The Importance of Rotational Control in Tibiofemoral Mechanics

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Introduction

• Briefly review knee joint anatomy and arthrokinematics.
• Provide insight into new ways to evaluate the knee for biomechanical contributing factors to pathology.
• Discuss manual therapy techniques to reduce dysfunction.
• Outline therapeutic exercise program to recondition lower extremity control.
Anatomy

- Osseous structures
  - Femur
    - MFC/LFC
  - Tibia
    - Lateral plateau--convex
    - Medial plateau--concave
      - 50% larger than lateral
  - Fibula
  - Patella
    - facets
Anatomy

- **Meniscus**
  - **Lateral**
    - Larger than medial
    - More fully circular
    - Consistent in width
    - Greater mobility than medial
  - **Medial**
    - C-shaped and broader posteriorly than anteriorly
    - Attached to deep medial capsule
Anatomy

- **Primary ligaments**—varying tension measures on different portions depending on joint position
  - ACL
  - PCL
  - LCL—thin and round
    - Popliteus runs underneath
  - MCL—broad and flat
    - Superficial & deep fibers
    - Deep fibers attach to medial meniscus
Anatomy

- Capsular and supporting structures
  - Medial structures— viewed as 3 layers
    - Superficial / Layer I
      - Fascia, sartorius, medial patellar retinaculum, fascial fibers of VMO, medial head gastroc
      - Some distal insertions of semitendinosis and gracilis near pes anserinus
    - Middle / Layer II
      - MCL/superficial fibers
    - Deep / Layer III
      - Considered true capsule
      - MCL/deep fibers, semimembranosus
      - Provides rotational support to MFC
Anatomy

- Capsular and supporting structures
  - Lateral structures—divided into 3 layers
    - Superficial / Layer I
      - Prepatellar bursa, ITB, biceps tendon
    - Intermediate / Layer II
      - LCL, lateral patella retinaculum
    - Capsule / Layer III
      - Deep ligaments (arcuate, fabellafibular), capsule, popliteus often pierces
Anatomy

- Other structures
  - Posterior capsule and stabilizing ligaments and muscles.
  - Bursa
  - Infrapatellar fat pad
  - Plica
  - Fascia
Anatomy
Muscular influences
Musculoskeletal structures

• Important to recognize that no two human structures are the same.
• Asymmetries exist all over the body.
• Muscles and tendons take on different roles:
  • depending on the joint(s) position of the bones that it influences
  • when changing their role from mover ↔ stabilizer
• Most motor functions of the muscles can be altered in the presence of pain, swelling, tissue damage, spasticity, trigger points, mechanical forces producing strain, and/or structural / functional malalignment.
Musculoskeletal structures

- Knee extensors
  - Rectus femoris
    - Also flexes hip
  - Vastus intermedius
  - Vastus lateralis
  - Vastus medialis
  - Patella tendon/ligament
  - Articularis genus
  - Iliotibial tract
    - In ranges between 0-30 degrees
Musculoskeletal structures

- **Knee flexors**
  - Biceps femoris
    - Also extends hip
    - Posterior ilium positioner (especially long head)
  - Semimembranosus
    - Also primary hip extensor
    - Knee medial rotator
  - Semitendinosus
    - Also hip extensor
    - Posterior ilium positioner
    - Knee medial rotator
  - Gastrocnemius
    - Also primary ankle plantarflexor
  - Iliotibial tract
    - In ranges greater than 40 degrees
Musculoskeletal structures

- Muscles influencing knee rotation
  - Also function as stabilizers
  - Popliteus
    - Medial/internal rotation (IR)
    - Also unlocks knee from terminal extension
  - Medial hamstrings
    - Medial rotation
  - Biceps femoris
    - Lateral/external rotation (ER)
Musculoskeletal influences

Proximal

- Influence of muscular hip control on stress onto the knee.
- Influence of mechanical hip and pelvis positioning with movement and producing altered loads distally.
- Decreased trunk control allowing momentum to carry the body past the point the pelvis and LE can stabilize effectively.
Proximal musculoskeletal influences

- **Adductors**
  - Adductor group
  - Gracilis
- **Abductors**
  - Glute med/min
  - Sartorius
  - Obturator internus
- **Medial rotators**
  - Glute med/min (also abduction)
  - TFL
  - Pectineus (also adduction)
- **Lateral rotators**
  - Glute max (also extensor)
  - Piriformis
  - Obturators
  - Gemellus
  - Iliopsoas
Proximal musculoskeletal influences

Proper positioning of the hip and pelvis in a symmetrical pattern with no compensatory patterns further reduces strain onto knee. Most people fall into patterns of dysfunction in acetabulofemoral (AF) movement due to improper muscle sequencing.
Proximal musculoskeletal influences

Core control and the ability to isolate the deep TrA and pelvic floor muscles in varying positions dictates how the lower body will function during activity.
Knee joint biomechanics directly influenced by proximal and distal joint position.

