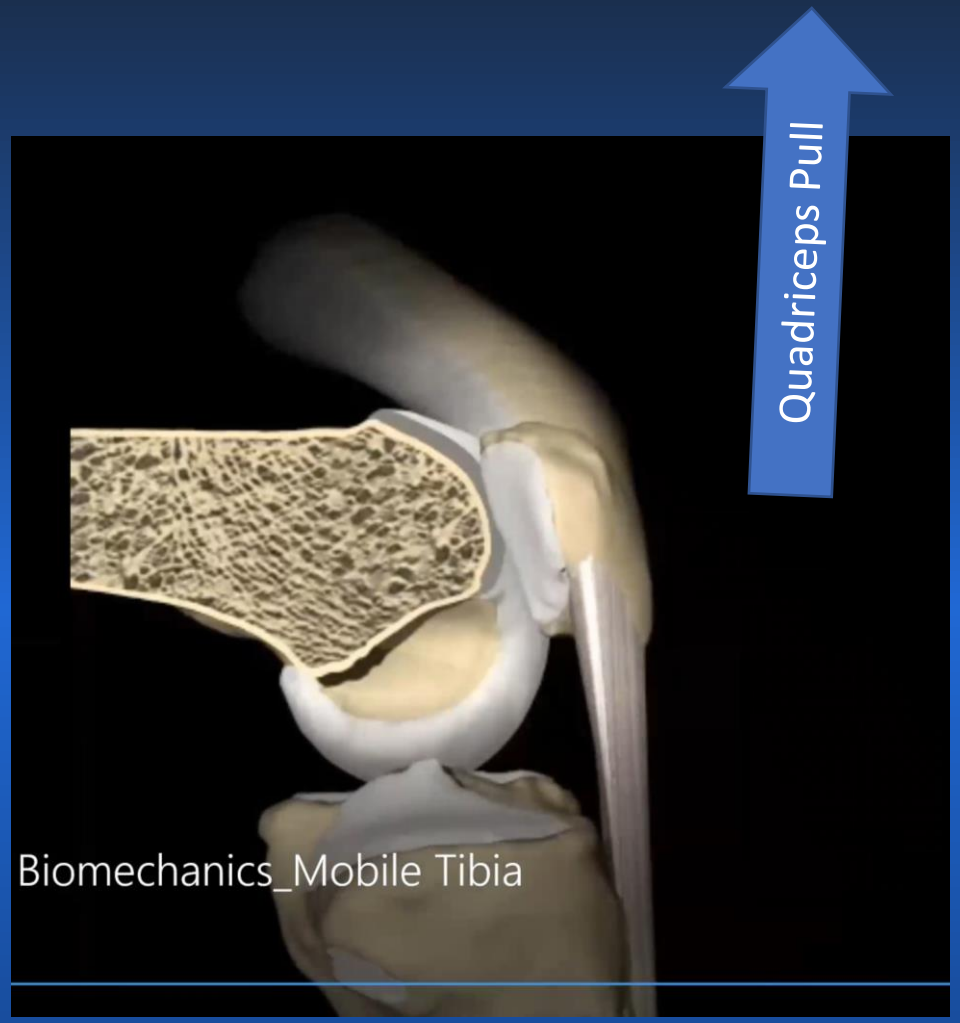
Biomechanics: OKC Quadriceps



Into terminal extension (50→0°)

- Quadriceps anterior pull at tibia
- Anterior tibial translation
- More pronounced in last 30°

Isometric Point @ mid-range (~60°)

- Negligible tibial translation either direction

From Deeper Flexion (>60°)

- Posterior line of pull through patellar tendon
- Slight posterior tibial translation

Escamilla JOSPT 2012; Markolf AJSM 2004; Aalbersberg B Biomech 2005; Lutz JBJS-Am 1993; Daniel Clin Sports Med 2000

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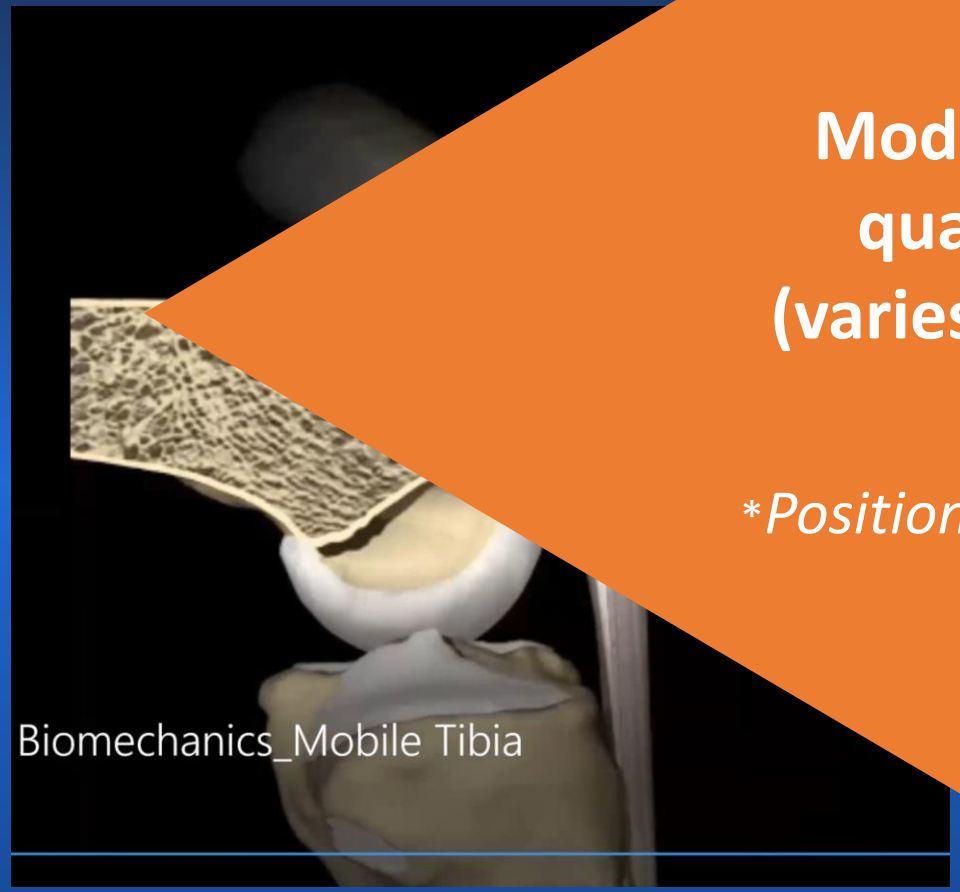
Biomechanics: OK



<u>Precaution</u>:
Modified arc of motion with quadriceps strengthening (varies per structures involved)

**Positional restrictions evolve gradually as healing progresses*

ps anterior pull at tibia
translation
last 30°

ior line of pull through patellar
ndon
- Slight posterior tibial translation

Escamilla JOSPT 2012; Markolf AJSM 2004; Aalbersberg B Biomech 20[illegible];
Lutz JBJS-Am 1993; Daniel Clin Sports Med 2000

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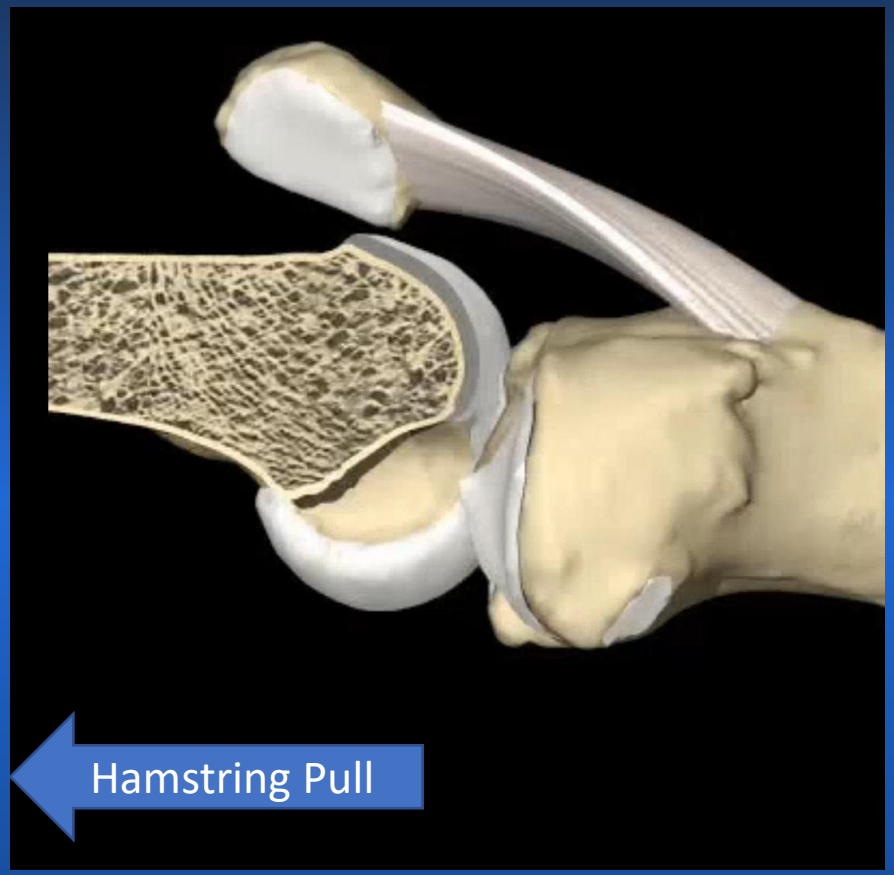
Biomechanics: OKC Hamstrings



From terminal extension (0→30°)

- Minimal mechanical advantage to induce posterior tibial translation

Into Progressive Flexion (>30°)

- Increasing mechanical advantage to create progressively more dramatic posterior tibial translation

Escamilla JOSPT 2012; Markolf AJSM 2004; Aalbersberg B Biomech 2005; Lutz JBJS-Am 1993; Daniel Clin Sports Med 2000

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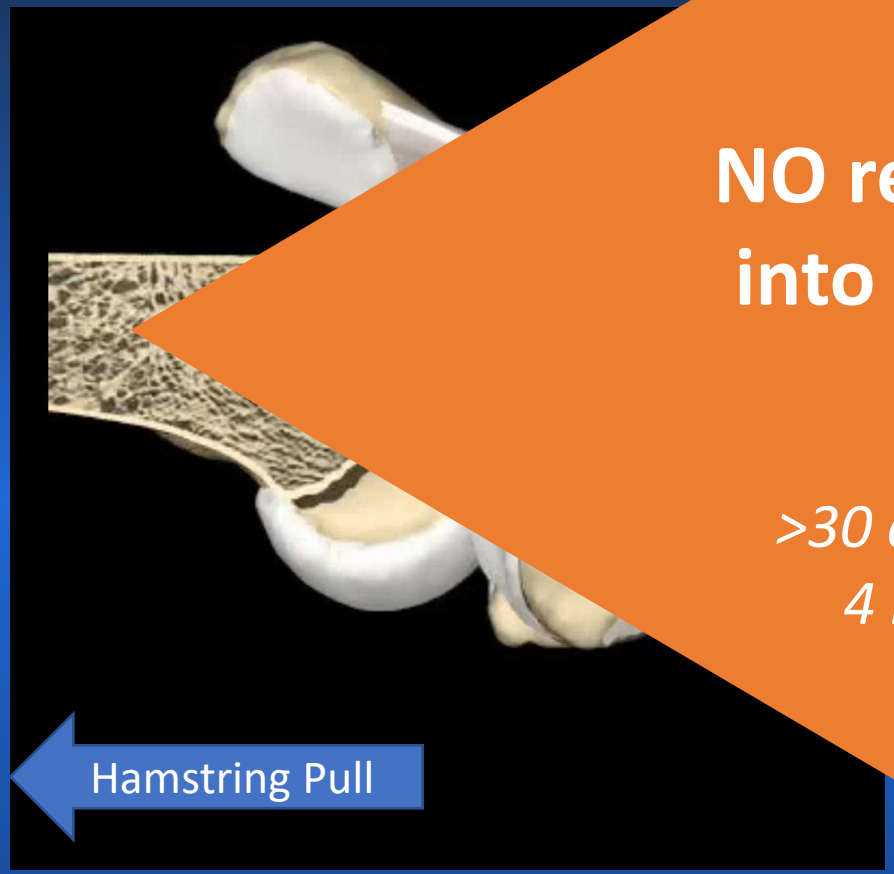
Biomechanics: OK gs



<u>Precaution</u>:
NO resisted hamstring curling into knee flexion x 4 months

>30 degrees = more joint shear, PTT
4 months = more mature graft

ical
osterior

mechanical
tage to create
rogressively more dramatic
posterior tibial translation

Escamilla JOSPT 2012; Markolf AJSM 2004; Aalbersberg B Biomech 20
Lutz JBJS-Am 1993; Daniel Clin Sports Med 2000

