

Funtional Anatomy and Biomechanics of the Patellofemoral Joint

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INTRODUCTION

Anterior knee pain are most frequently encountered in knee clinics, many physicians use a "recipe"-type of approach to their treatment. But many predisposing factors have been included internal rotation of the femur, valgus knee alignment, external rotation of the extensor mechanism, patellar alta, a flat trochlear groove, patella with poor congruence and ligamentous laxity. Many scientific principles on which these commonly used treatment are based, can lead to refinements and improvements in treatment.

Embryology

patella' s anlage in 20mm embryo at 7.5 wks of gestation

- round cell. aggregation
- cartilage anlage 30mm (Walmsley 1939, Gray, 1950)

FUNCTIONAL ANATOMY

A. Bony Structure

- patella
- trochlea portion of distal femur

1. Patella

- 47 to 58 mm in length, 51 to 57 mm in width, 25mm in variable thickness
- Patella index [$I = \text{width} \times 100 / \text{length}$] : usually > 100 (De Vriese, 1913)

Anterior Surface

convex

rough superior 1/3 : insertion of quadriceps tendon

middle 1/3 : numerous vascular orifices

inferior 1/3 : V-shaped point enveloped patellar tendon

Posterior surface

- inferior portion : 25% of Ht. nonarticulating portion
superior portion : 75 % of Ht. articulating portion
- lateral facet ; larger
medial facet ; small
odd facet ; vertical articulate with MFC in extreme flexion
- articular cartilage; 5mm or more in thickness, but thinner with age.

Base of patellar for quadriceps tendon

Apex of patellar for patellar tendon

2. Trochlear Surface of the femur

1) Lateral trochlear facet

- function as femoral pulley with patella.
- provide a buttress to lat. patellar subluxation during 15 to full flexion.
- flat lateral facet with lat. patellar instability.

2) supra trochlear fossa

- contact with patella under full extension.

3) medial trochlear facet

4) dysplasia

B. Synovium of the patellofemoral joint

1. suprapatellar pouch

2. peripatellar synovium;plica syndrome

3. infrapatellar synovium.

hypertrophy in genu recurvatum, patellar alta.

C. Soft tissue stabilizer

1. Passive stabilizer

inferior : patellar tendon

lateral : superficial oblique retinaculum

deep transverse retinaculum : **epicondylopatellar band -lat patellofemoral ligament (sup. lat. stabilizer)**

deep transverse retinaculum patellotibial band

medial : **medial patellofemoral ligament**

medial meniscopatellar ligament

above : central quadriceps tendon expansion

2. Active stabilizer Fulkerson

4 main muscular element of quadriceps

- rectus femoris
- vastus medialis & VMO
- vastus lateralis & VLO
- vastus intermedius

Blood supply

- medial sup. genicular a.
- medial inf. genicular a.
- lateral sup. genicular a.
- lateral inf. genicular a.
- ant. tibial recurrent a.

Nerve supply

- saphenous n.
- ant. femoral cutaneous n.
- lateral sural n.

PATELLOFEMORAL BIOMECHANICS

Functions of the patella

1. facilitating extension of the knee, by increasing the distance of the extensor apparatus from the axis of flexion and extension, & low friction hyaline cartilage. The patella increases the force of extension as much as 50%.
2. which act as a guide for the quadriceps tendon in centralizing the divergent input for four muscles, decrease the possibility of dislocation of extensor apparatus.
3. protect cartilage of trochlear & condyle.
4. play a role in the aesthetic appearance of the knee. eg. flatten knee in patellectomy.

Dynamics

A. Anatomic adaptation

- Increased density of lat. facet on CT scan, suggest that the high force
- Sagittally perpendicular trabecular orientation provide the joint loading pattern in patella & trochlear

B. Patellofemoral compression force

- summation of the force in quadriceps tendon & patellar tendon
- Increasing flexion angle increase compression force on the patellofemoral joint (eg. 0.5 BW)

in walking, 7.8 BW in squatting)

- The torque generated by quadriceps, is the product of weight, which multiplied by the distance between the center of the upper body and center of the knee joint. (eg. modification of hip flexion in P-F arthritis patients)
- The resultant force is distributed to move large lateral facet than medial facet.

C. Patellofemoral contact are

- Patellofemoral contact begins on the inferior patella at full extension and moves superiorly with increasing knee flexion.
- Total contact area increases with flexion angle, reaching a maximum at about 90 degree

D. Patellofemoral contact pressure

- normal pressure force/unit contact area
- During physiologic flexion, patellofemoral force also increase with flexion angle to a maximum 70-90 flexion and increase contact pressure. But protect with thickness of articular cartilage.
- Because the resultant P-F force and contact area are greater on the lateral facet than the medial facet in the flexion angle, contact pressure in each facet is equal.
- During extension against resistance (quadriceps strengthening exercise), the contact pressure is maximum on 30 degree flexion.

KINEMATICS

Q-angle.

- define an angle between the quadriceps tendon and the patella tendon at full extension
- contribution of Q-angle are internal rotation of hip. terminal E/R of tibia(screw home effect)
- products a valgus force on the patella which resist by medial retinaculum & vastus medialis

Patellofemoral motion

- During 0-20 degree flexion, patella is not yet entrenched in the patellofemoral groove on the femur, maintained by the tension of the quadriceps (tracking problem)
- After 20 degree flexion, patella is maintained by congruity of trochlea.
- During tracking, patella enter the P-F groove laterally by Q angle and move medially by derotate the tibia

Restraint against lat. dislocation by cutting study

- Last 30 degree flexion, med. P-F ligament(MPFL) is primary stabilizer(Hautmaa,1998)
lat. retinaculum has a restraining effect(Desio,1998)
- Beyond 30 degree flexion, stability of patella provided by bony trochlear.

Biomechanics of surgical procedures

wide variety of procedures have been advocated for the treatment of anterior knee pain

1. Elevation of the tibial tuberosity

- Reduced contact pressure in normal knee and had a pressure redistribution superiorly following elevation.

2. Lateral release

- did not consistently unload the lateral facet as empirically

3. Altering the Q-angle

- As decreased Q-angle, over all pressure decreased slightly while medial facet pressure increased slightly and may be useful for lat. facet problem only.

4. Patellectomy

- reduce the quadriceps moment arm and causes loss of knee extension
- may result in instability if the quadriceps mechanism as the stability effect if the patella in the patella groove has been lost
- some author recommended tubercle elevation after patellectomy to restore extension torque

CONCLUSION

- There are many different causes of anterior knee pain and many site of chondromalasic patella.
- No one procedure is a panacea for reducing contact pressure.