Malalignment at the knee in the frontal plane of more than approximately 4 degrees results in considerably increased forces across the TF joint. ("Musculoskeletal Biomechanics of the Knee Joint. Principles of Preoperative Planning for Osteotomy and Joint Replacement", Orthopade. 2007 Jul;36(7):628-34.)
Biomechanics

- During flexion, the femoral condyles roll posteriorly while they glide anteriorly on the tibial plateau.
- During extension, the condyles roll anteriorly and glide posteriorly.
- During knee flexion from an extended position, the lateral TF contact point will move a greater distance posteriorly than the medial contact point.
- During knee extension, there is greater anterior excursion of the lateral TF contact point than medially.
Forces affecting TF rotation

- Muscular response
- Pronation/supination
- Proximal and distal bony alignment
- Proximal femur control
- Altered arthrokinematic TF movement
Rotation principles

Every joint in the human body rotates or spins to some degree with movement (except the sutures of the skull). It is the ability to control excessive rotation and retraining the timing that is imperative in reducing joint and musculoskeletal strain. There are certain muscles which need to be inhibited while others that need to be facilitated in order to restore normal biomechanical control.
Forces affecting TF rotation

- Muscular response
  - Popliteus, hamstrings, gracilis, sartorius, TFL/ITB, medial head of gastroc
  - It is important to remember that the actions of most muscles affecting movement change based on alterations in joint position proximally and/or distally. For example, the hamstrings increase their effectiveness as knee flexors as the hip moves into flexion and lose some as the hip moves into more extension. However, the motor control of the monoarticular muscles such as the popliteus and biceps femoris remain unchanged. Along these same lines is the role of the hamstrings as medial rotators of the tibia. Their effectiveness increases as the knee increases flexion closer to 90 degrees.
Forces affecting TF rotation

• Pronation/supination:
  • As the foot goes from supination to pronation, and the tibia goes from stabilized ER to active IR, a lot of that motion is due to momentum. Some of it is active IR, but medial knee muscular and capsular tissue needs to stabilize; proximal and distal femur musculature needs to control excessive movement. Capsular structures take on a role of acting like “check reins” to reduce further movement.
Forces affecting TF rotation

• Proximal and distal bony alignment
  • Hip retroversion or anteversion
  • Pelvic width/Q-angle
  • Hip or pelvis malalignments
  • Tibial varum/valgum
  • Foot/ankle forefoot/rearfoot varus or valgus
Forces affecting TF rotation

• Proximal femur control
  • Important to have the ability of hip and pelvis stabilizers to allow for proper femoralacetabular and acetabular -femoral control.
  • Restricted or excessive femoral mobility in the joint will ultimately affect distal mechanics.
Forces affecting TF rotation

- Altered arthrokinematic TF movement
  - Soft tissue tone and restrictions
  - Decreased meniscal mobility
  - Edema and/or joint inflammation
  - Guarding

- Post-ACL surgical considerations such as graft choice and mechanisms of injury and subsequent surgery.

Symptoms or conditions influenced by altered TF mechanics and control

* Most PF conditions and general diffuse joint pain
* Most knee –itis’
* Many foot/ankle chronic conditions such as plantar fasciitis, Achilles tendinitis, posterior tibialis tendinoses
* ACL injured or post-op ACL surgery
* Many meniscal pathologies, including post-op
Examination of TF rotational dysfunction

- Visual
- Palpation
- Active movement assessment
- Passive/manual motion assessment
- Other contributing factors
Examination of TF rotational dysfunction

• Visual
  • Standing posture
  • Ambulation
  • Functional movements
  • Resting position of leg
Examination of TF rotational dysfunction

- Visual—standing posture
  - Typically asymmetric foot stance with one leg more horizontally abducted
  - Femoral IR/”squinting patella”
  - “Corkscrew” leg
  - Increased pronated foot posture
  - Often anterior pelvic tilt and/or increased lumbar lordosis
Examination of TF rotational dysfunction

- **Ambulation**
  - Increased apparent rotation throughout the lower kinetic chain
  - Heel-whip at toe-off and swing phase of gait
  - Poor ability to control pronation, especially barefoot
  - Lateral shifting to one side more than contralateral or “Sailor’s gait”
Examination of TF rotational dysfunction

**Functional movements**
- Assessing and breaking down certain movement patterns to further isolate source(s) of impairment aids in the development of a comprehensive treatment plan.
- Looking for compensatory movement (i.e. forward trunk position, side leaning to counterbalance, hip hiking, poor foot/ankle control)