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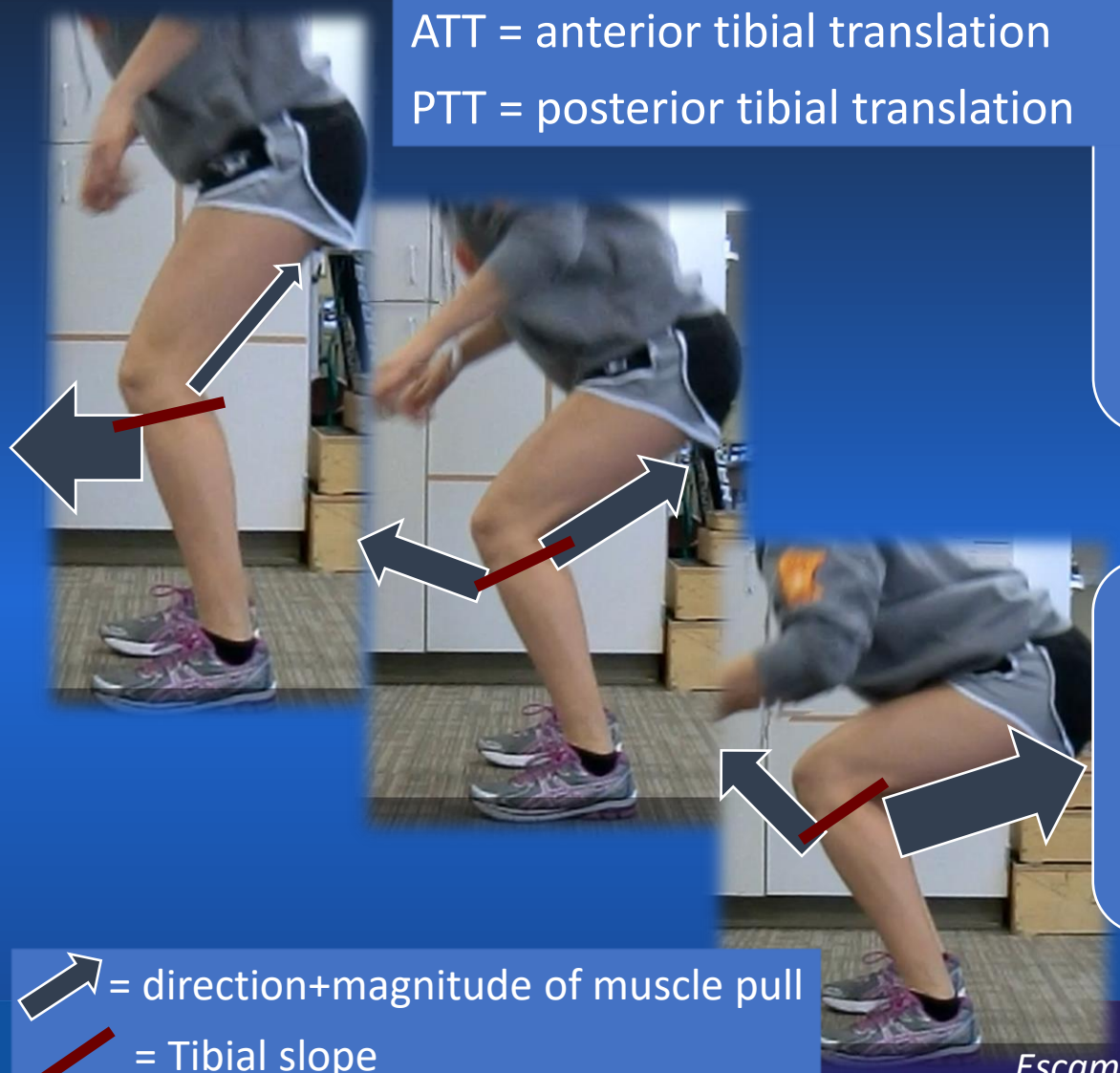
Biomechanics: Weight Bearing (CKC) Exercise

ATT = anterior tibial translation

PTT = posterior tibial translation



Early Flexion <45/50°

Maximized
- Quad mechanical advantage
- ATT

Minimized
- HS mechanical advantage
- PTT

Deeper Flexion >60°

Maximized
- HS mechanical advantage
- PTT

Minimized
- Quad mechanical advantage
- ATT

= direction+magnitude of muscle pull

= Tibial slope

**General estimates*

Escamilla JOSPT 2012; Shelbourne JOR 2011; Escamilla Clin Biomech 2009; Toutoungi Clin Biomech 2000

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Biomechanics: Weigh Bearing (CKC) Exercise

ATT = anterior tibial transl

PTT = posterior tibi

Minimized
- HS mechanical advantage

Precaution:
No squatting >70°x 4 months post-op

>70 degrees = more joint shear, PTT
4 months = more mature graft

Quad
- Quad mechanical advantage
- ATT

= direction+magnitude of muscle pull

= Tibial slope

**General estimates*

Escami 012; Shelbourne JOR 2011; Escamilla Clin Biomech 2009; Toutoungi Clin Biomech 2000

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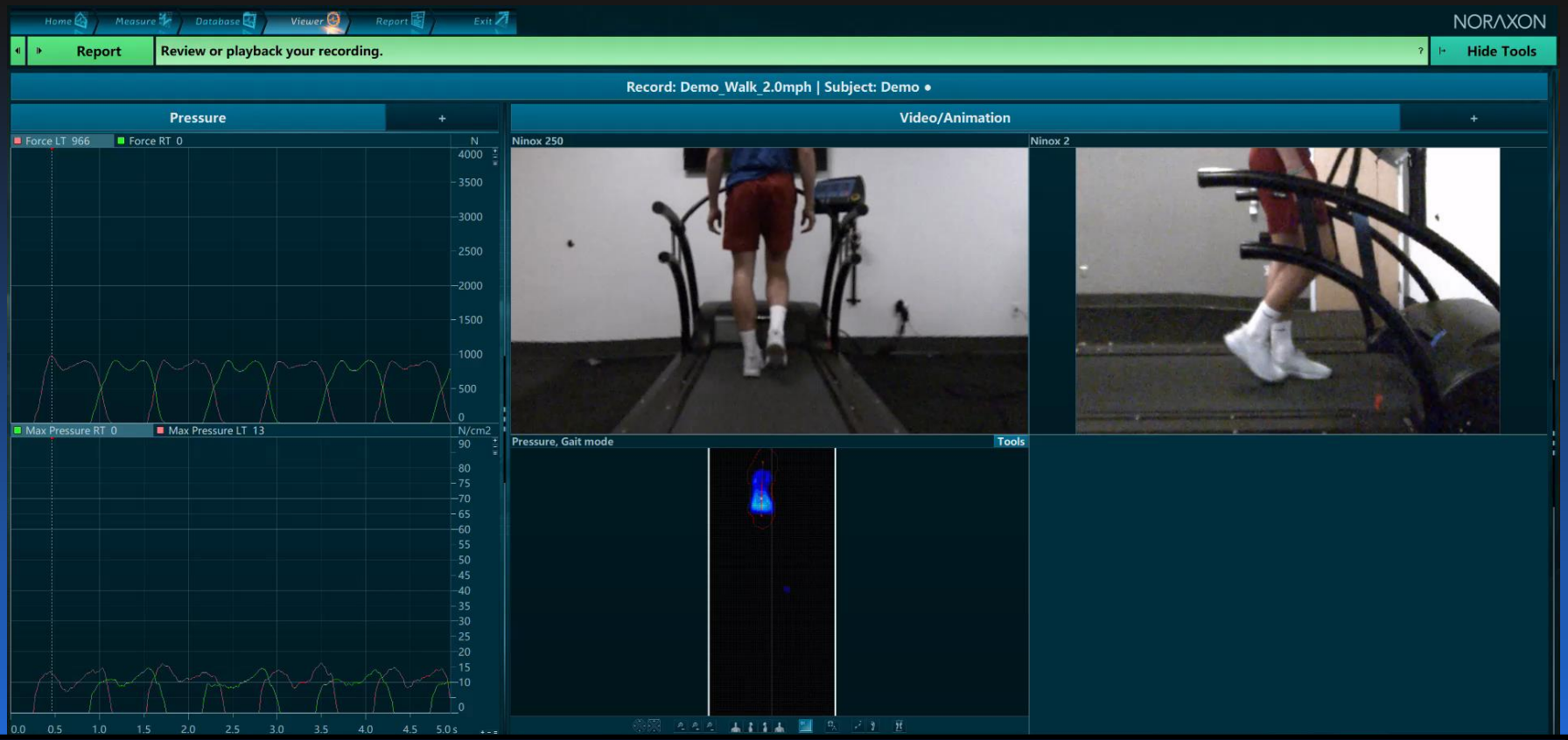
Biomechanics: Gait



- Best quality, most abundant literature related to ACL
  - Studies re: PCL, other structures lacking, outcomes/observations more variable
- Loading response:
  - Sagittal Plane: Quad activation + excursion into shallow flexion + tibial slope = ATT → ACL strain
    - ACL injury → Increased demand placed on MCL to control ATT
  - Transverse Plane: MLKI disrupts static structures that normally control rotational movement

Wu AJSM 2010; Andriacchi J. Biomech 2005; Hosseini Nasab PloS one 2016; Shelbourne JOR 2011; Shelburne Med Sci Sport Exer 2005; Paterno NAJSPT 2008

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Biomechanics: Gait

- Mid-stance:
  - Adduction moment through knee
  - Knee stabilized by lateral, posterolateral structures
    - PLC, biceps femoris, ITB
  - Varus thrust gait as a result of injury to these structure
    - ↑ tensile stress at lateral knee structures
    - ↑ compressive forces through medial compartment

Biomechanics: Gait

<u>Precaution</u>:
Post-operative weight bearing restrictions (NWB, PWB, ??)

Currently under investigation within our practice

Very little high-quality literature on non-ACL ligament loading with gait

ent through knee

of

lateral knee

essive forces through medial
partment

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Foundations for Post-Op Precautions

Biology	Tissue-specific healing timeframes & considerations
Biomechanics	• Joint biomechanics • Structure-specific considerations • Movement/exercise-specific considerations
Confounders	• Intrinsic & extrinsic factors • Modifiable & non-modifiable

Confounders: Healing

Non-Modifiable

- Baseline joint health
  - Prior (chronic) injury, alignment, OA
- Implants/foreign materials
- Infection
- Age
  - Older = slower, impaired healing
- Sex hormones
- Systemic disease
- Medication

Modifiable

- Nutrition
  - TCO bone health team??
- Psychological stress
  - TCO sports psych team??
- Smoking
  - Delays tissue healing
  - Increases complications

Patient education
Collaborative, team approach

Confounders: Orthopaedic & Beyond

Neurovascular injury

- Vessel: Emergency vascular bypass, compartment release
  - Wound healing (emergency surgery same day/week as knee surgery)
- Nerve: Foot drop→orthotics need (AFO)→altered gait pattern
  - Additional delayed surgery (after knee recovers)

Additional Trauma

- Fracture, joint dislocation above/below knee
- Internal injuries, brain injury/concussion, DVT, infection
- Psychological response to traumatic injury (with or w/o brain injury)

Social, Economic Factors

- Health insurance
- Financial resources (time off work)
- Transportation to/from clinic for high # of visits, long duration of care
- Advocacy, In-home support (especially in early recovery)

EARLY POST-OPERATIVE REHABILITATION:
Key Priorities

POST OP RECOVERY PHASES

POST OP RECOVERY PHASES

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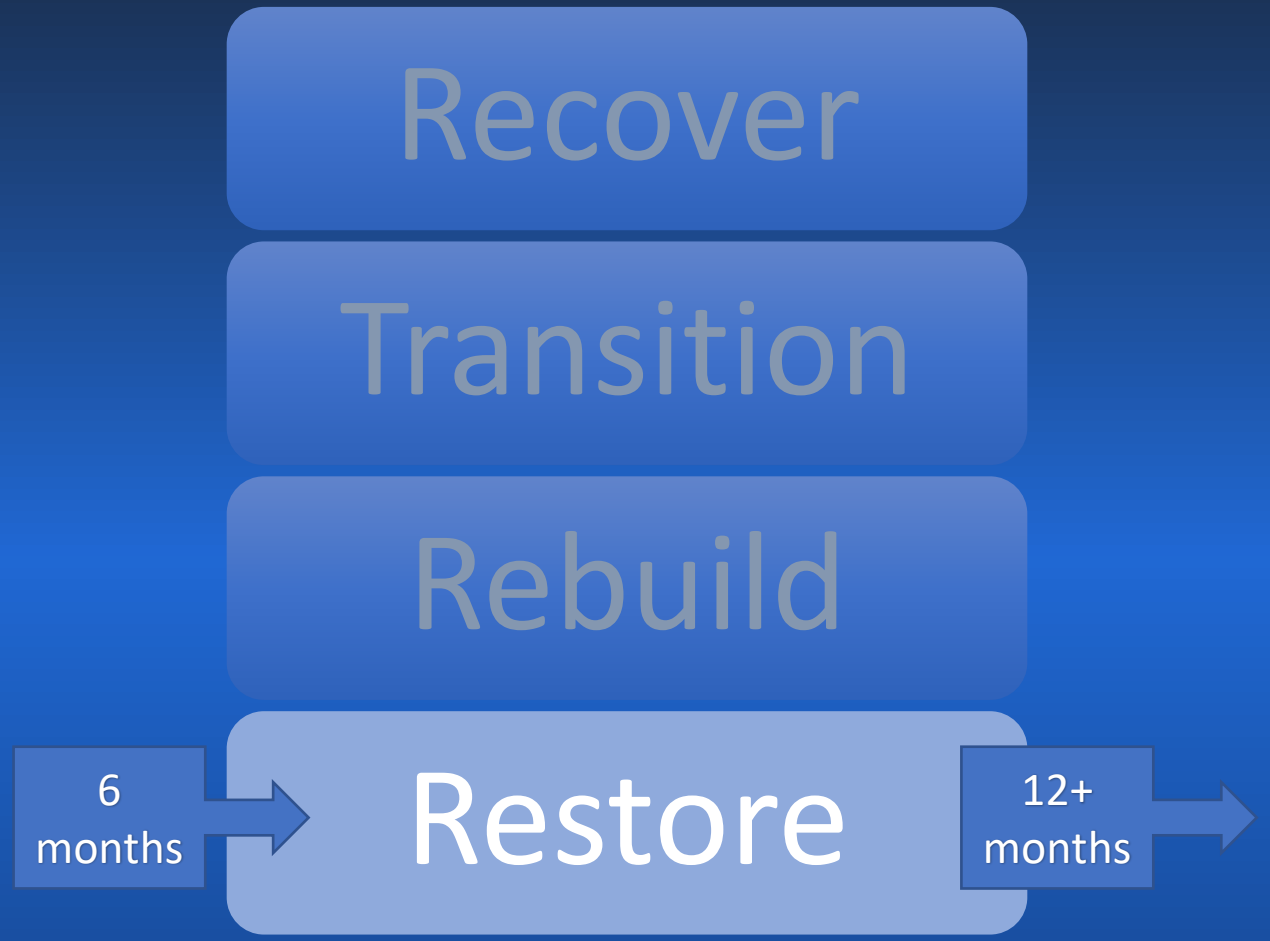

