Biomechanics of the Knee

Knee: Largest & perhaps most complex joint in body. _____

2 separate joints in knee: 1) femoral jt.
2) femoral jt.

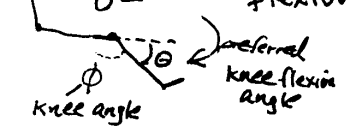
situated between the two longest bones in the body — moment arms for bending moments are large.

Kinematics (study of motion w/o regard to the forces causing motion.)

- 3D motion is allowed at the knee but most occurs in one plane: _____ (flex-ext)
  Also allows movement in _____ plane when (and only when) knee is flexed: (Internal/External rotation)
  Some very limited motion occurs in _____ (abduction/adduction) However, this is not voluntary for the most part. Because of this the knee is regarded only as a _____ joint ("modified hinge joint")

RANGES OF MOTION: (normal ranges)

0– flexion 0– ext rot 0– int rot
at 90° flexion



These values decrease when knee becomes less flexed

Passive abduction/adduction — "few degrees possible" - max when knee is 30° flexed
None possible at

Ranges of motion during walking

Murray et al. (1964) Flex/ext N=60

Bone pins: Levens et al. (1948) Int/ext rot. ROM N=12
"elgon": Kettlekamp et al. (1970) slightly higher values for int/ext than Levens

Both studies indicate: _____ occurs during knee _____ in stance and end of swing phase
before HS
_____ occurs during knee _____ in swing phase

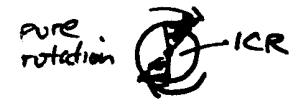
Kettlekamp also measured AB/ADduction ROM~

Other activities — see Tables !

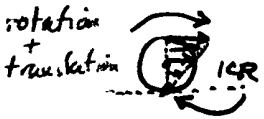
Surface joint motion — what goes on between the surfaces of the femur and the tibia? Does one surface roll of the other during knee motion? or does it slide along the other? or some combination thereof?

Instantaneous center of Rotation (ICR)

Instantaneous Center of Rotation



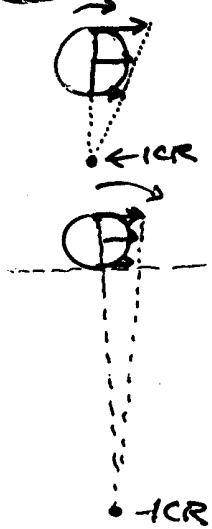
wheel spinning about its own axle



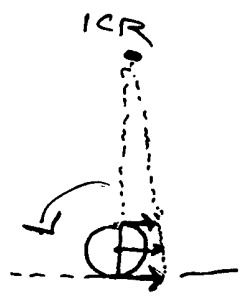
wheel w/o on ground

wheel w/o on ground

ICR is undefined

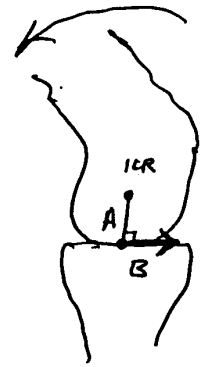


wheel rolling + slipping on ground



see Fig ; for ICR of knee joint

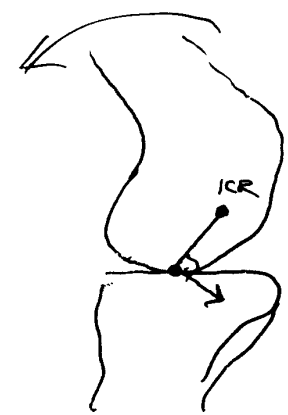
Direction of the contact point displacement (see Fig)



Examine the direction of movement of contact point ($\vec{B}$) relative to the tibia surface

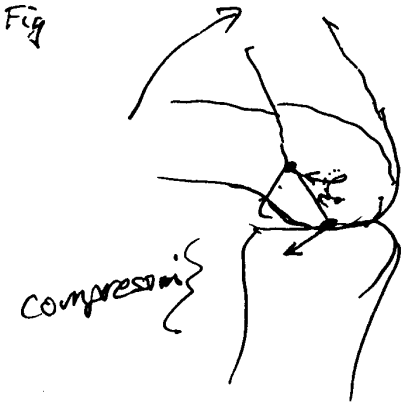
If the direction of $\vec{B}$ is

" " then we say the femur is over the tibia. (Normal)



Abnormal!