**Functional tests**
- Single leg balance
- Two-legged squat or overhead squat test
- Single leg squat (bilaterally)
- Bilateral jumping
- Unilateral hopping
Examination of TF rotational dysfunction
Observing other functional movements which may be contributing to their symptoms important as well—especially tasks which are repetitive.
Examination of TF rotational dysfunction

**Palpation**—common regions of tenderness and associated soft tissue restriction
- Inferior medial and/or lateral patella
- Medial capsule and joint line
- Pes anserinus
- Medial hamstrings, especially where they pass the posteromedial tibia
- Popliteus at tibial>femoral insertions
  - Proximal insertion pain often misdiagnosed as ITBFS
- Medial gastroc head
- Posterolateral capsule
- Fibula head ant>post
Examination of TF rotational dysfunction

Palpation-Inf. Med. patella  Palpation-Inf. Med. patella
Examination of TF rotational dysfunction
Palpation—medial capsule and joint line
Examination of TF rotational dysfunction
Palpation—pes anserinus and medial hamstrings
Examination of TF rotational dysfunction
Palpation—popliteus at tibial and femoral insertions
Examination of TF rotational dysfunction

Palpation—medial gastrocnemius head, popliteus, posterior medial structures
Examination of TF rotational dysfunction

- Active movement assessment—assessing AROM as well as quality of motion at TF joint
  - Seated OKC 90/90 ER/IR
  - Seated CKC 90/90 ER/IR
Active movement assessment
Seated OKC 90/90 ER/IR
Active movement assessment
Seated OKC 90/90 ER/IR
Examination of TF rotational dysfunction

- Passive/manual motion assessment
  - Supine circumduction palpation exam
Passive/manual motion assessment
Supine circumduction palpation exam

Beginning position

Ending position
Passive/manual motion assessment

Supine circumduction palpation exam

- One hand grasping the calcaneus while the other hand grasps joint line with thumb on lateral and forefinger (or 2-4 pads of fingers) along medial.
  - Thumb can be dropped to feel motion at fibula head for a few cycles as well.
- Starting with the hip and knee in fairly neutral positions. Begin with internally rotating tibia while bringing hip into flexion and ER.
- While cycling the knee through the motion, feel for the quality of movement of the tibia on the femur. You should feel the medial tibial condyle drop posteriorly while the lateral condyle travels anterior and vice versa when bringing leg back into starting position.
- Perform a number of times to feel where restrictions seem apparent, i.e. bands of tissue getting taut under your fingers as you move the tibia.
- Also feeling for restrictions in femoral rotation suggestive of altered loads distally.
Examination of TF rotational dysfunction

- Other contributing factors
  - Fibula position
  - Anterior talus orientation
  - Hip capsule restrictions
Treatment of TF rotational dysfunction

- Manual soft tissue techniques
- Positional release therapy
- Mobilizations with movement
- Self mobilization techniques
- Therapeutic exercises/HEP
Treatment of TF rotational dysfunction
Manual soft tissue techniques

- Soft tissue massage (STM) to the medial → posterior capsule and joint line, beginning with more superficial tissue and working deeper. Work slowly into direction of resistance.
- STM to popliteus, medial gastroc, and HS as needed. Popliteus is often thickened and therefore lost some contractile qualities.
Treatment of TF rotational dysfunction

Positional release techniques

- Often referred to as strain/counterstrain
- Philosophy is to based on the theory that tissue can develop tone or a shortened state in a specific location which can only be reduced by breaking the hyperactive (gamma gain) cycle. This is achieved by placing the affected tissue in a shortened state of comfort to reduce the tone (gamma efferent activity) and disrupting the dysfunctional position—essentially tricking it into submission.
- While palpating the area of irritation, the practitioner moves bones to manipulate the tissue into a shortened state which typically eliminates the point tenderness. This position is maintained and held for about 90 seconds. The body is then slowly taken out of this position which decreases the possibility that the affected tissue will return to its previous state.
Treatment of TF rotational dysfunction

- Positional release techniques—MCL point/medial knee
  - Patient supine with leg off side of table and bent about 30 degrees, palpate the point of tone/pain at medial joint line, place a varus load onto the knee than IR lower leg until tone is reduced. Hold 90 seconds, then slowly bring out.
Treatment of TF rotational dysfunction

Positional release techniques—ACL point/inferomedial fat pad

Patient supine with towel roll under the distal femur, palpate point of tone/pain; lower leg held in IR by practitioner’s body then posterior glide of tibia with IR at the same time. 90 seconds, slowly release.
Treatment of TF rotational dysfunction
MWM’s for anterior talus—inability to squat fully or anterior ankle impingement with calf stretching, perform MWM’s to the talus focusing on posterior gliding as they actively PF and DF.
Treatment of TF rotational dysfunction
Mobilization with movement techniques
Moving tibia and femur through the range which was tested for dysfunction, the supine circumduction MWM.
Treatment of TF rotational dysfunction
Self mobilization techniques
   Grasp proximal tibia with leg in IR, shift weight forward and back while keeping IR pressure and femur going straight.
Treatment of TF rotational dysfunction