POST OP RECOVERY PHASES

Early Post-Surgical Rehab Pyramid

Effectively re-introduce loading → Functional Strengthening

Effectively re-activate target muscles safely → Isolated Strengthening

Nourish Joint → Restore ROM

Manage Complications, Protect Joint, Manage Symptoms

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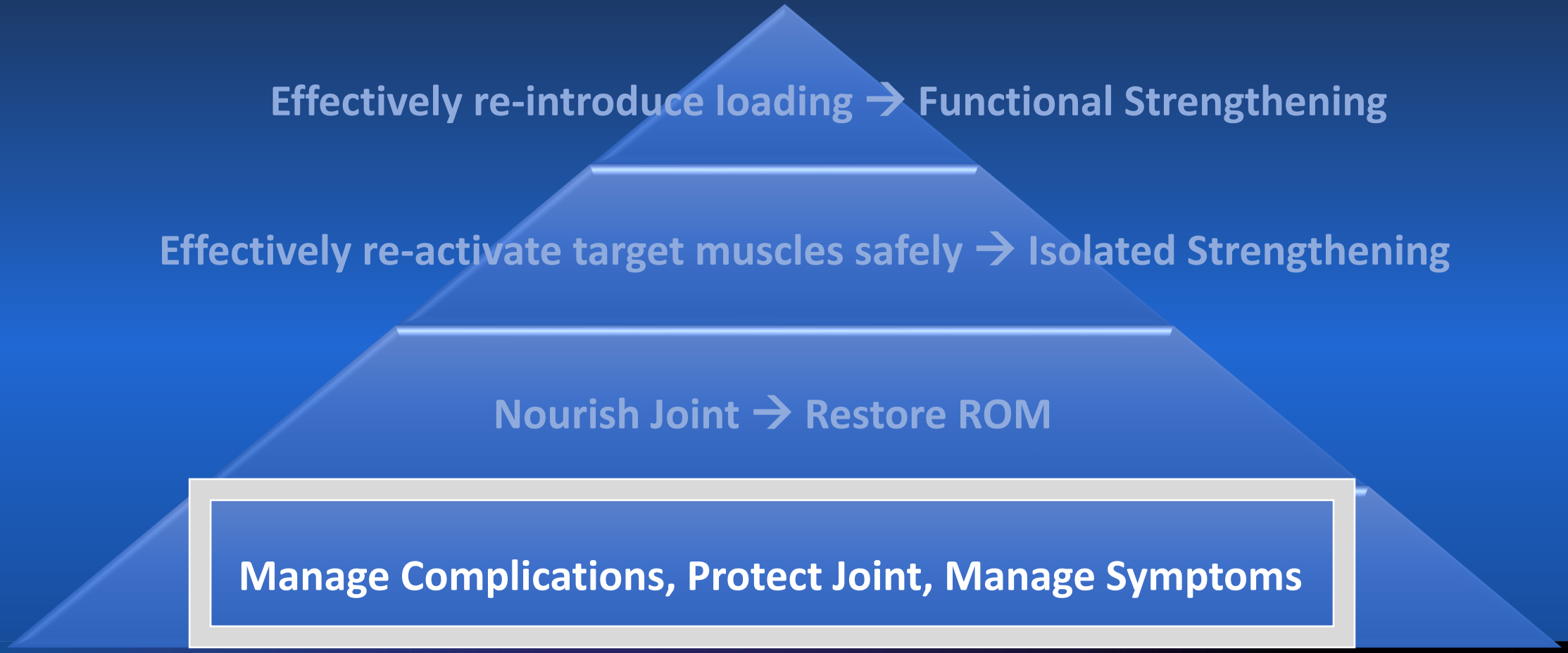
Early Post-Surgical Rehab Pyramid



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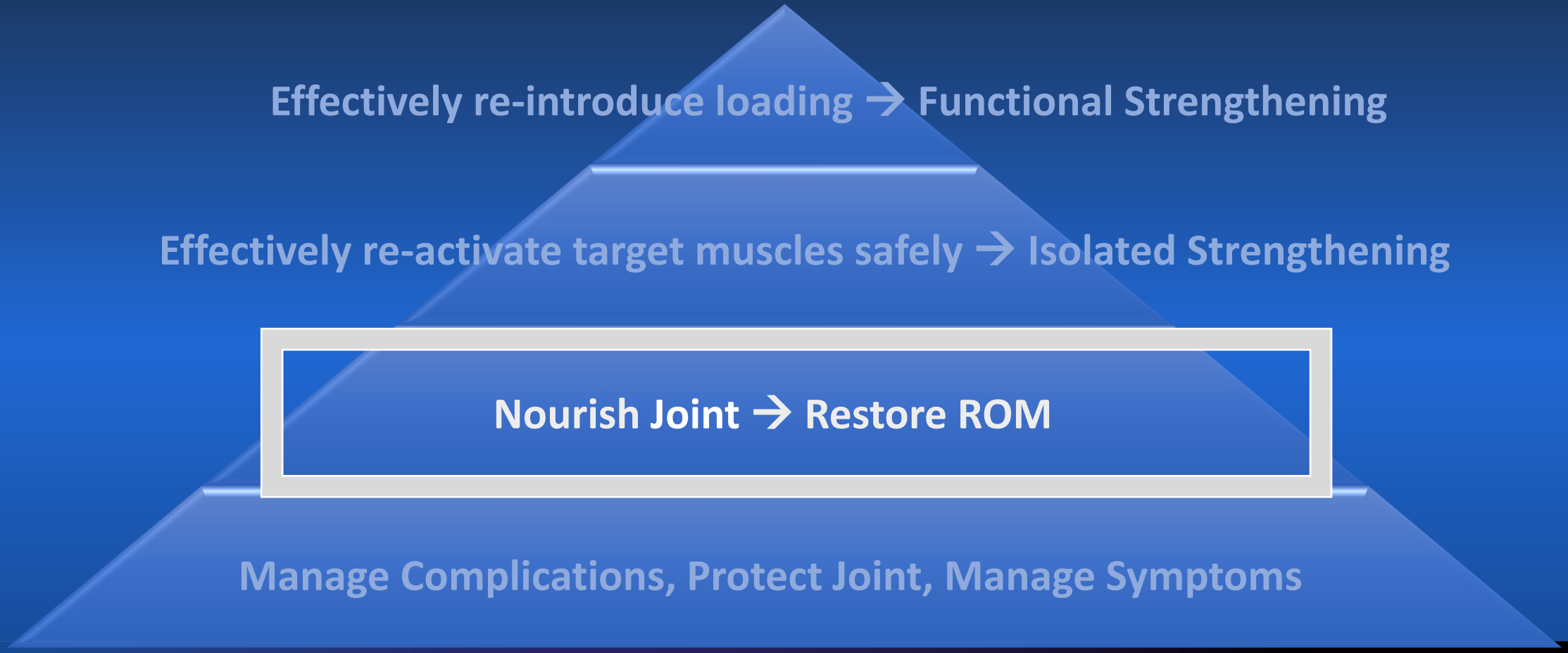
Early Post-Surgical Rehab Pyramid



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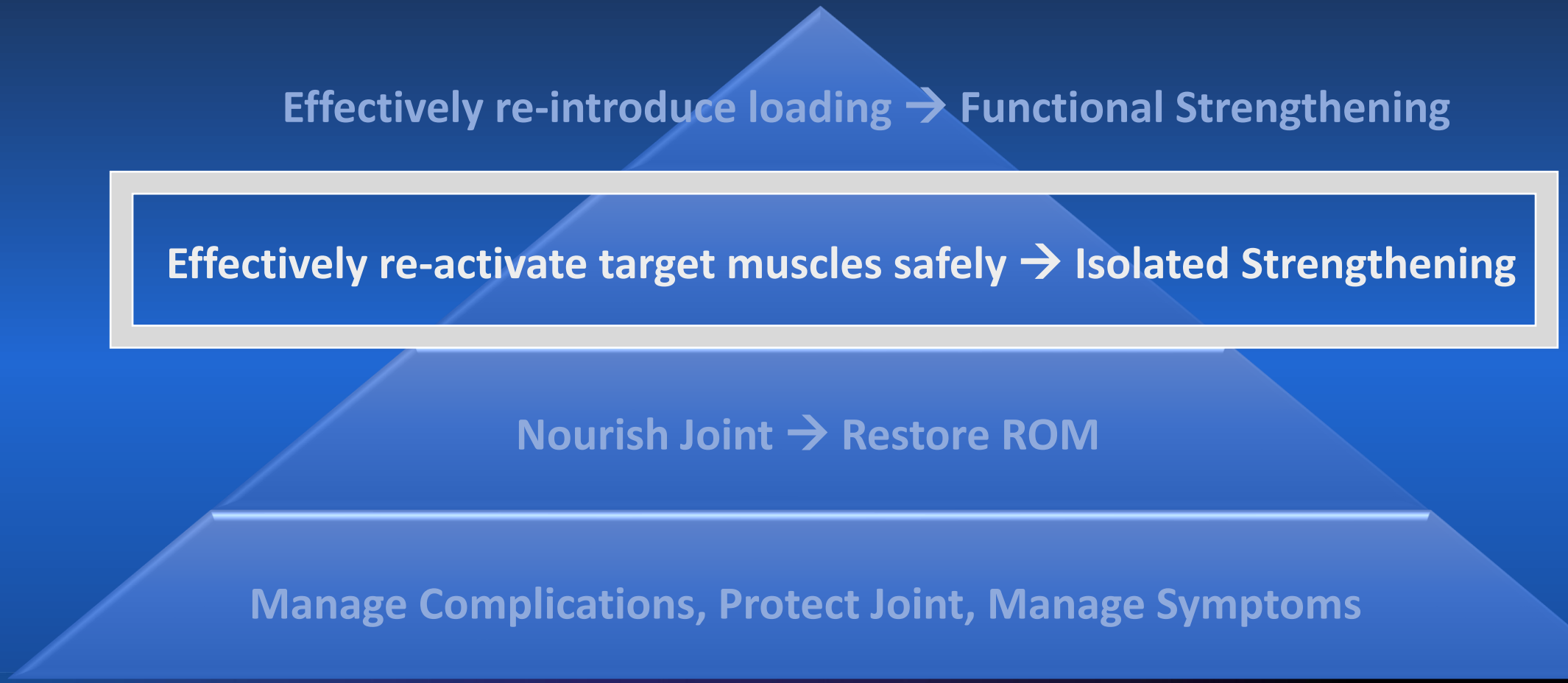

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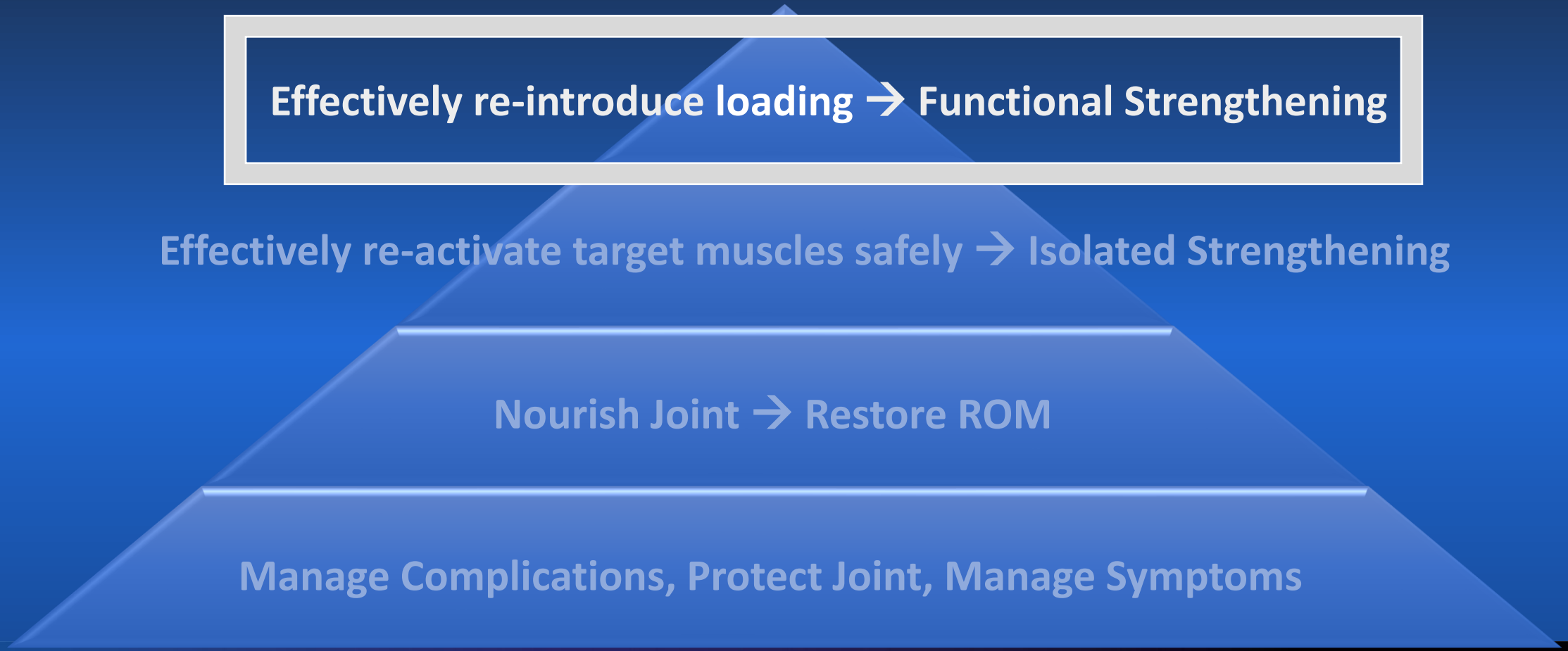

