

KNEE BIOMECHANICS AND CHOOSING THE APPROPRIATE TKR IMPLANT



MURTAZA ADEEB

**FRCS ENG, FRCS ED{ORTH}, DIPLOMA SPORTS
MED, MRCS, MBBS**

**CONSULTANT JOINT REPLACEMENT SURGEON
INAMDAR HOSPITAL
JEHANGIR HOSPITAL**

BIOMECHANICS



- ▶ **SCIENCE OF THE ACTION OF FORCES,
INTERNAL AND EXTERNAL ON THE LIVING
BODY**

- ▶ **KINEMATICS:**
 - ▶ STUDY OF MOTION

- ▶ **KINETICS:**
 - ▶ STUDY OF THE EFFECTS OF FORCE ON THE MOTION
OF BODIES

KNEE BIOMECHANICS



▶ KINEMATICS

- ▶ RANGE OF MOTION
- ▶ JOINT MOTION

▶ KINETICS

- ▶ AXES OF THE LOWER EXTREMITY
- ▶ KNEE STABILIZERS
- ▶ JOINT FORCES

KINEMATICS

RANGE OF MOTION: FLEXION/EXTENSION



- ▶ From 10 degrees of extension to 130 degrees of flexion
- ▶ Functional ROM is from full extension to 90 degrees of flexion
- ▶ 117 degrees flexion required for squatting and lifting
- ▶ 110 degrees flexion required to arise from a chair

KINEMATICS

RANGE OF MOTION: ROTATION



- ▶ ROTATION VARIES WITH FLEXION
- ▶ AT 90 DEGREES, APPROX. 40 DEGREES OF EXTERNAL ROTATION AND 30 DEGREES OF INTERNAL ROTATION POSSIBLE
- ▶ ABDUCTION/ADDUCTION ESSENTIALLY 0 DEGREES

KINEMATICS

JOINT MOTION



- ▶ **KNEE MOTION IS A SERIES OF MOVEMENTS ABOUT A CHANGING INSTANT CENTRE OF ROTATION: POLYCENTRIC ROTATION**

KINEMATICS JOINT MOTION



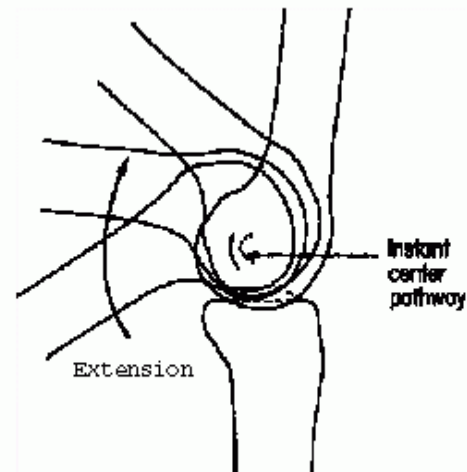
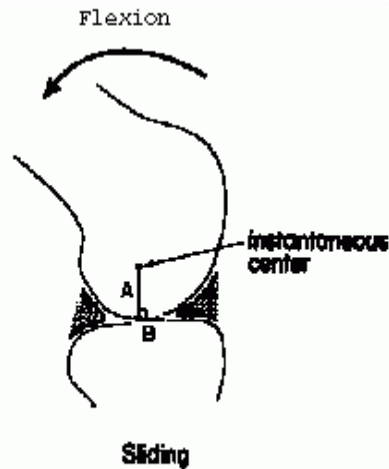
- ▶ INSTANT CENTRE OF ROTATION
- ▶ SCREW HOME MECHANISM
- ▶ POSTERIOR ROLLBACK

KINEMATICS

INSTANT CENTRE OF ROTATION



- ▶ IF PLOTTED THIS APPEARS AS A J SHAPED CURVE ABOUT THE FEMORAL CONDYLE MOVING POSTERIORLY AS THE KNEE FLEXES.