Self mobilization techniques

“Knee arounds”—kneeling with foot planted flat, pole placed in front of pinky toe, keeping foot flat, bring knee forward and around outside of pole, then back, making sure to keep weight from shifting laterally.
Treatment of TF rotational dysfunction
Taping into IR—Patient standing with tibia in IR and femur in ER, start with tape at fibula head, grasp femur distally to pull into ER and pull tape medially. Pull around back of thigh and finish at lateral thigh.
Treatment of TF rotational dysfunction
Taping into IR
Treatment of TF rotational dysfunction
Tibial IR factilitation—TB resisted tibial IR in seated 90/90 position
Treatment of TF rotational dysfunction
Glute med exercises as IR and abductor

Sidelying with leg in IR

Lift into abduction and extension maintaining hip IR
Treatment of TF rotational dysfunction
External rotators as stabilizers

Clam exercise—starting position

Clam exercise—finish position
Treatment of TF rotational dysfunction

Superclam

Bridging with TB for ER
Treatment of TF rotational dysfunction

- Half-kneeling screen doors
  - Half kneeling on one leg with TB wrapped around outside of leg just above knee. Shift weight forward while keeping foot flat and then rotate leg outwards against band. Come back to neutral, avoiding femoral IR. This shows set-up position.
Treatment of TF rotational dysfunction

Half-kneeling screen doors
Starting position

Half-kneeling screen doors
Finishing position
Treatment of TF rotational dysfunction

- TB resisted HS curls with IR
  - Sitting on a chair or physioball with band around heel and another wrapped around both legs just below knees, flex knee while maintaining IR of tibia and outward pressure against band at knees. Maintain good erect posture and avoid shifting weight laterally. This shows set-up position.
Treatment of TF rotational dysfunction

TB resisted HS curls with IR
Starting position

TB resisted HS curls with IR
Finishing position
Treatment of TF rotational dysfunction

Plank hip extensions
Starting positions

Plank hip extensions
Finishing position
Treatment of TF rotational dysfunction

Plank hip extensions with knee flexion
Starting position

Plank hip extensions with knee flexion
Finishing position
Treatment of TF rotational dysfunction

Squats with TB at knees and bolster at feet

Starting position

Finishing position
Treatment of TF rotational dysfunction

Lunges with TB resisted femoral IR
Starting position

Lunges with TB resisted femoral IR
Finishing position
Treatment of TF rotational dysfunction
Tibial IR facilitation for poor horizontal abduction control with loading
Treatment of TF rotational dysfunction

Leg press with TB resistance
Starting position
(note foot position)

Leg press with TB resistance
Finishing position
(note foot position)
Treatment of TF rotational dysfunction

Leg press with TB resistance
Starting position
(note changed foot position)

Leg press with TB resistance
Finishing position
(note changed foot position)
Treatment of TF rotational dysfunction

Supine HS bridge on physio with knee flex→ext (note ER foot position)
Starting position

Supine HS bridge on physio with knee flex→ext (note ER foot position)
Finishing position
Treatment of TF rotational dysfunction

• It is important that careful instruction and monitoring of all exercises occurs to ensure optimal benefit and avoidance of desired compensatory patterns.
• Note changed starting position of feet with knees and heels separated but forefeet turned in towards each other. This IR is maintained throughout the exercise of extending hip and then going from flexion into extension and back.
Treatment of TF rotational dysfunction
Treatment of TF rotational dysfunction

TB resisted step-ups
Starting position

TB resisted step-ups
Finish position
Treatment of TF rotational dysfunction

CKC glute wall exercise--Starting position
Maintain ER of femur into wall with squat

CKC glute wall exercise--Finish position
Maintain ER of femur into wall with squat
Treatment of TF rotational dysfunction

Monster walks—maintain semi-squat position; do forward and back

Monster walks—keep both legs from going into femoral IR when stepping
Treatment of TF rotational dysfunction

Trendelenburg jumps
Starting position

Trendelenburg jumps
Finish position
Conclusion

• All knee conditions, acute or chronic, should be screened for TF rotational dysfunction.
• It is important to get your hands on the patient and start feeling for soft tissue thickening, joint mobility restrictions, and try to manually normalize dysfunction.
• It is imperative that other factors which may be contributing to the pathology are identified and a treatment plan to address these is implemented. This includes educating the patient on sitting, standing, walking and positional postures during the day. Make their day more symmetrical.
• The development of a therapeutic exercise program which includes self mobilization techniques, careful instruction of an HEP and review of mechanics is essential.
References

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Thank you...