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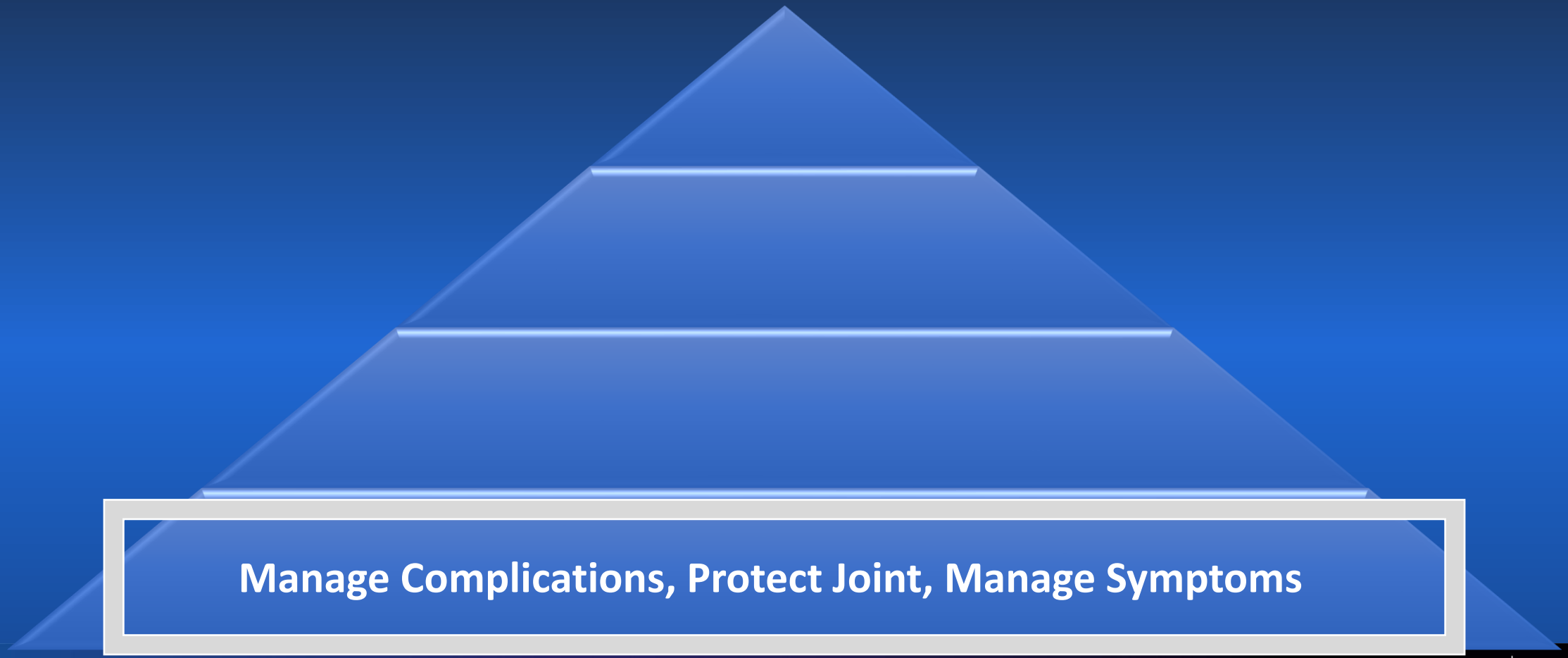


Education: Day 1 Post-Op Clinic

<u>Patient Education Folder</u>:

- ✓ PT referral
- ✓ Protocol
- ✓ TRAC testing scheduling document (4, 7, 10 mo.)
- ✓ Post-op priorities education document
- ✓ Contact information
- ✓ Medical education document (wound care, medication, etc.)
- ✓ Intra-operative photos

Observing for Post-Operative Complications

- DVT
- Nerve Injury
- Vascular Injury/Compartment Syndrome
- Infection
- Fracture

Complications: DVT

DVT

- Painful, progressive lower leg swelling (ankle, foot, toes swollen)
- Painful to palpation of the calf
  - Can be general tenderness or tenderness to the deep veins
    - Usually along saphenous vein (central calf)
- Pain with passive ankle DF
- DVT risk factors best defined using Wells' Criteria for DVT

Well's Criteria

Active cancer Treatment or palliation within 6 months	**No 0**	Yes +1
Bedridden recently >3 days or major surgery within 12 weeks	**No 0**	Yes +1
Calf swelling >3 cm compared to the other leg Measured 10 cm below tibial tuberosity	**No 0**	Yes +1
Collateral (nonvaricose) superficial veins present	**No 0**	Yes +1
Entire leg swollen	**No 0**	Yes +1
Localized tenderness along the deep venous system	**No 0**	Yes +1
Pitting edema, confined to symptomatic leg	**No 0**	Yes +1
Paralysis, paresis, or recent plaster immobilization of the lower extremity	**No 0**	Yes +1
Previously documented DVT	**No 0**	Yes +1
Alternative diagnosis to DVT as likely or more likely	**No 0**	Yes -2

- A score of 1-2 is considered moderate risk with a pretest probability of 17%.
- A score of 3 or higher suggests DVT is likely. Pretest probability 17-53%.

Complications: Nerve Injury

Nerve injury

- Sensory-motor deficits expected for the first 1-2 days post-op if patient received a nerve block during surgery
- Progressive deterioration (rather than gradual recovery) of:
    - Specifically pathway of superficial and deep peroneal nerves
    - Superficial peroneal nerve
        - Motor (myotomes)
            - lateral compartment of leg
            - peroneus longus
            - peroneus brevis
        - Sensory (dermatomes)
            - majority of skin on the dorsum of foot, excluding webspace between hallux and second digit
            - anterolateral distal 1/3 of leg
        - No associated reflex
    - Deep peroneal nerve
        - Motor (myotomes)
            - tibialis anterior
            - extensor digitorum longus/brevis
            - peroneus tertius
            - extensor hallucis longus/brevis
        - Sensory (dermatomes)
            - articular branch to the ankle joint
            - 1st dorsal webspace
        - No associated reflex

Complications: Vascular Injury

Vascular injury→ Compartment syndrome

- Disproportionately high pain that does not respond to analgesics
- Severe pain with stretch of the involved compartment
- Parasthesia or numbness
- Loss/reduction of lower extremity pulse (dorsalis pedis/posterior tibial pulses)
    - Reduced capillary refill at toes/foot
    - Dusky appearance of toes/foot
    - Foot is cold
- Progressive lower leg swelling (into foot, toes as well)
- Firmness/tightness at lower leg compartments
- Compartment syndrome risk factors include: lower leg trauma, vascular compromise, excessively tight/compressive dressing
- 5 Ps (pain, palor, pulselessness, paresthesia, paralysis)

Complications: Infection, Fracture

Infection

- Foul smelling, purulent/pus-like discharge
  - Blood and serosanguinous fluid are normal for the first few days after surgery.
- Progressive redness, warmth (expanding/intensifying rather than retracting/diminishing)
- Tenderness around affected area
- Fever >101.5 degrees

Fracture

- Pain increased from baseline with weight bearing or muscle activation
- Focal pain and swelling over the involved region of bone
- Associated trauma/MOI after surgery

Management for Dr. LaPrade's Patients

STEPS TO TAKE WHEN RED FLAGS OBSERVED

1. **Contact the medical team for consult:**
    a. PT team member to contact MD team:
        i. teamlaprade@tcomn.com attention Chris Armstrong, PA
    b. Patients may call 952-456-7412 if needed

2. **Pursue urgent medical visit referral and/or imaging consult as recommended**
    a. TCO urgent care
        i. Locations: https://tcomn.com/ortho-urgent-care/?gclid=EAIaIQobChMIo--Wsti78QIVUGpvBB0i2gdHEAAYASAAEgLDLfD_BwE
    b. Duplex ultrasound for DVT screening
        i. CDI (US available in Eagan on select days)
            1. Eagan office should be able to coordinate a visit at another location if US not available on-site
        ii. Vascular & Interventional Experts (VIE)
            1. Located on-site at TCO locations
                a. Minnesota Drive, Edina (available Mon-Fri)
                b. Plymouth (available Fri)
                c. Woodbury (available Tues)

3. **Send to ED**
    a. Edina: Fairview/M Health Southdale
    b. Eagan: Fairview/M Health Ridges (Burnsville)
    c. Link to all Fairview/M Health ED Locations: https://www.fairview.org/specialties/emergency-services-and-critical-care#locations1

Joint Protection: WB Restriction

RESEARCH PROTOCOLS IN PROGRESS

Ligament(s) Involved	Control Precaution	Experimental Precaution
Multi-Ligament	NWB	PWB (40% of BW)
PCL	NWB	PWB (40% of BW)
PLC	NWB	PWB (40% of BW)
FCL	PWB (40% of BW)	WBAT
6-week weight bearing restriction period for all		

Exclusion: unstable meniscus repair, revision surgery, fracture

Joint Protection: Bracing

- MLKR patients remain in a brace **longer**:
  - ADLs: until 6 month stress x-rays show stable knee
  - Higher level activities: throughout the 1st year
- PCLR:
  - Immobilizer until swelling reduces enough to transition into dynamic PCL brace (usually 2-3 weeks)
- Non-PCLR:
  - Immobilizer until WB (6 weeks) - transition to hinged brace
- AFO indicated for common peroneal n. injury

Symptom Management: Swelling

Swelling Management: All of the time

Vasopneumatic Cryotherapy:
-30 min on/off in first week
-Multiple times daily in first 2-3 weeks

Compression Stockings:
NWB: 6 weeks at surgical limb, 2 weeks at non-surgical
WBAT: 2 weeks at surgical limb only

Tubigrip Stockings

Swelling Management: Some of the time

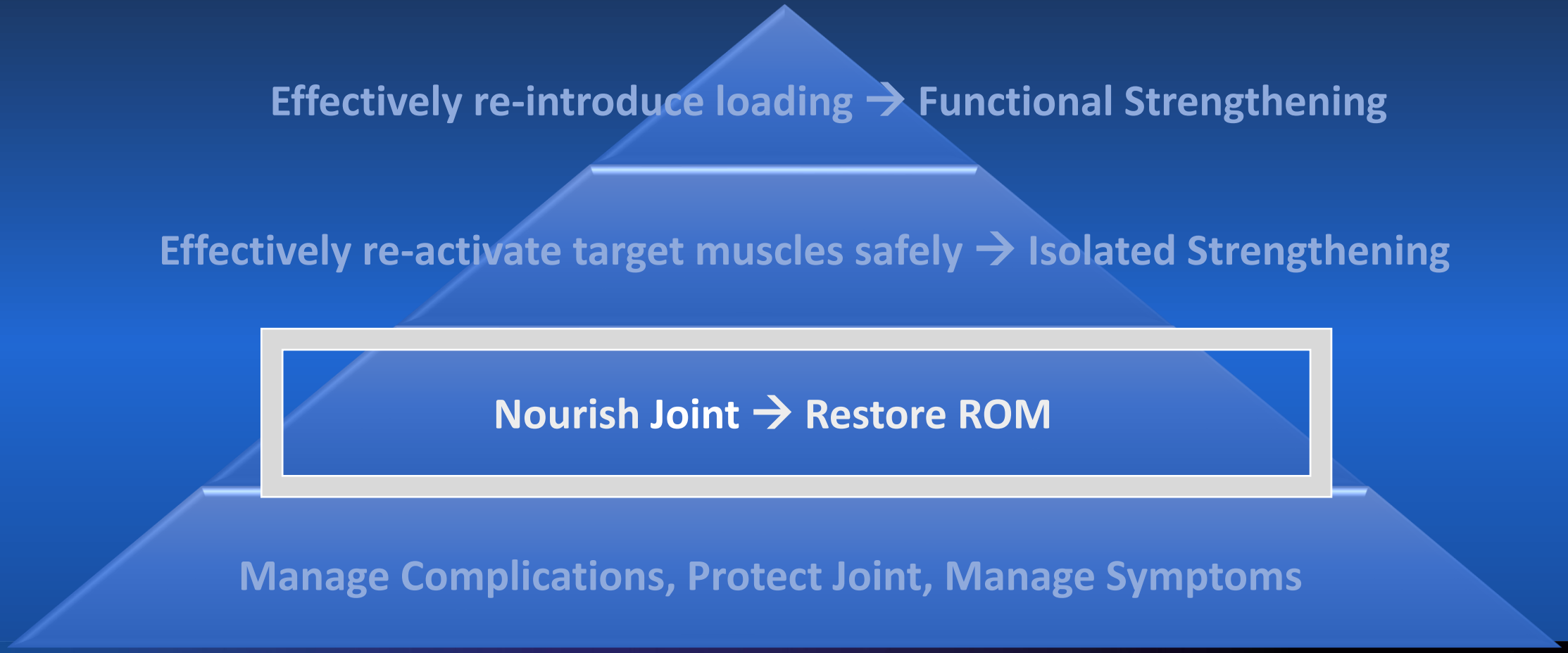
Kinesiology Tape for Lymphatic Flow

Foam Croutons “Burritos”:

