Treating the Arthritic Knee: Current Concepts in Rehabilitation of PFP and OA

- *Brian Schiff, PT, OCS, CSCS*

Background

Supervisor - EXOS @ Raleigh Orthopaedic

Practiced since 1996 in outpatient sports/ortho clinics

S & C coach for MLS - Columbus Crew 2002-2006

Owned my own training facility 2000-2010

FMS certified, board certified orthopaedic clinical specialist (OCS), credentialed in dry needling

Write for PFP Magazine

PT consultant for Carolina Hurricanes

EXOS™
@ Raleigh Orthopaedic

www.apcraleigh.com

Objectives

- Summarize current research related to patellofemoral pain, OA and exercise
- Screen and assess clients to determine asymmetry and compensatory movement patterns
- Design effective rehabilitation programs to maximize function for nonoperative patients of various ages/abilities affected by PFP and OA
- Learn a comprehensive approach to treatment including dry needling, soft tissue mobilization, progressive exercises and return to play criteria based on threshold training principles

Today's Active Population

Know Your Clients

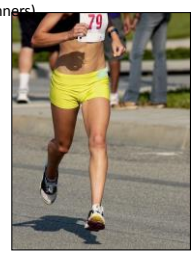
- Be aware of exercise trends, training parameters, physical demands required
- Educate them about their injury and clearly explain how rehab and training plans will intersect
- Do NOT overlook psychological aspect of injury and time off
- Realistic optimism is key

Presentation

- PFJ
- Tibiofemoral OA
- Traumatic arthritis
- RA
- Psoriatic arthritis

CMP

- Common in active population (runners)
- Female > male
- Malalignment
- Must consider CKC mechanics
- Grade I-IV



Tibiofemoral OA

- Affects 33 million Americans
- Gradual wear and tear
- Activity related
- Obesity
- Alignment predilection

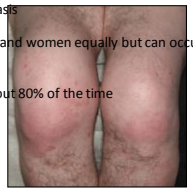
Traumatic arthritis

- Sudden blunt force trauma causes marked chondral defect or injury
- Dashboard injuries
- Accidents

- Autoimmune
- Often symmetrical
- Roughly 1.3 million Americans impacted
- Onset often b/w ages 25-50
- Severe pain, fatigue, loss of appetite, & stiffness

Psoriatic Arthritis

- Chronic inflammation of skin and joints
- Affects about 10% of those with psoriasis
- Usually strikes b/w ages 30-50 in men and women equally but can occur in childhood
- Skin disorder precedes joint issues about 80% of the time



Physical Findings

- Muscle inhibition
- Pain with loading
- Limited dorsiflexion
- Poor frontal plane mechanics w/squat

Basic Loading Principles

- By 90 deg of flexion all portions of patella except odd facet have some contact
- At 135 deg all lateral and odd facet
- Medial facet changes more common but lateral facet changes more commonly progress to OA
- PFJRF increase to 3.3 x BW at 60 deg with activity such as stair climbing or running uphill
- PFJRF climb even higher in deeper flexion angles
- Contact areas may determine pain with activity

Bracing

- The use of the hip external rotation strap resulted in angular changes at the hip and pelvis which may be beneficial for patients with medial knee osteoarthritis.

Wallace & Barr Arthritis 2012

- Study with TF OA patients when evaluated at 2.7 years, 41% of the 30 patients were still using the brace, 35% had discontinued brace use, and 24% had undergone arthroplasty. Contacted at an average of 11.2 years, 17 (58.6%) of the 29 patients had undergone arthroplasty. None were still wearing the brace
- The use of an unloader brace is effective in providing short-term pain relief and improved function; however, most patients subsequently opt for TKA on the symptomatic knee.

Wilson et al Orthopedics 2011

PFJ Bracing

- Study on effect of a patellar brace on 3D patellar kinematics (flexion, spin and tilt; proximal, lateral and anterior translation) at sequential, static knee postures using a validated magnetic resonance imaging (MRI)-based method
- 19 patients with radiographic lateral patellofemoral OA.
- Bracing changed patellar kinematics, but these changes did not appear large enough to be clinically meaningful because no reduction in pain was observed in the parent study.