KINEMATICS

SCREW HOME MECHANISM



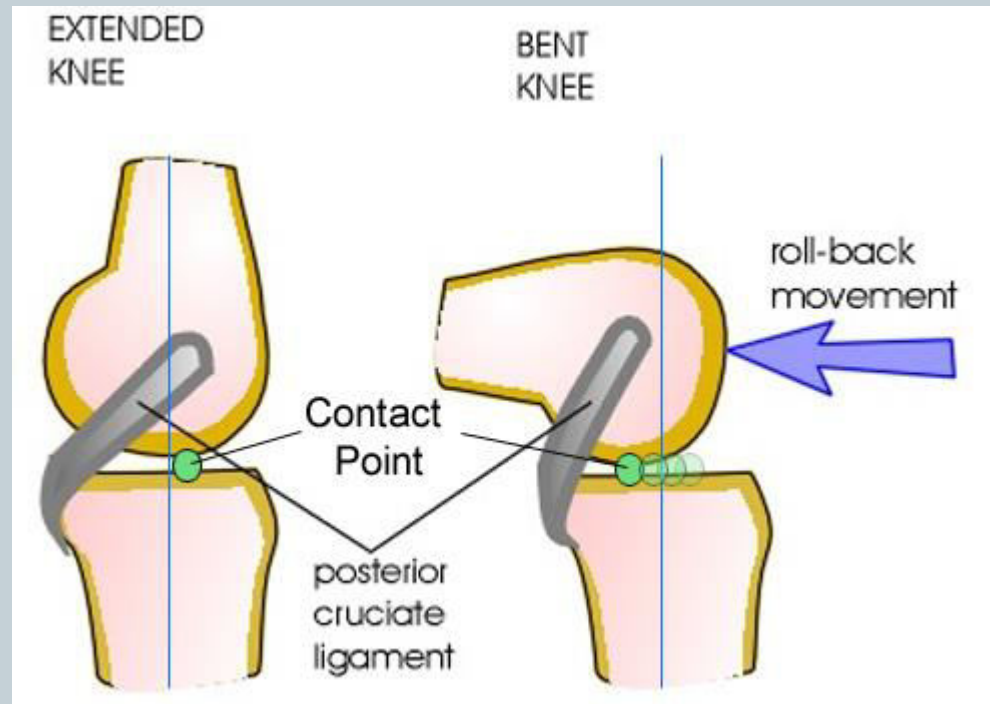
- ▶ **FEMUR INTERNALLY ROTATES AND TIBIA EXTERNALLY ROTATES DURING THE LAST 15 DEGREES OF EXTENSION**
- ▶ **DEPENDENT ON THE CONVEXITY OF THE MEDIAL FEMORAL CONDYLE AND THE MUSCULATURE**

FEMORAL ROLLBACK



- **POSTERIOR SHIFT OF THE FEMORAL TIBIAL CONTACT POINT AS KNEE FLEXES**
- **ALLOWS FEMUR TO CLEAR TIBIA TO PROVIDE FURTHER FLEXION**

FEMORAL ROLLBACK



KINETICS

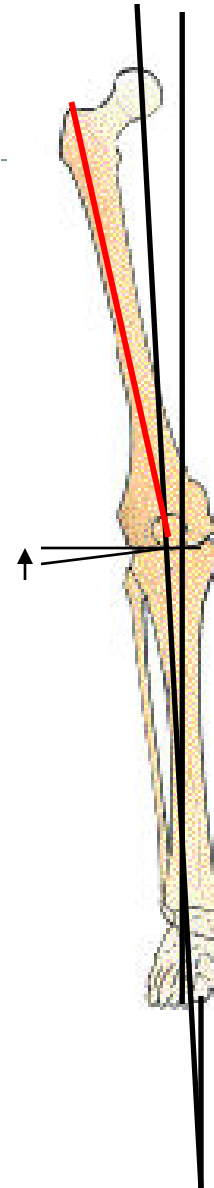


- AXES OF THE LOWER EXTREMITY
- KNEE STABILIZERS
- JOINT FORCES

KINETICS AXES OF THE LOWER EXTREMITY



- ▶ **ANATOMICAL AXIS**
ALONG THE SHAFTS OF THE
FEMUR AND THE TIBIA.
NORMAL VALGUS ANGLE AT
THE INTERSECTION
- ▶ **MECHANICAL AXIS**
FROM THE CENTRE OF THE
FEMORAL HEAD TO THE
CENTRE OF THE ANKLE