Fig

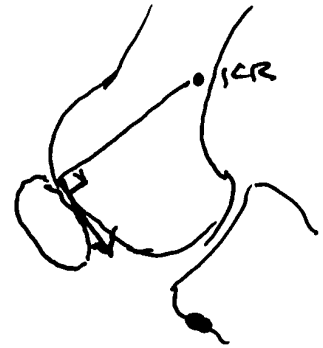


Example of Abnormal ICR pattern in "Bucket-handle" derangement of knee (meniscus tear)

Screw-Home mechanism" (see Fig ,)
- used to determine if the normal screw home mechanism is intact. If not present, then may indicate altered surface joint motion. Damage to the surfaces may result over time.

However: Data from LaFortune PhD. Dissertation Penn State (1984). used bone pins in living subjects during walking. Found of the screw home mechanism during walking. Also found skin moves a lot over the bones.

see Fig



Normal surface joint motion indicates gliding of patella over the femoral surface

As knee moves from full extension to full flexion, the patella glides distally down the femoral condyles

Patellofemoral pain is the most common knee ailment. Improper patella tracking as it moves down & up the grove between the femoral condyles can produce abnormal loading between patella & the femur.

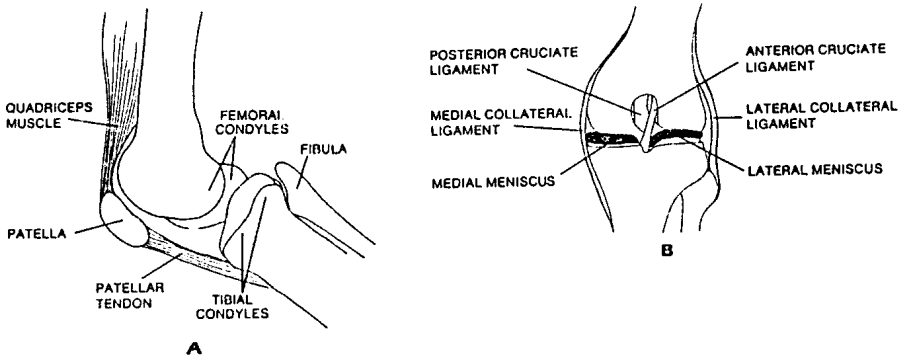


FIG. 6–1
Two-joint structure of the knee. **A.** Lateral view. **B.** Anterior view without patella.

(Note: These are figures and tables from Chapter 6 of old book.)

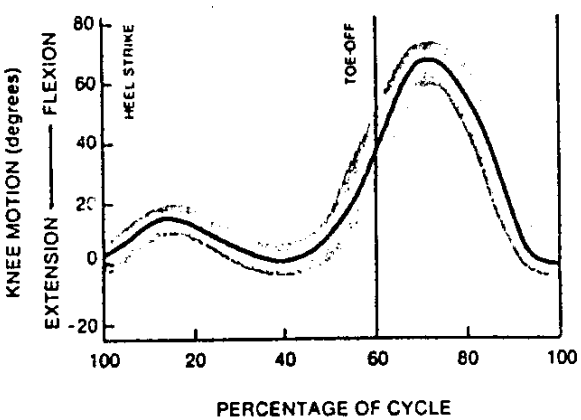


FIG. 6–3
Range of motion of the tibiofemoral joint in the sagittal plane during level walking, one gait cycle. Shaded area indicates variation among 60 subjects (age range 20 to 65 years). (Adapted from Murray et al., 1964.)

TABLE 6–1

RANGE OF TIBIOFEMORAL JOINT MOTION IN THE SAGITTAL PLANE DURING COMMON ACTIVITIES

ACTIVITY	RANGE OF MOTION FROM KNEE EXTENSION TO KNEE FLEXION (DEGREES)
Walking	0– 67*
Climbing stairs	0– 83†
Descending stairs	0– 90
Sitting down	0– 93
Tying a shoe	0–106
Lifting an object	0–117