McWalter et al Osteoarthritis Cartilage 2011

PFJ Bracing

- On-Track and PTO assessed -> large changes in pain and contact area occurred without sizable changes in patellar alignment
- Results suggest that changes in patellar alignment by itself may not be responsible for pain alleviation after patellar bracing

Powers et al Med Sci Sports Exerc 2004

Bracing/Taping Review

- 5 trials involved 362 participants who were assessed for pain, functional improvement, isokinetic muscular strength, motivation, subjective success, worst pain, usual pain, subjective clinical pain, and PF congruence angle
- The Protonics orthosis significantly decreased pain and improved function based on the Kujala score versus no treatment.
- HEP with McConnell taping and biofeedback decreased pain and improved function based on the Functional Index Questionnaire versus home exercise and monitored therapy
- Protonics orthosis vs. no RX resulted in a PF congruence angle change
- McConnell taping versus Couman bandage improved satisfaction with applied therapy and isok muscle strength at 300 deg/s of knee flexion

Jessee et al J. Athl Train 2012

Bracing/Taping Review

- Strength of retrieved research-based evidence of effectiveness of orthotic devices in the treatment of PFPS was graded C
- A comprehensive exercise and stretching program with tape application was more effective in decreasing worst pain and usual pain and increasing functional improvement
- This finding indicates that PFPS is best treated by using more than 1 intervention

Jessee et al J. Athl Train 2012

My Takeaways

- Research inconsistent on taping and bracing
- It appears changing the mvmt of the femur is more important than altering the patella
- Need more studies
- Do not be confined to one Rx approach and use things diagnostically

Current PFPS Research

- Intrinsic risk factors include:
  1. ↓'d quadriceps flexibility
  2. ↓'d quadriceps explosive power
  3. Altered muscle patterning b/w VL & VMO
  4. Hypermobility of the patella
- No apparent link to hip weakness
- Hip strength was not a predictor of frontal plane knee motion

Davis and Powers JOSPT 2010

More PFPS Research

- Altered patellofemoral joint kinematics in females with PFP appears to be related to excessive medial femoral rotation, as opposed to lateral patella rotation. Our results suggest that the control of femur rotation may be important in restoring normal patellofemoral joint kinematics.

Souza et al JOSPT 2010

Core and SL Squat

- Participants (n = 14) performed a single leg squat from a 6 inch step under 2 conditions: core intentionally engaged (CORE) and no intentional core engagement (NOCORE)
- Intentional core activation influenced hip and knee kinematics during single leg squats with greater positive effect noted in the LOWCORE group.
- Findings may have implications for preventing and rehabilitating knee injuries among women.

Shirey et al Int J Sports Phys Ther 2012

ITB Research

- 35 female runners w/history of ITB issues
- ITBS group exhibited significantly greater peak rearfoot invertor moment, peak knee internal rotation angle, and peak hip adduction angle compared to controls.
- Prior ITB issues may increase risk for recurrence due to increased strain and indicate atypical hip and knee kinematics may be present
- The rear-foot position may have a lesser role in causation of ITBS
- Addressing hip stability, strength and eccentric control is paramount to injury prevention
- Observing frontal/transverse plane knee mechanics is prudent

Ferber et al JOSPT 2010

Hip Research

- 18 subjects w/PFPS (overuse) matched w/18 controls
- Hip ER & ABD strength assessed as well as kinematic with stair descension
- Significantly lower hip external rotator strength (P = .002) and hip abductor strength (P = .006) for subjects with PFPS
- On average, these subjects generated 24% less hip external rotator torque and 26% less hip abductor torque compared to controls
- All subjects maintained a varus knee position

Bolga et al JOSPT 2008

Hip Research

- Females with PFP exhibit ↑'d hip IR & gluteus max. activation
- Females with PFP have↓'d hip ext. strength
- Also demonstrate an ipsilateral trunk lean to control ABD weakness