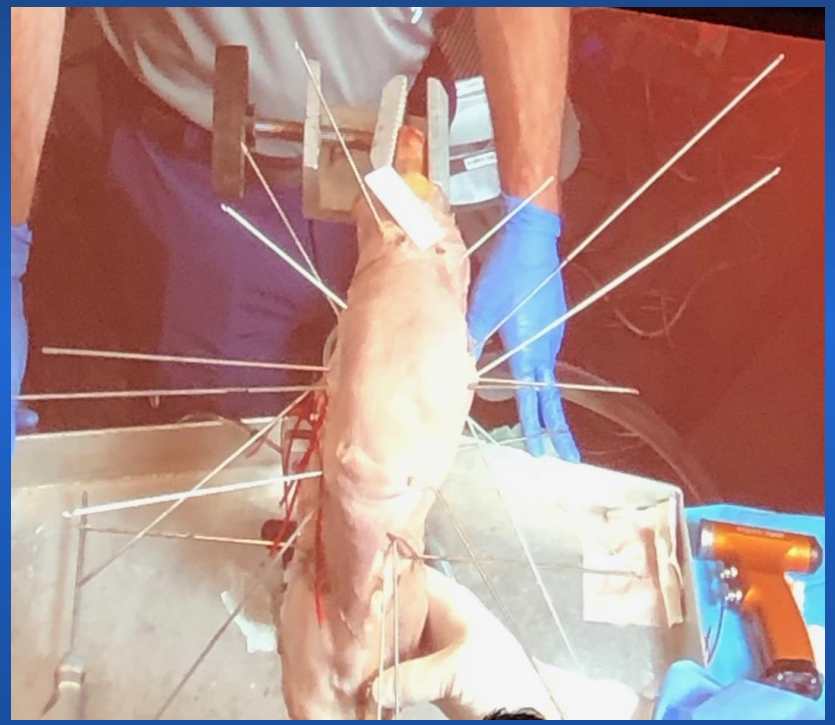
Construct packet(s) of small foam croutons to apply under tubigrip over an area of stagnant fluid accumulation (enclose within cover-roll tape or small size tubigrip (ends taped/stitched shut) to make a little “burrito” of croutons)

*creates channels in the fluid to help drain it

Early Post-Surgical Rehab Pyramid

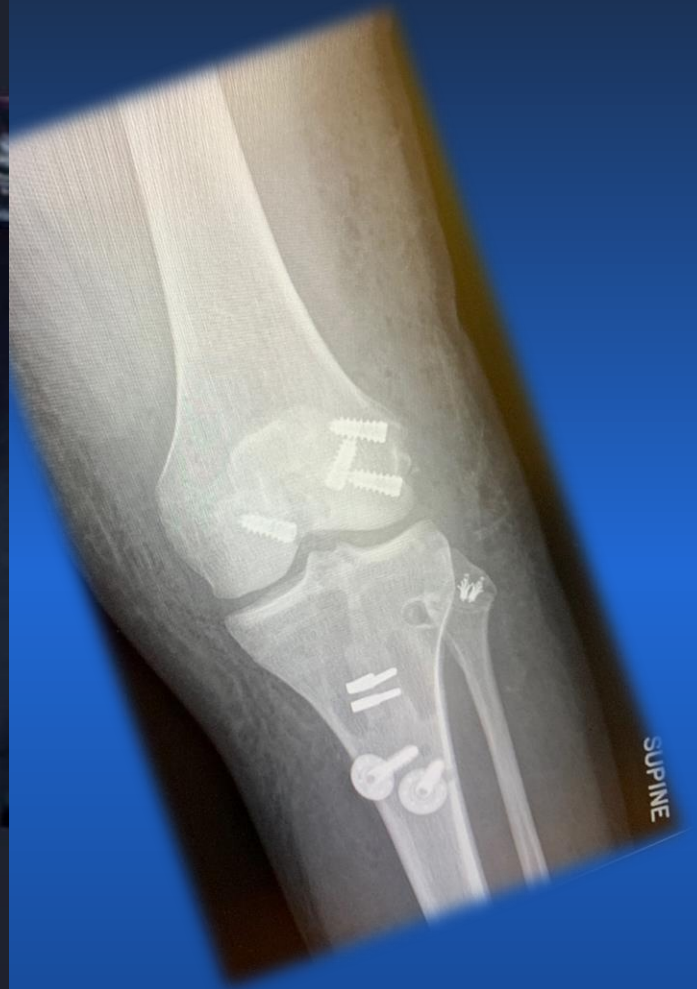


Nourish the Joint → ROM



Nourish the Joint → ROM

Nourish the



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Nourish the Joint → ROM

Single-Stage Multiple-Ligament Knee Reconstructions for Sports-Related Injuries

Outcomes in 194 Patients

Robert F. LaPrade,[*†] MD, PhD, Jorge Chahla,[‡] MD, PhD,
Nicholas N. DePhillipo,[†§] MS, ATC, OTC, Tyler Cram,[†] ATC, Mitchell I. Kennedy,[‖] BS,
Mark Cinque,[‖] MD, Grant J. Dornan,[‖] MSc, Luke T. O'Brien,[¶] PT, MPhty (Sports),
Lars Engebretsen,[§#**] Prof., MD, PhD, and Gilbert Moatshe,[§**] MD, PhD
Investigation performed at The Steadman Clinic, Vail, Colorado, USA

- Immediate ROM permitted (0-90 deg limit x 2 wks, then progress as tolerated)
- Mean post-operative Knee ROM (2 yr f/u): **0-0-134 deg**
- Post-operative multi-direction **knee laxity within acceptable range** (stress radiography)

Single-Stage Multiple-Liga t Knee Reconstructions for S Injuries

Outcomes in 194 P

Robert F. LaPrad
Nicholas N
Mark C
Lars Enge
Investigation pe

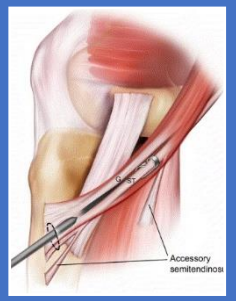
Early ROM
following MLKI Knee
Reconstruction is
SAFE

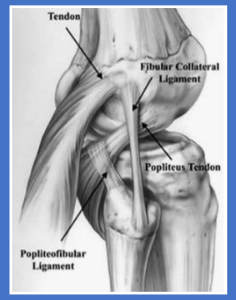
- Immediate ROM permitted as tolerated)
- Mean post-operative Knee ROM (2 yr f g
- Post-operative multi-direction **knee laxity within acceptable range** (stress radiography)

ROM: Precautions & Unique Considerations

No Hyperextension (HE)	• Avoid graft tension on structures that natively limit knee HE • PCL & PLC: Avoid HE x 8 weeks • FCL & POL: Avoid HE x 2 weeks then gradual return to symmetry
Prone &/or PROM Knee Flexion ROM	• PCL: PRONE x 2 weeks (avoid positional sag into PTT), PASSIVE x 6 weeks (avoid hamstring pulling into PTT) • FCL, PLC: PASSIVE → AAROM gradually over 6 weeks (fibular head disruption, secondary contributors to PTT stability)
Patellofemoral Compartment Adhesion Management	• Inflammation x 48-72 hrs→ proliferation (collagen spray) x 2 wks • Extensor mechanism = pulley system (patella/tendons = rope) • Scar under the tendons, between the tissue layers = supergluing the rope to the pulley = ineffective pulley!

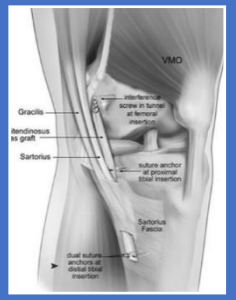
Graft Considerations





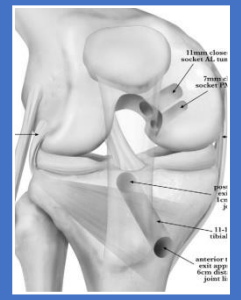
FCL/PLC

Hypertrophic Changes



MCL

Ossification



PCL

Double Bundle Allograft

Autograft Harvest:

- Additional soft tissue trauma about the joint
- Tendon healing required from stripping
- Additional regions of collagen proliferation
- Increased likelihood of scarring

EXCESS SCAR = STIFF JOINT

MANAGE THESE REGIONS TO MINIMIZE EXCESS SCAR

(Manage inflammation, supported ROM, manual interventions, gentle & effective early muscle activation)

Hypertrop

ndle Allograft

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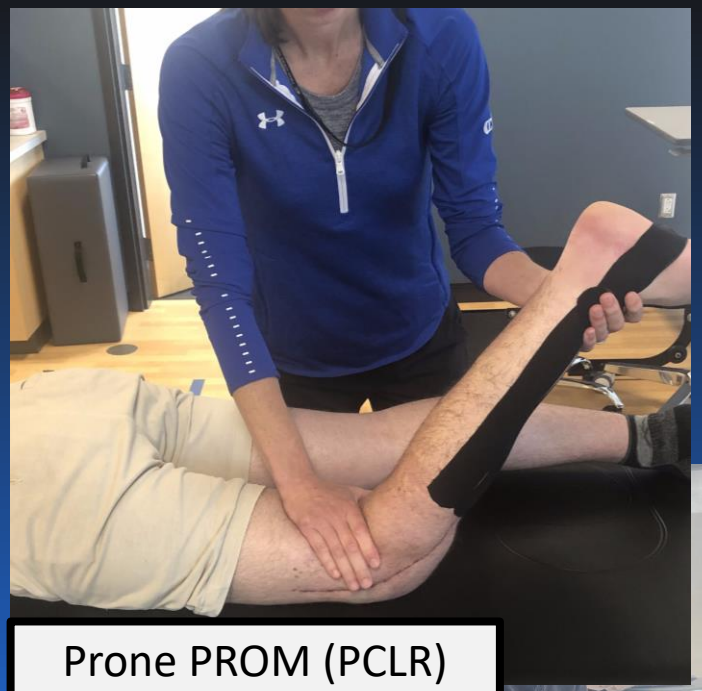
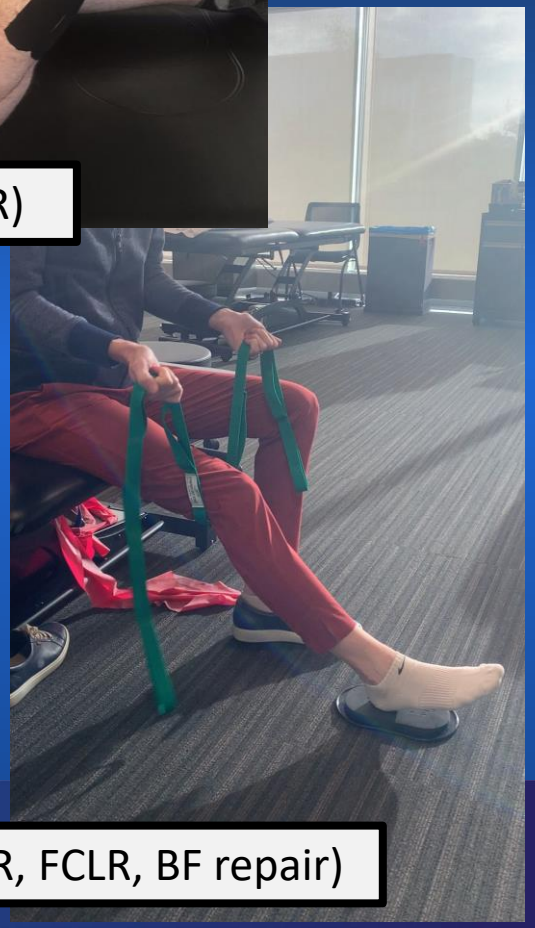
ROM Support Strategies

- **Patellar/Peripatellar Mobilizations**
  - Patella
  - Quad & Patellar Tendons
  - Suprapatellar pouch
  - Infrapatellar fat pad
- **Strong, repetitive quad activation**
  - Couple with patellar mobilizations
    - Proximal with contraction
    - Distal with relaxation

ROM: Flexion Precautions



Prone PROM (PCLR)



Seated PROM (PLCR, FCLR, BF repair)

- Prone PROM 0-90^{o}x 2 weeks (PCL)
  - Avoid posterior tibial sag/translation (PTT) d/t positioning
  - PROM to minimize HS pulling induced posterior shear
- PASSIVE ROM (PROM) x 6 weeks
  - PCL, PLC, biceps femoris repair
  - Minimize dynamic PTT via hamstring pulling
- No hyperextension (PCL, PLC) x 8 weeks

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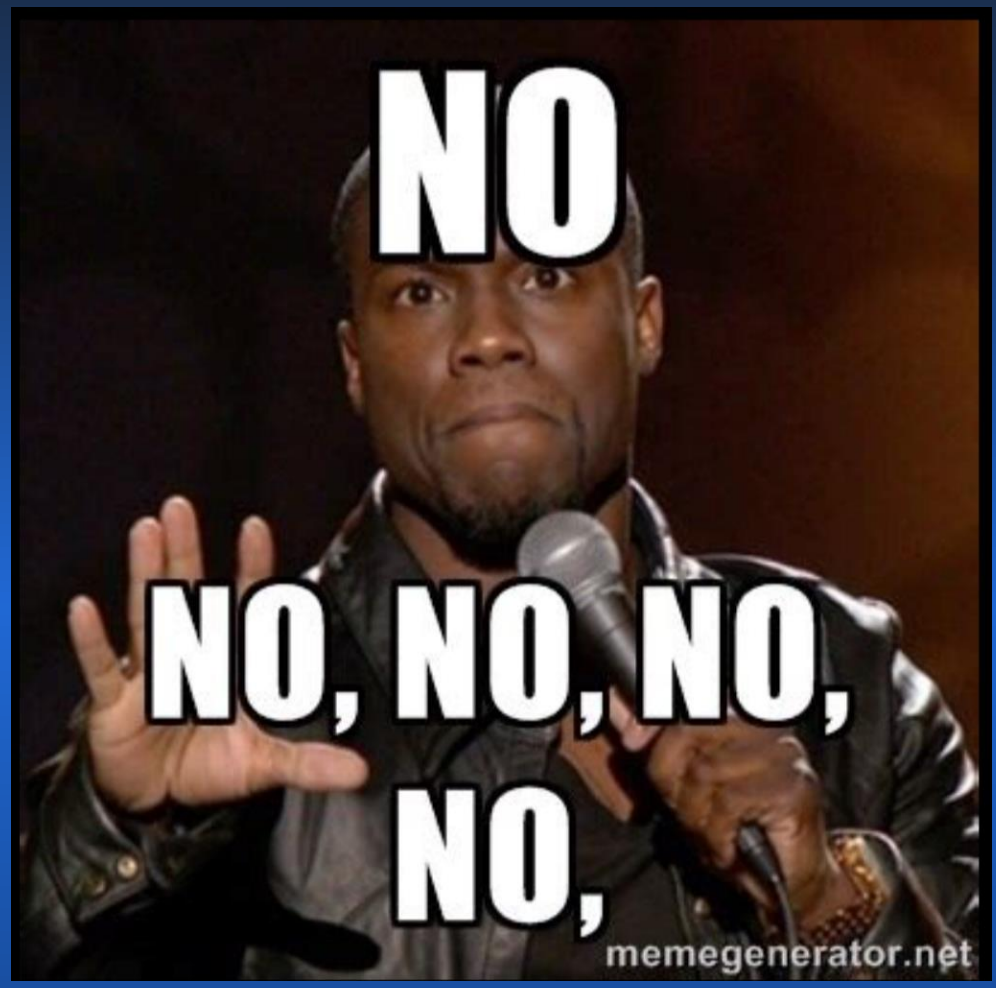
ROM: Hyperextension Precaution