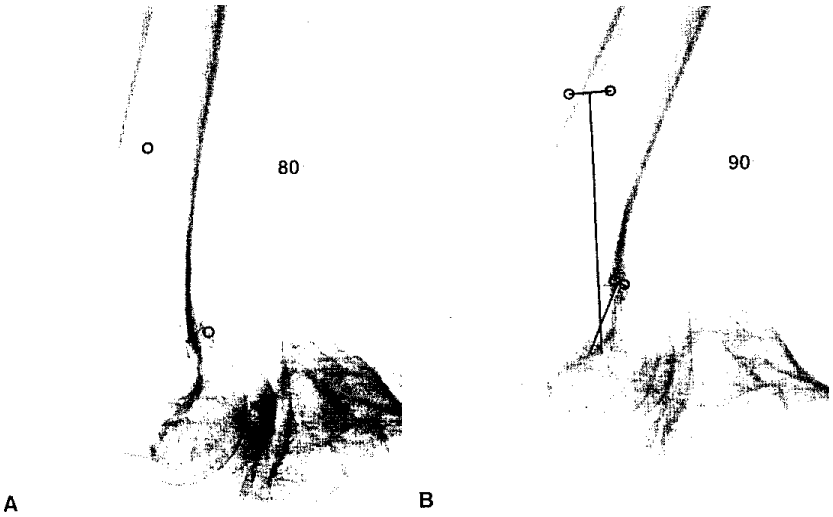
*Data from Kettelkamp et al., 1970. Mean for 22 subjects. A slight difference was found between right and left knees (mean for right knee 68.1 degrees; mean for left knee 66.7 degrees).
†These and subsequent data from Laubenthal et al., 1972. Mean for 30 subjects.

TABLE 6–2

AMOUNT OF KNEE FLEXION DURING STANCE PHASE OF WALKING AND RUNNING

ACTIVITY	RANGE IN AMOUNT OF KNEE FLEXION DURING STANCE PHASE (DEGREES)
Walking	
Slow	0– 6
Free	6–12
Fast	12–18
Running	18–30

(Data from Perry et al., 1977. Range for seven subjects.)



Adapted from Figure 7-4 in new book

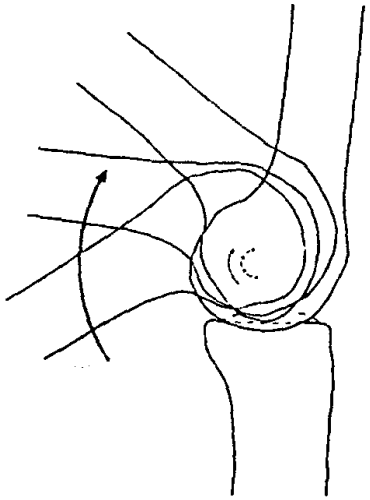


FIG. 6–5
Semicircular instant center pathway for the tibiofemoral joint in a 19-year-old man with a normal knee.

FIG. 6–9
Screw-home mechanism of the tibiofemoral joint. During knee extension the tibia rotates externally. This motion is reversed as the knee is flexed. **A.** Oblique view of the femur and tibia. Shaded area indicates the tibial plateau. **B.** Top view showing the position of the tibial plateau on the femoral condyles in knee flexion (top) and extension (bottom). The solid outlines represent the femoral condyles; the broken lines represent the tibial plateau. (Adapted from Helfet, 1974.)

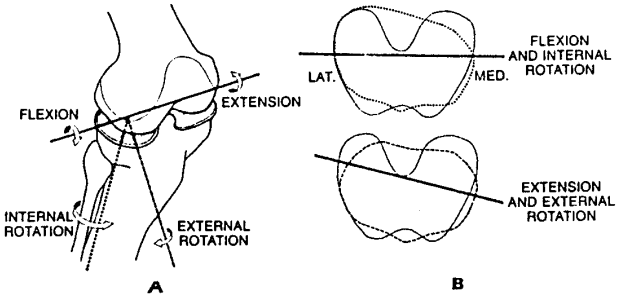
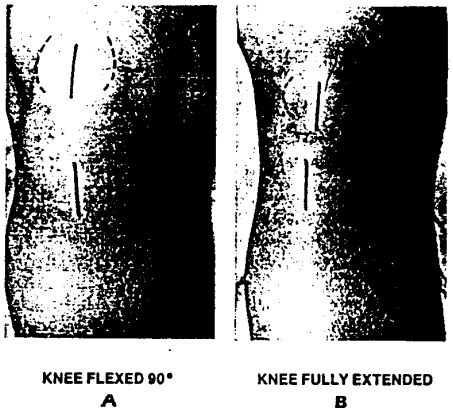


FIG. 6–10
Helfet test. **A.** In a normal knee flexed 90 degrees the tibial tuberosity aligns with the medial half of the patella. **B.** When the knee is fully extended the tibial tuberosity aligns with the lateral half of the patella.



End Knee Part 1 (Anatomy and Kinematics)

Beginning page K11 will be Knee Part 2 (Kinetics)