Souza & Powers JOSPT 2009

Muscle Activation

- Healthy subjects, the lateral step-up and the lunge exercises produced EMG levels greater than 45% maximum voluntary isometric contraction (MVIC) in the VMO, which suggests that they may be beneficial for strengthening that muscle.
- The side-bridge exercise could be used for strengthening the gluteus medius and the external oblique abdominis muscles
- Quadruped arm/lower extremity lift exercise may help strengthen the gluteus maximus muscle

Ekstrom et al JOSPT 2007

Study at Belmont University looked at 18 different exercises using surface EMG to study activation of the gluteus maximus and medius. The top 5 exercises stimulating > than 70% MVIC for each muscle group:

- Gluteus Medius

1. Side plank abduction with dominant leg on bottom (103% MVIC)
2. Side plank abduction with dominant leg on top (89% MVIC)
3. Single leg squat (83% MVIC)
4. Clamshell 4 (hip clam - 77% MVIC)
5. Front plank with hip extension (75% MVIC)

Boren et al Int J Sports Phys Ther 2011

Belmont Study Cont'd

- Gluteus Maximus

1. Front plank with hip extension (106% MVIC)
2. Gluteal squeeze (81% MVIC)
3. Side plank abduction with dominant leg on top (73% MVIC)
4. Side plank abduction with dominant leg on bottom (71% MVIC)
5. Single leg squat (71% MVIC)

Boren et al Int J Sports Phys Ther 2011

Images from Boren et al. Int J Sports Phys Ther 2011

Images from Boren et al. Int J Sports Phys Ther 2011

Squatting

- Depth adjusted based on pain and mechanics
- ROM restrictions in hip and/or ankle may necessitate restriction
- Front vs. Back squats
- Alternate loading (DB, KB, sandbags, etc)

Squatting

- Escamilla et al. looked at foot position and impact on knee w/squatting
- Reported statistically significant 15% and 16% increases in patellofemoral and tibiofemoral compressive forces, respectively, in subjects who squatted with a wide stance as compared with a narrow stance

Escamilla et al Med Sci Sports Exerc 2001

Squatting

- Narrow stance results in 4-6 cm of anterior translation compared to mod or wide
- Wide stance may be better to minimize shear force and narrow stance better for reducing compression
- Compressive force more on descent at higher flexion angles and ascent in lower flexion angles

Escamilla et al Med Sci Sports Exerc 2001

Upward Squatting

- Upward squatting task (no load) at 60 degrees
- By keeping the knee flexed at 40° at the IP instead of 60° the subjects from group PFPS avoided larger patellofemoral compressive reaction force
- Authors conclude that individuals with PFPS used a protective biomechanical mechanism by avoiding large knee flexion (greater than 40°) during the beginning of the upward squat - major strategy of the CNS to deal with PFPS is this biomechanical response and not a neurophysiologic change (i.e., pattern of muscle activations)

Dionisio et al J Strength Cond Res 2011

Lunges

- Between 70° and 90° of knee flexion PFJF and stress was significantly greater when performing a forward lunge with a short step compared to a long step
- Between 10° and 40° of knee flexion PFJF and stress were significantly greater when performing a forward lunge with a stride compared to without a stride
- Choosing a long step and no stride is less stressful on the P-F joint b/w 0-90 degrees (> stress @ deeper angles w/short step and w/stride at lower angles)

Escamilla et al JOSPT 2008

Lunges

- The greater PFJF and stress with a stride, as compared to without a stride, between 10° to 20° during the descent and 10° to 40° during the ascent, occurred in part because the estimated quadriceps forces were approximately 40% greater with a stride during these knee angles and PFJF is proportional to quadriceps force

Escamilla et al JOSPT 2008

Step-Down & Step-Up

- 20 healthy subjects (10 male, 10 female)
- Perform FSU, LSU and FSD same step height
- FSU and LSU produce much less PFJRF
- More PFJS in eccentric phases
- Caution w/use of FSD with PFP

Chatchda et al JOSPT 2011

Knee Extensions

- More shear force in terminal range
- Possible lateral compressive force if abnormal mechanics
- Higher risk than reward given probability of VL and VMO imbalance
- Limit range to 90-40 for isolated work