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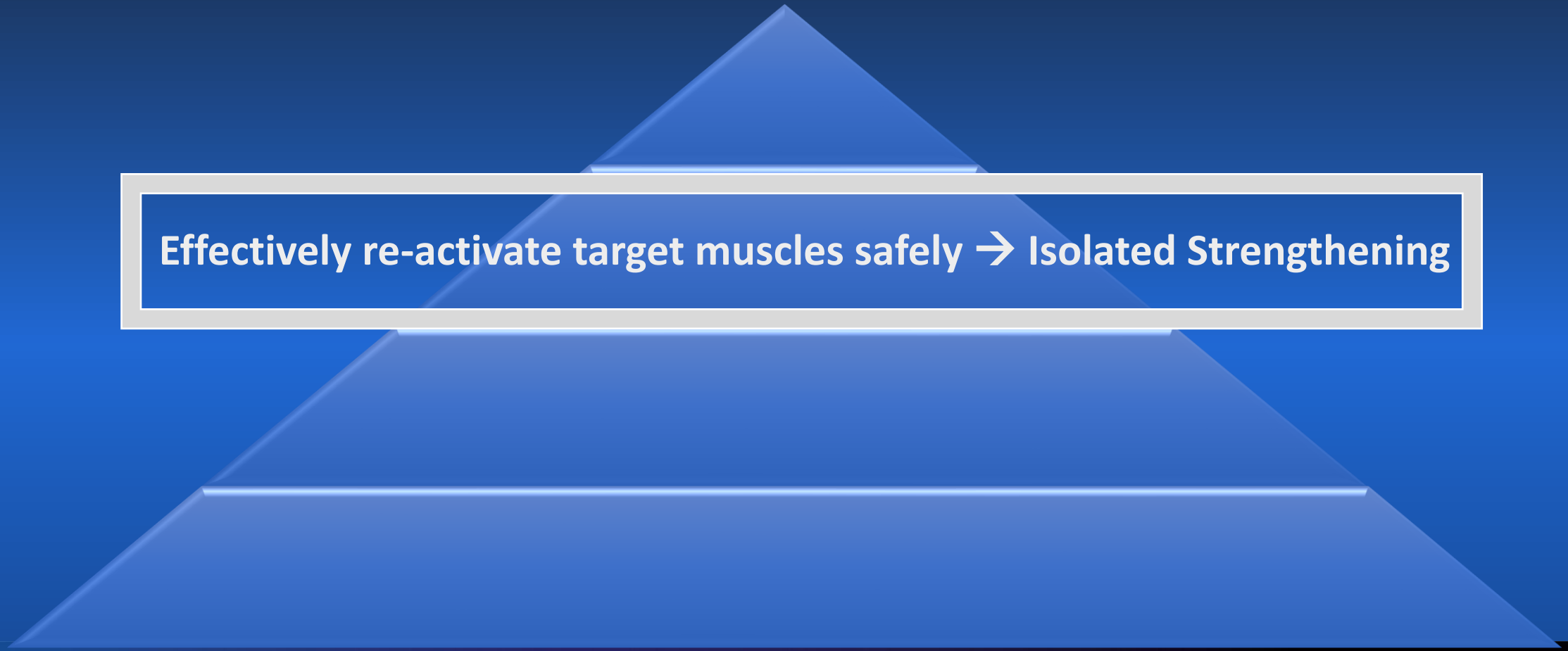
ROM: Hyperextension Precaution

Early Post-Surgical Rehab Pyramid



Muscle Re-action: Nerve Injury

FCL/PLC Procedures
Common Peroneal Nerve (CPN)

- **Transient CPN Neuropraxia**
  - Not unusual when nerve block used
  - Should resolve within 2-3 days
  - **If NOT – contact medical team**
- **Complete CPN Injury/Palsy**
  - Critical to retain ankle DF ROM
  - Improves future outcomes with tibialis posterior tendon transfer

Muscle Re-activation: Nerve Injury

- Low Frequency Electrical Stimulation (≤20 Hz)

HHS Public Access
Author manuscript
Eur J Neurosci. Author manuscript; available in PMC 2017 February 01.

Published in final edited form as:
Eur J Neurosci. 2016 February ; 43(3): 336–350. doi:10.1111/ejn.13005.

Strategies to promote peripheral nerve regeneration: electrical stimulation and/or exercise

Tessa Gordon[*] and **Arthur W. English**[≈]

[*]Department of Surgery, The Hospital for Sick Children, Toronto, Ontario M4G 1X8

[≈]Department of Cell Biology, Emory University School of Medicine, Atlanta, GA 30322

Contents lists available at ScienceDirect

Experimental Neurology

journal homepage: www.elsevier.com/locate/yexnr

Brief post-surgical electrical stimulation accelerates axon regeneration and muscle reinnervation without affecting the functional measures in carpal tunnel syndrome patients

Tessa Gordon, Nasim Amirjani, David C. Edwards, K. Ming Chan *

Basic Research Article

Electrical Stimulation to Promote Peripheral Nerve Regeneration

Neurorehabilitation and Neural Repair
2016, Vol. 30(5) 490–496

DOI: 10.1177/1545968315604399
nnr.sagepub.com
SAGE

Michael P. Willand, PhD[1], May-Anh Nguyen[2], Gregory H. Borschel, MD[1], and Tessa Gordon, PhD[1]

Gordon Exp Neurol 2010, Elzinga Exp Neurol. 2015; Willand 2016; Gordon 2016

Muscle Re-activation: Nerve Injury

Neuromuscular Electrical Stimulation (Quad)	Low Frequency Electrical Stimulation (Nerve Injury)
• Stimulation Frequency: 50-100 Hz • Dosing: 10-15 minutes (intermittent), 3-7x/wk, until strength recovers • Target: Directly to muscle	• Stimulation Frequency: ≤20 Hz • Dosing: 1 hour daily (constant) x 2 weeks • Target: Along pathway of nerve (proximal to injury location)

Quad Re-activation: Electrical Stimulation (NMES)

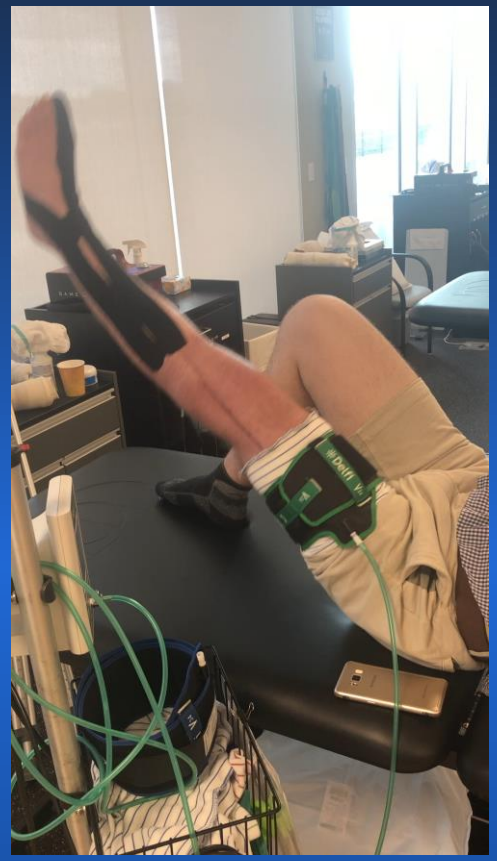
- Over-ride quadriceps activation deficit
  - *Hart JATA 2010*
- Recover Strength
  - *Kim JOSPT 2010*
  - Gatewood *Knee Surgery, Sports Traumatology, Arthroscopy* 2017

Quad: Blood Flow Restriction Therapy (BFR)

- Tennent Clin J Sports Med 2017
  - BFR group had increase in:
    - thigh girth
    - extension and flexion strength

- Excellent tool for patients who are NWB x 6 weeks
  - Safe to initiate within the first 2 weeks after surgery
    - *Hughes BJSM 2017, Patterson Front. Physiol .2019, Minniti AJSM 2019*

- Introduction of BFR:
  - Bleeding resolved
  - Initiate at lower intensity then build to therapeutic dosing (80%) as tolerated
  - Modify time under occlusion per tolerance



Quad: Blood Flow Restriction Therapy (BFR)

TABLE 1 | Model of exercise prescription with BFR-RE.

	Guidelines
Frequency	2–3 times a week (>3 weeks) or 1–2 times per day (1–3 weeks)
Load	20–40% 1RM
Restriction time	5–10 min per exercise (reperfusion between exercises)
Type	Small and large muscle groups (arms and legs/uni or bilateral)
Sets	2–4
Cuff	5 (small), 10 or 12 (medium), 17 or 18 cm (large)
Repetitions Pressure	(75 reps) – 30 × 15 × 15 × 15, or sets to failure 40–80% AOP
Rest between sets	30–60 s
Restriction form	Continuous or intermittent
Execution speed	1–2 s (concentric and eccentric)
Execution	Until concentric failure or when planned rep scheme is completed

Patterson Front. Physiol .2019

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Quad: Blood Flow Restriction Therapy (BFR)

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Editorial > Arthroscopy. 2021 Sep;37(9):2870-2872. doi: 10.1016/j.arthro.2021.04.073.

Editorial Commentary: Blood Flow Restriction Therapy Continues to Prove Effective

Robert F LaPrade [1], Jill K Monson [2], Jon Schoenecker [2]

Patterson Front. Physiol .2019

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Day 1 → **Recover** → 6 weeks

Pain/Effusion Management

Progressive ROM

Quad Activation

Prepare for Gait

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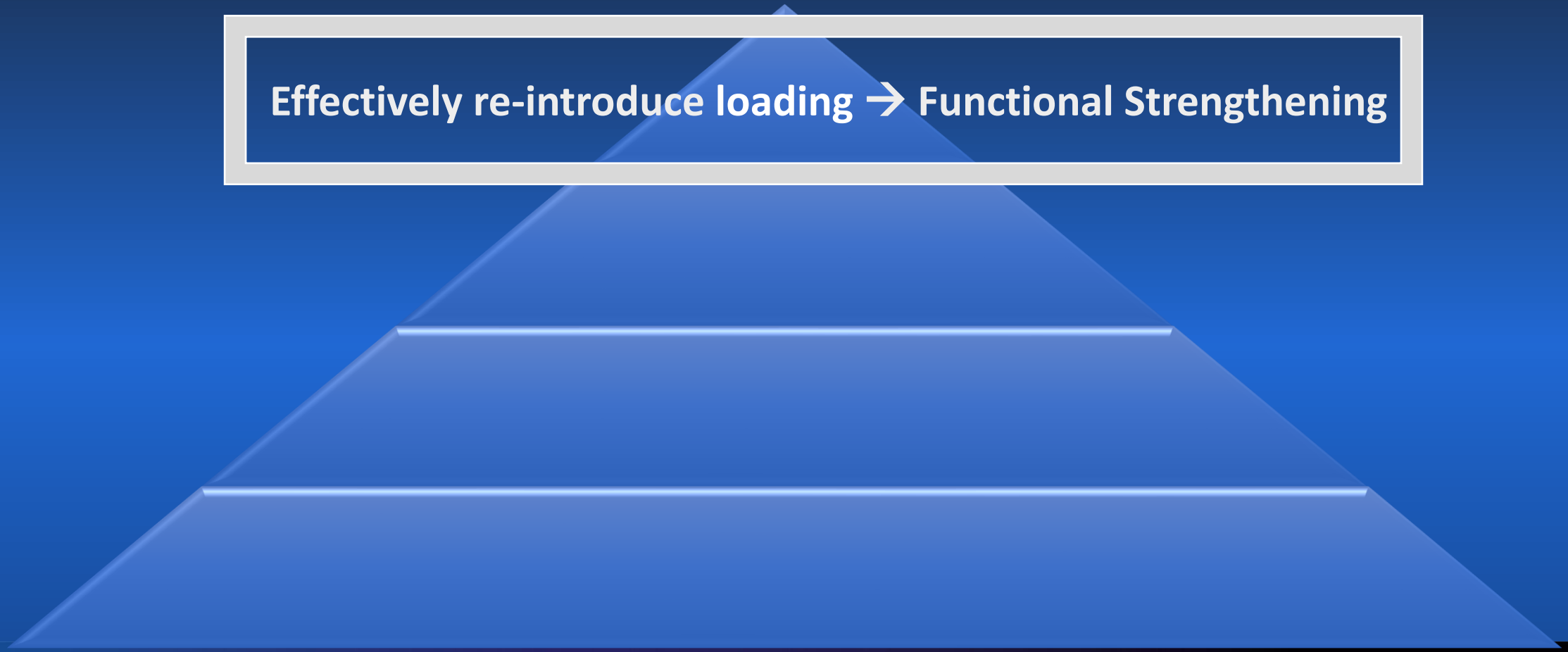
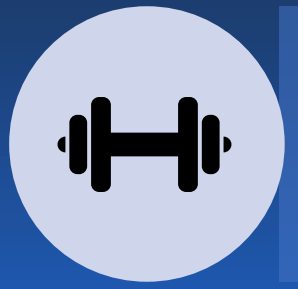
POST OP RECOVERY PHASES