PFJ Stress

- Threshold for pain w/stairs = 4.0 MPa
- Squatting - greatest force = 12.3 MPa @ 90
- Knee ext - greatest force = 8.4 MPa @ 0
- Recommendations for safe PRE's are:
  1. Squat 0-45 degrees
  2. Knee ext 90-45 degrees

Powers et al JOSPT 2014

Preferential Gluteal Activation

- Clams
- Sidestepping
- Unilateral bridge
- Quadruped hip extension (knee straight)
- Quadruped hip extension (knee bent)

Selkowitz et al JOSPT 2013

TABLE 1 NORMALIZED ELECTROMYOGRAPHIC AMPLITUDE OF EACH MUSCLE FOR EACH EXERCISE*

Exercise	Tensor Fascia Lata	Gluteus Medius	Superior Gluteus Maximus
Sidelying hip abduction	32.3 ± 13.1	43.5 ± 14.7 (P = .012)†	23.7 ± 15.3 (P = .033)†
Bilateral bridge	8.2 ± 7.4	15.0 ± 10.5 (P = .001)†	17.4 ± 11.9 (P = .005)†
Clam	11.4 ± 11.4	26.7 ± 18.0 (P = .006)†	43.6 ± 26.1 (P<.001)†
Hip hike	31.4 ± 14.4	37.7 ± 16.1 (P = .196)	17.7 ± 15.2 (P = .001)‡
Lunge	21.6 ± 14.5	19.3 ± 12.9 (P = .622)	20.1 ± 11.1 (P = .728)
Quadruped hip extension, knee extending	15.6 ± 9.3	27.3 ± 14.9 (P<.002)†	28.5 ± 16.6 (P<.007)†
Quadruped hip extension, knee flexed	18.7 ± 10.6	30.9 ± 15.2 (P = .001)†	30.1 ± 12.5 (P = .012)†
Sidestep	13.1 ± 7.1	30.2 ± 15.7 (P = .002)†	27.4 ± 16.7 (P = .002)†
Squat	4.6 ± 3.8	9.7 ± 7.3 (P = .027)†	12.9 ± 7.9 (P<.001)†
Step-up	21.4 ± 11.4	29.5 ± 14.9 (P = .055)	22.8 ± 15.6 (P = .754)
Unilateral bridge	18.1 ± 12.9	30.9 ± 20.7 (P = .007)†	34.6 ± 16.8 (P = .001)†

*Values are mean ± SD percent maximum voluntary isometric contraction.
†Significantly greater than tensor fascia lata (P<.05).
‡Significantly less than tensor fascia lata (P<.05).

Image from JOSPT 2013

TABLE 2 Gluteal-to-TFL Index for Each Exercise

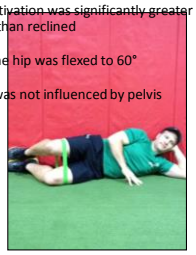
Exercise	Gluteal-to-TFL Activation Index
Clam*	115
Sidestep*	64
Unilateral bridge*	59
Quadruped hip extension, knee extending*	50
Quadruped hip extension, knee flexed*	50
Sidelying hip abduction	38
Step-up	32
Bilateral bridge*	32
Squat*	28
Hip hike	28
Lunge	18

Abbreviation: TFL, tensor fascia lata.
**Exercises in which both gluteal muscles demonstrated significantly higher normalized electromyographic signal amplitude than the TFL.*

Image from JOSPT 2013

Clam Research

- The magnitude of GMax and GMed activation was significantly greater when the pelvis was in neutral rather than reclined
- GMed activation was greatest when the hip was flexed to 60°
- Activation of the tensor fasciae latae was not influenced by pelvis position or hip angle



Wilcox & Burden JOSPT 2013

PT Eval & Assessment

- Traditional orthopedic assessment
- DL and SL squat
- FMS *
- Lower Quarter YBT *
- Taping response (if indicated)

* Optional or done on visit 1 or 2

FMS

Lower Quarter YBT Video

Reduce Loading

- Alter G treadmill
- Aquatic therapy
- Cross training
- Galloway running approach

Mainstays of Rx

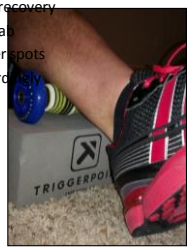
- Medial patella glides in PFP clients with lateral compression/tilting
- Soft tissue mobilization
- Dynamic warm-up
- Ankle mobility
- Hip and core training
- SL exercises

Non-operative Treatment Approach

- Rx always based on pain & swelling
- Phases designed to progressively and safely load the joint
- Goal is return to premorbid function
- Wolff's Law
- Heat/ice as needed

Self MFR

- Use prior to exercise and after for recovery
- Target ares of greatest need in rehab
- Lacrosse or TP ball great for smaller spots
- Teach how to grade pressure accordingly



Foam Rolling Video

Dry Needling

- Effective way to eliminate TrP's
- Reduce tension
- Increase blood flow and decrease muscle acidity
- Decrease pain

IASTM

- Great adjunct to Rx
- Follows dry needling
- Effective for ITBS
- Less fatigue for PT

Warm-up & Mobility

- Hip lift march
- SL march
- Buttkickers
- SL RDL
- Supported hip swings

Warm-up Video

ROM Exercises

- Gravity assisted knee bend (1-2 sets of 15)
- Active heel slides (1-2 sets of 15)
- Prone knee curls (1-2 sets of 15)
- Heel Prop (5-10 minutes 1-2 times per day)
- Ankle mobility (wall mobilization)

Phase I - Inflammation Reduction

- Maximum joint protection 3-21 days
  - Quad sets
  - Straight leg raise x all 4 directions
  - Wall sits
  - Calf raises

Phase I Summary

- No pain during exercises
- Minimal to no soreness after the exercise
- Begin with 1 set of 10 and advance the sets and reps as able
- Progress to phase II once you have completed all of phase I with no increased pain or swelling
- May perform the exercises daily as tolerated

Phase II – Early Strengthening

- Mod joint protection for 4-6 weeks
  - Clamshells/standing ER
  - Partial range squats
  - Static single leg stork stand
  - Standing hip abduction raises
  - Single leg press
  - Posterior -> lateral box step downs
  - Hamstring bridge (double progressing to sin

Phase II Summary

- Use upper body assistance to reduce load on the affected knee (s)
- Gradually reduce assistance based on the body's pain response
- Avoid painful range of motion (pain > 4/10)
- Allow a minimum of 48 hours between workouts
- Perform 1-3 sets of 10-15 repetitions

Phase III - Hypertrophy

- Min joint protection for 4-6 week

  Progressive bilateral squats with stability ball

  Modified FW weight shift lunge

  Forward lunge onto box

  Forward lunge

  P, A, L reaches

  Single leg bodyweight squat

  Stability ball hamstring straight leg bridge, stability ball hamstring bridge with leg curl and bent knee stability ball hamstring bridges

Strengthening Video

Bridging Video

Phase III Summary

- Remember - knee behind toes with squatting and lunging
- To increase difficulty, add more weight or increase time under tension at the bottom of the squats, lunges and reaches
- Only advance to unassisted single leg exercises when you can maintain proper form
- Pain during exercise should be no > 4/10 and allow 48 hours between workouts
- To build strength, focus on doing 2-3 sets of 8-12 repetitions

Phase IV - Impact Conditioning

- Criteria to enter this phase
  1. Single leg squat = 90% of uninvolved LE
  2. No swelling
  3. No marked pain with the previous phase progressions

Phase IV

- Initiate anterior step downs if indicated (assisted and unassisted)
- Add rotational strengthening (multi-planar lunges) such as fwd diagonal lunges, side to side lunges and bkwd diagonal lunges
- Begin light jogging (goal is to complete 5 minutes without increased pain or swelling prior to initiating hopping drills)
- If above met, next begin low level plyometrics and monitor # of foot contacts closely

Phase IV

- *Plyos*
  1. FW/BW & side-to-side line hops
  2. Drop squats
  3. Speed skater
  4. Quick split jumps
  5. Rebound jumps