Early Post-Surgical Rehab Pyramid



GOALS for Transition

Transition off crutches



Load: Muscle | Tendon

Continue to avoid:

- OKC hamstring
- Squat >70 degrees

Work Capacity

Clean Up Time

- Pain/Effusion
- Range of Motion
- Quad Function
- Gait

Gait s/p MLKR

Knee Surg Sports Traumatol Arthrosc (2017) 25:1489–1499
DOI 10.1007/s00167-016-4104-3

CrossMark

KNEE

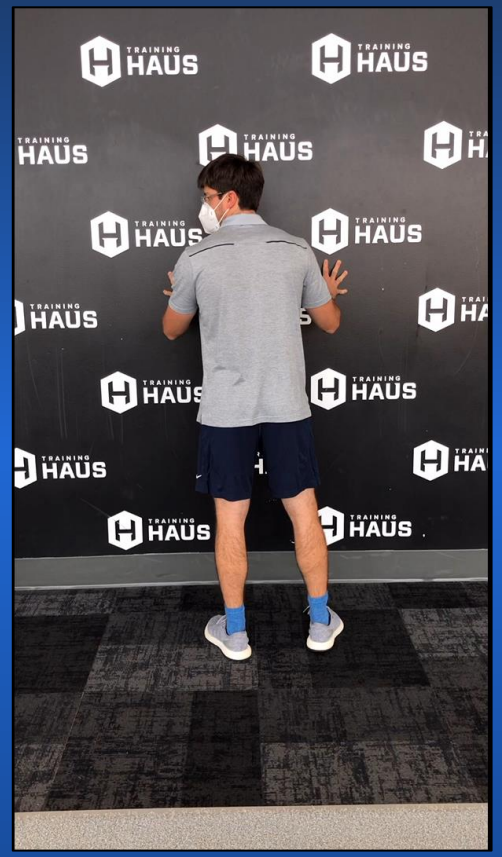
Gait adaptations following multiple-ligament knee reconstruction occur with altered knee kinematics during level walking

Corey J. Scholes[1] · Joe T. Lynch[1] · Milad Ebrahimi[1] · Brett A. Fritsch[1] · David A. Parker[1]

- Initial Contact: significantly greater knee flexion observed at surgical limb
- Loading response: significantly reduced knee flexion (excursion) at surgical limb

“More constrained pattern of knee motion”

Gait Retraining



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Isolated **Open Chain** Strengthening: Extension

Isotonic through arc 0-60°

Iso at 0°

Iso at 60°

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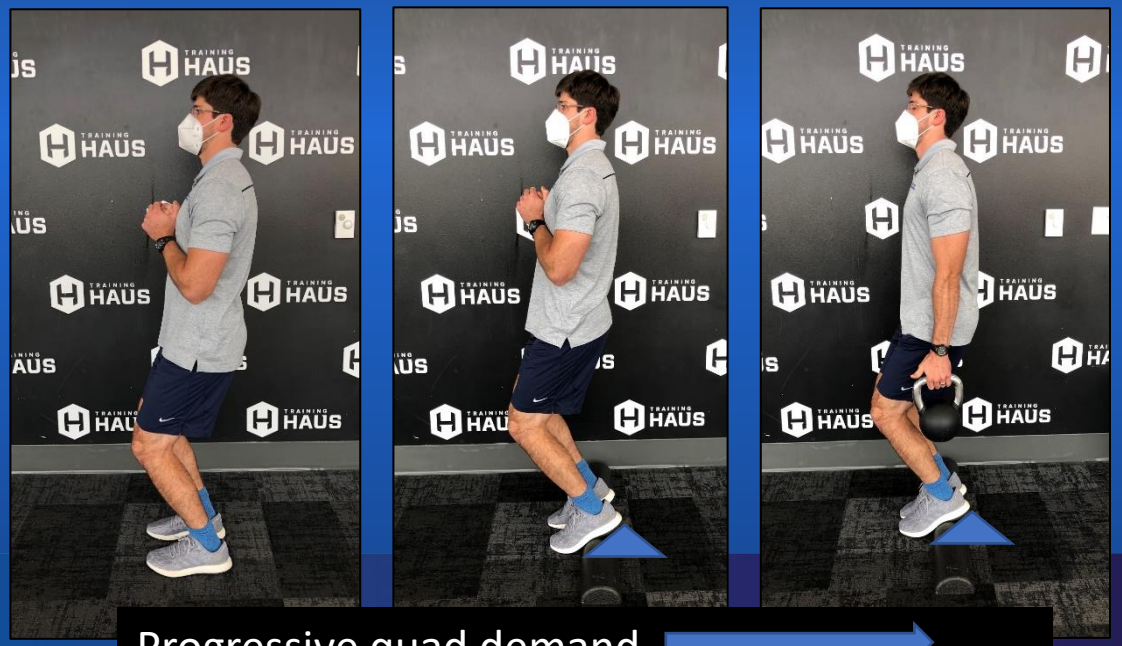
Isolated **Open Chain** Strengthening: Flexion

- **Shallow ISOs**
- **Hip hinge**
- **Bridge**
- **AROM slides**

8-16 weeks

Early Load Progressions

Weight shift



Progressive quad demand

Considerations:

- Pain, effusion, ROM, OKC vs. CKC, precautions, ensuring effective dose-response

NWB activation

WB isometrics

Progressive depth

Heavy, slow eccentrics

Velocity-based eccentrics

Restore Full Motion

Extension

Don’t forget to address neural tension to restore full end range extension!

Flexion

Mobilization strategies to reduce posterior pinching with end range flexion progressions

Clean Up Time

- Pain/Effusion
- Range of Motion
- Quad Function
- Gait

Dr. LaPrade TRAC Testing Protocol: MLKR Patients

LOCAL PATIENTS:

- **Do NOT need same-day testing** corresponding with MD appointment
- Complete testing 1-3 weeks prior to MD visit (to allow for outcomes to be shared prior to date of MD visit)

OUT-OF-TOWN PATIENTS:

- **Require same-day testing** to correspond with MD appointment

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Dr. [illegible] Protocol:

- **Testing timelines are listed at the TOP OF EVAL NOTE and IN THE PROTOCOL**
- **Have patient call to schedule WELL IN ADVANCE**
- **WHEN IN DOUBT…EMAIL JILL! jillmonson@tcomn.com**

LOC[illegible]

- **Do N[illegible]** MD appoi[illegible] [illegible]ointment
- Complete testing [illegible] allow for outcomes to be [illegible] MD visit)

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4 Month Clinical Testing Protocol: Baseline

Effusion

Girth:
calf, knee, thigh

Limb Length

ROM:
ankle, knee

Strength (HHD):
hip abduction

FUNCTIONAL TESTS

One Leg Rise Test
(Culvinor, 2016; Ericcson, 2013)

Y Balance Anterior Reach
(Smith, 2014; Stiffler, 2017)

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4 month Training HAUS Lab Protocol: 45 min

1. Strength

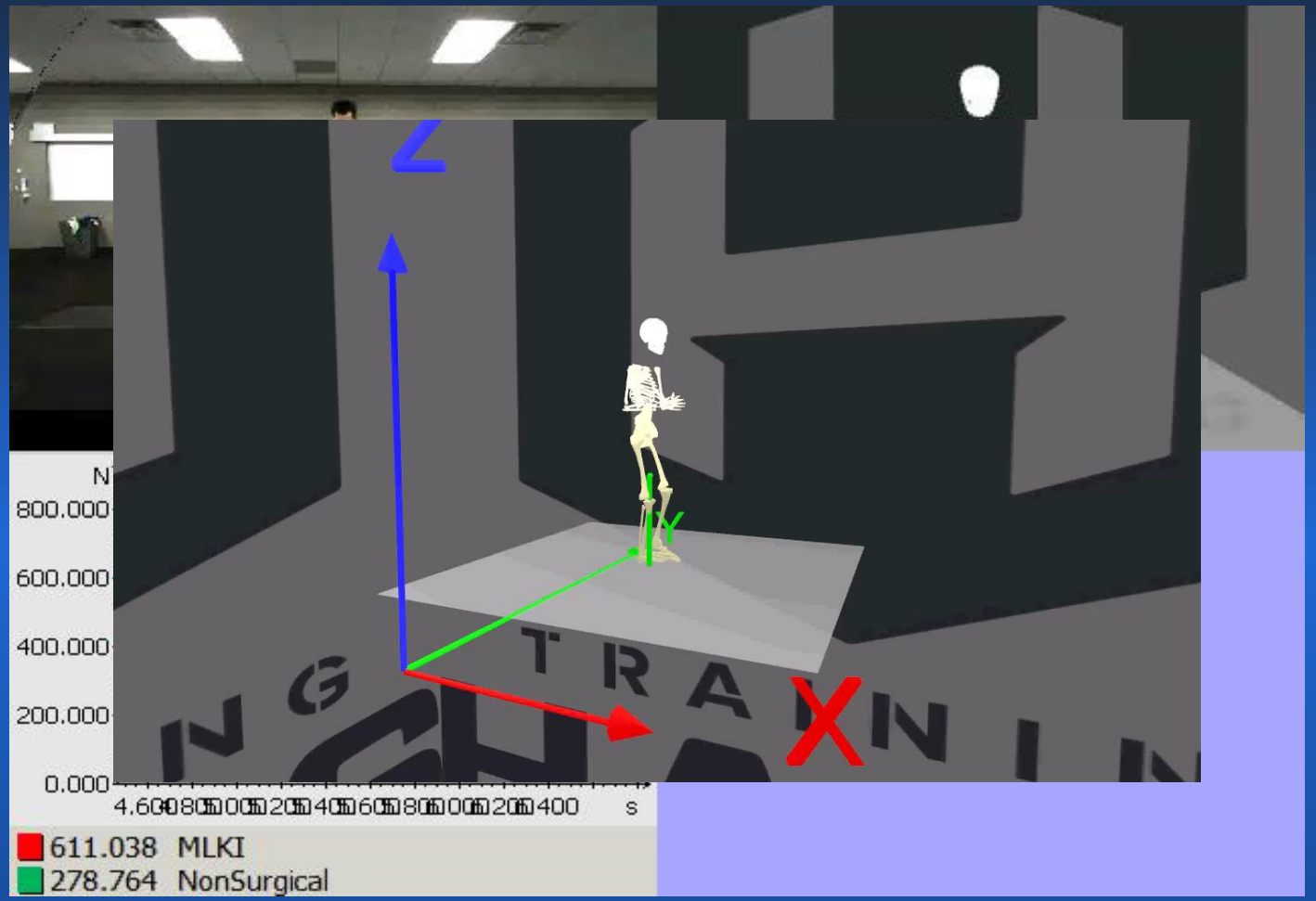
- Maximal Isometric Quadriceps Test @ 90° of flexion
- LSI and Relative strength to BW

TWIN CITIES ORTHOPEDICS | TRAINING HAUS

4 month Training HAUS Lab Protocol: 45 min

2. Coordination

- Double Leg Squat
  - Force Distribution between Limbs
- Single leg squat
  - Sagittal/Frontal Strategy



TWIN CITIES ORTHOPEDICS | TRAINING HAUS

Clean Up Time

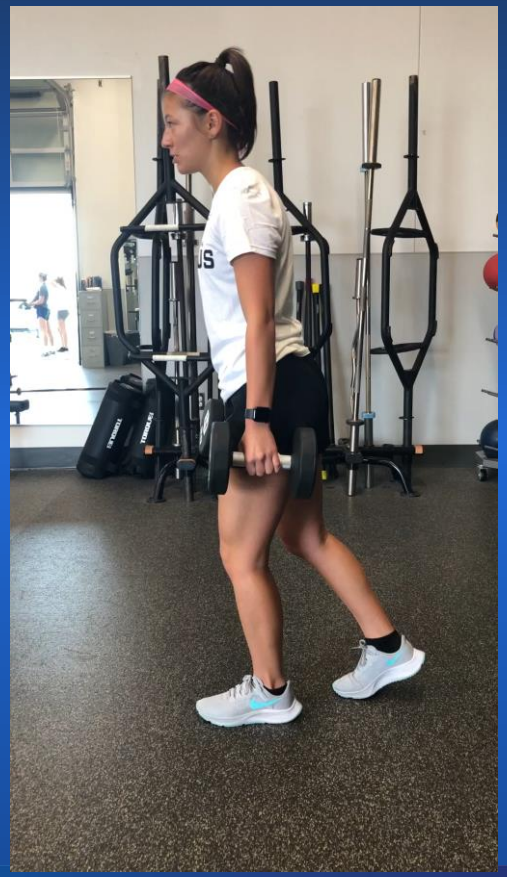
- Pain/Effusion
- Range of Motion
- Quad Function
- Gait

POST OP RECOVERY PHASES

Anterior Loading Progressions

Emphasize:

- 85% on Front Limb
- Parallel Shin/Spine
- Neutral Hip

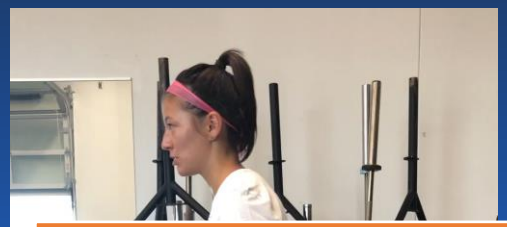
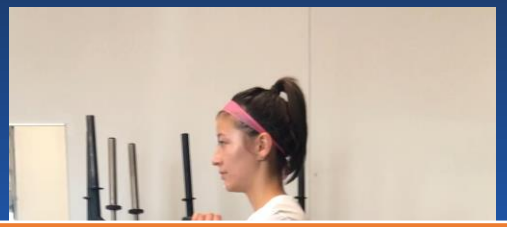
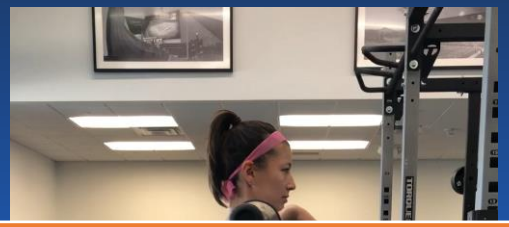