Phase IV

- Agility
  1. Forward jog to backpedal
  2. Rapid step-ups on box
  3. 2 cone shuffle
  4. Lateral repeat step-over
  5. Figure 8 cone run
  6. T Drill

Phase IV Summary

- Utilize these exercises if and only if you plan to participate in higher level activities such as tennis, running, soccer, etc.
- Keep total foot contacts between 60-100 and perform the hopping at the beginning of the workout following the warm-up
- Perform agility drills at 50% initially for 20-30 seconds
- Perform agility/jumping once per week for 4 weeks before adding at most a second day to your training
- Allow at least 72 hours of recovery between jumping and agility sessions
- Continue lunges and single leg strengthening 2-3 times per week

Surgical Intervention

- Debridement
- Meniscus repair and transplant
- Microfracture
- ACI
- OATS
- TKA

Rehab After Meniscus Repair/Transplant

- Limit flexion in CKC to 60 for post horn repair
- Avoid hyperext in ant horn repairs and until 9-12 weeks in transplants
- Isolated HS resisted curls limited in complex MMR and MMT due to medial HS insertion along PM capsule
- Running program begins about week 20 for peripheral tears, week 30 for complex repairs, and no <1 year for all transplants
- Most undergoing transplants have marked degenerative changes and not encouraged to return to strenuous impact activity

Noyes et al JOSPT 2012

Return to Play After Articular Cartilage Repair

- Progression impacted by size of lesions, location of defect, concomitant pathology, age, sport demand, BMI meniscal status and surgical technique
- Timing varies b/w 7 and 18 months
- Avg. time to return longest for ACI (18-25 months) and shortest for OATS (6.5-7 months)
- After microfracture athletes returned to sport 8-17 months

Mithoefer et al JOSPT 2012

Rehab After Articular Cartilage Repair

- Phase I - Protection & Joint Activation with TDWB femoral and WBAT patella or trochlea, CPM, patella mobs, emphasis on gluteal/quad retraining, gait
- Phase II - Progressive Joint Loading & Functional Restoration with CKC exercises, dynamic balance, and eventually light plyos
- Phase III - Activity Restoration with sport-specific movement patterns and resolution of any remaining impairments. On field component lasts 90 min 3-5x/week for at least 8 weeks
- All phases have criteria for advancing to next one

Mithoefer et al JOSPT 2012

Surgical Summary

- No easy fix for articular cartilage problems
- Results vary based on biological and biomechanical factors
- Rx should be centered around patient age, history, and desired goals
- Work closely with MD on postoperative guidelines and rehab progression

Return to Activity

- Assess status/completion of graded rehab
- Discuss risk vs reward of proposed activity
- Ideally LQYBT no > 4 cm deficits and FMS of 14 or higher (if applicable)
- Design realistic and progressive practice plan while journaling pain and/or swelling

Understanding Pain

- Assess the baseline pain on a scale of 0-10 and monitor the pain level during the activity noting whether it escalates, decreases or stays the same
- If it reaches a 5/10 at any time, the intensity or volume of the activity must be immediately diminished until the pain level decreases to a 4/10 or less
- Moderate pain (5/10 or more) is a precursor to mechanical failure

24 Hour Recovery Rule

- Aside from monitoring pain during activity, it is essential to record the post-activity pain level
- The post-activity pain level should return to baseline or less in the following 24 hours
- If it does not, this means that the body did NOT absorb the increased stress effectively and safely and needs more time to recover. The intensity and/or volume of the next training session should be reduced until the 24 hour rule is met.

Threshold Training

- With proper threshold training, the client learns how to grade and evaluate the stress on his/her body during each training session, while gaining an understanding of the body's exact threshold. The threshold (activity tolerance level) should elevate or progress with steady training and use of the pain response to guide appropriate increases or decreases in intensity and volume.

Dosage Matters

- "Exercise is a drug. If we give the right drug in the right dose – everything works. But, if we give the wrong drug or even the right drug in the wrong dose, we cause more problems rather than provide solutions."
- - *Alwyn Cosgrove*

Contact Info

- Brian Schiff, PT, OCS, CSCS
- www.BrianSchiff.com
- info@BrianSchiff.com
- Twitter - @brianschiff

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