"Distalize" Load & Add Time Under Tension

TWIN CITIES ORTHOPEDICS | TRAINING HAUS

Anterior Loading Progressions

Emphasize:
- 85% on Front Limb
- Parallel Shin/Spine
- Neutral Hip


ISOLATED QUAD exercise on the menu for a VERY LONG TIME

IDENTIFY and CORRECT QUAD AVOIDANCE in CKC


“Distalize” Load & Add Time Under Tension

TWIN CITIES ORTHOPEDICS | TRAINING HAUS

Overload Progressions

Considerations for Loading:
- Pain, effusion, ROM, OKC vs. CKC, precautions, ensuring effective dose-response

"Kick Stand Squat"
- 85% of weight on Front Limb
- Parallel Shin/Spine
- Knee Over Toe
- Neutral Hip in Transverse/Frontal Plane
- Pressure through Big Toe, Ball of the Foot & Heel
- Goal is to prevent Hip Dominant squat strategy we often see in MLKR

NWB activation

WB isometrics

Progressive depth

Volume & Heavy, slow eccentrics

Velocity-based eccentrics

Posterior Loading Progressions

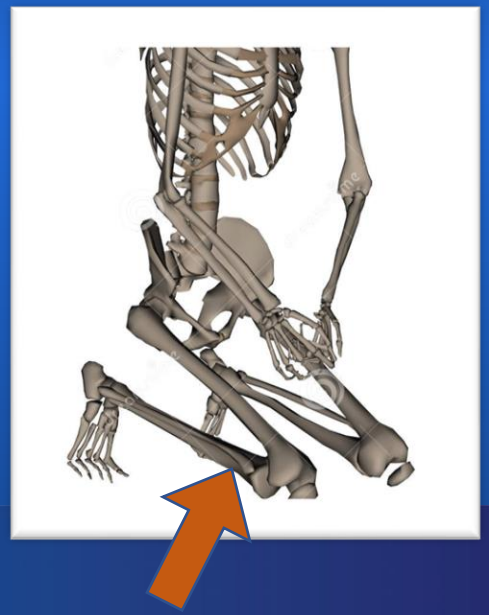
Early:
avoid open chain

Middle:
progressive open chain

Late:
heavy, eccentric

16-24+ weeks

>6 months



Caution with Nordics/Kneeling

****Wait until normal stress x-rays with MD at 6-month follow-up appointment****

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Goals: Beyond Limb Symmetry Index (LSI)

Compare to pre-surgical limb status

EPIC (Estimated Pre-Injury Capacity) *(Wellsandt, 2017)*

[BRIEF REPORT]

ELIZABETH WELLSANDT, DPT, PhD[1,2] • MATHEW J. FAILLA, PT, PhD[1,3] • LYNN SNYDER-MACKLER, PT, ScD[1,4]

Limb Symmetry Indexes Can Overestimate Knee Function After Anterior Cruciate Ligament Injury

Compare to body size / dimensions

- "Allometric Scaling": weight, height, limb length

Compare to healthy normals

- Appropriate matching: Age, Sex, Sport, Level of sport/experience

Are Muscle Strength and Function of the Uninjured Lower Limb Weakened After ACL Injury?: Two-Year Follow-up After Reconstruction
Kyu Sung Chung, MD et al. AJSM 2015

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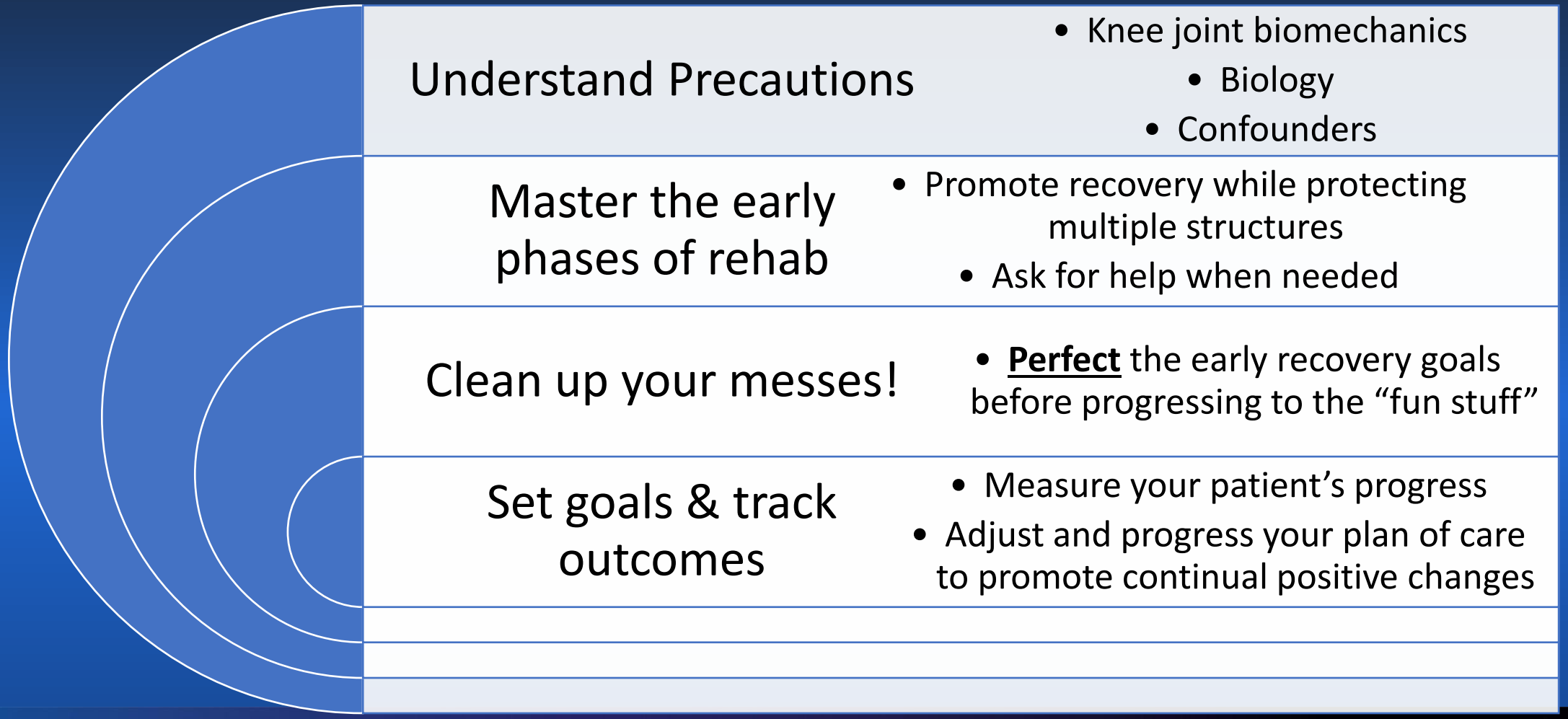
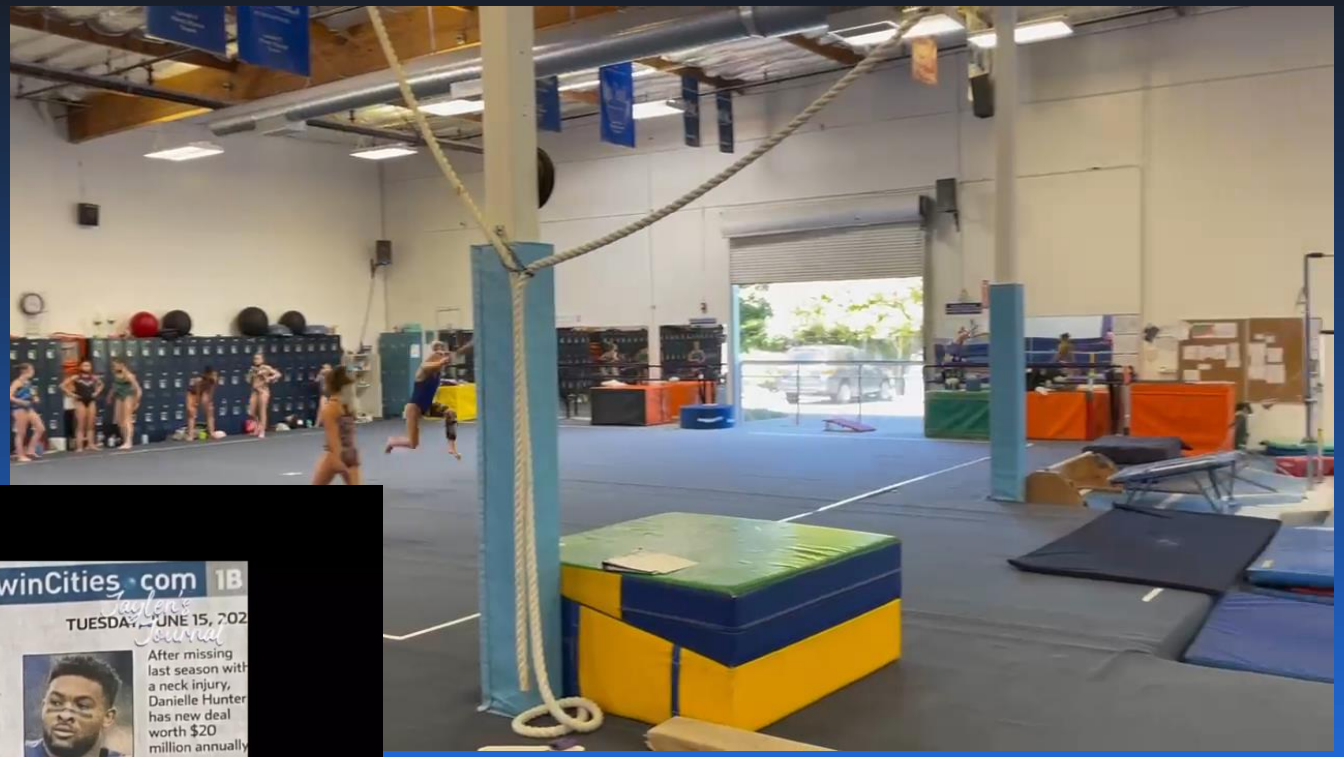
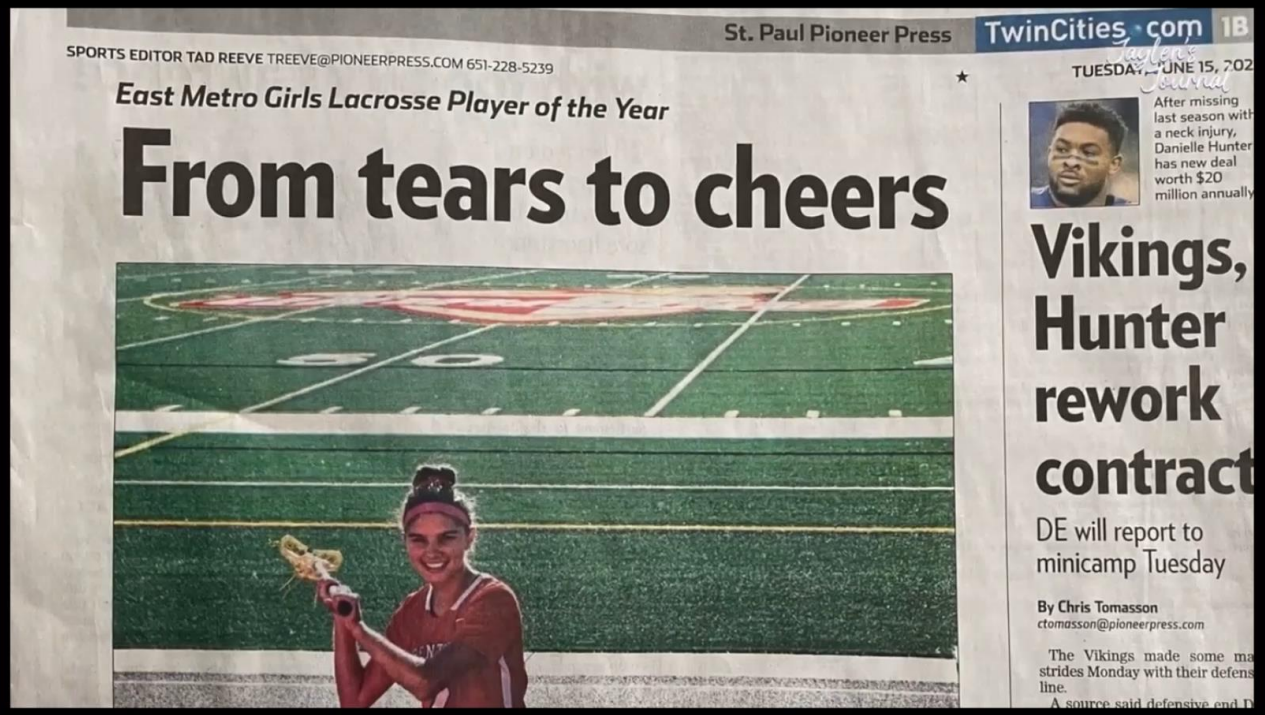
In Conclusion



Thank you!





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TUESDAY, JUNE 15, 202

East Metro Girls Lacrosse Player of the Year

From tears to cheers

After missing last season with a neck injury, Danielle Hunter has new deal worth $20 million annually

Vikings, Hunter rework contract

DE will report to minicamp Tuesday

By Chris Tomasson
ctomasson@pioneerpress.com

The Vikings made some ma strides Monday with their defens line.

A source said defensive end D