KINETICS KNEE STABILIZERS



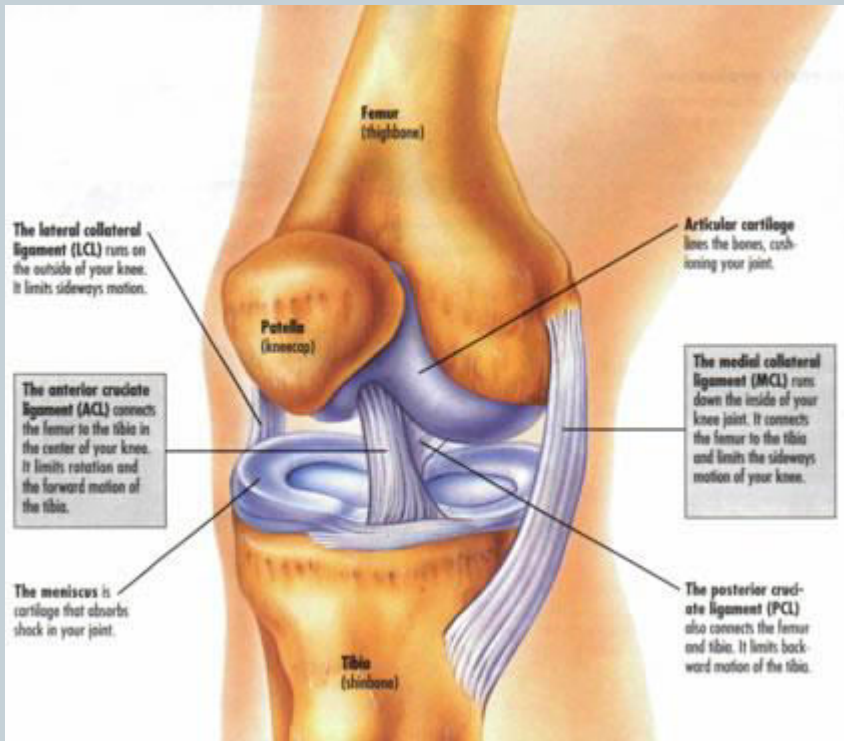
- **MUSCLES AND LIGAMENTS**
- **EXTENSOR MECHANISM**
- **CRUCIATE LIGAMENTS**

MEDIAL COLLATERAL LIGAMENT



- **DEEP AND SUPERFICIAL**
- **DEEP**
 - ORIGIN MEDIAL EPICONDYLE
 - INSERTION MEDIAL MENISCUS
- **SUPERFICIAL**
 - ORIGIN MEDIAL EPICONDYLE
 - INSERTION MEDIAL CONDYLE OF TIBIA
- **RESISTS VALGUS FORCE**

MCL ANATOMY

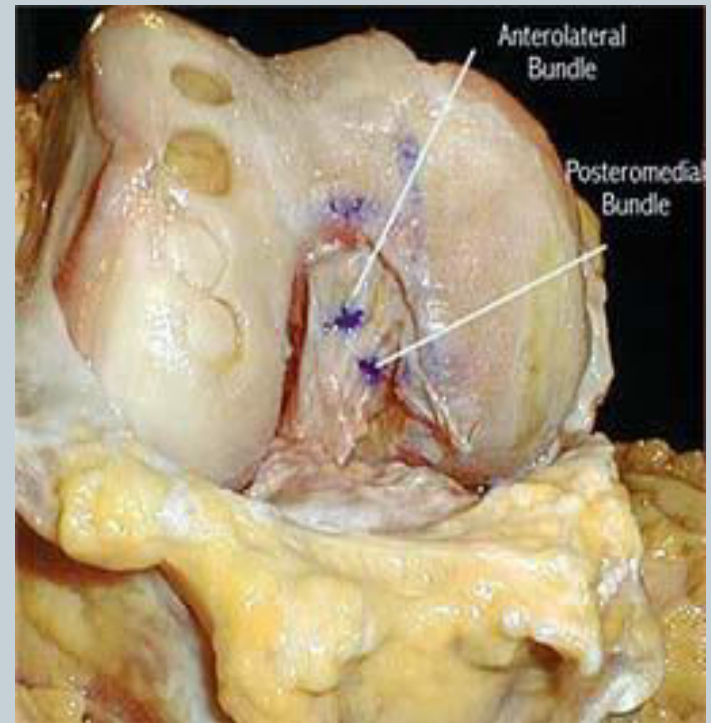
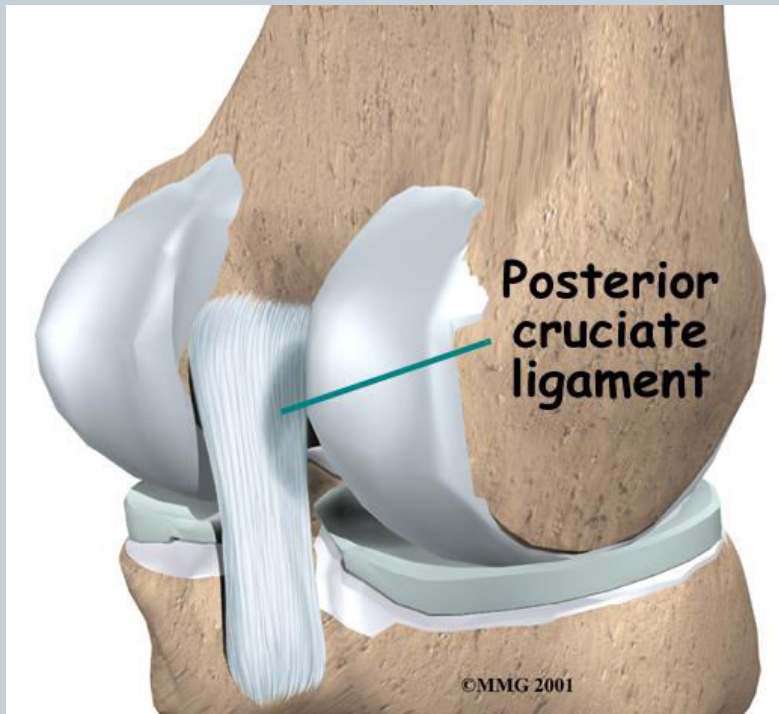


POSTERIOR CRUCIATE LIGAMENT



- **ORIGIN FROM POSTERIOR TIBIAL SULCUS**
- **INSERTION POSTEROLATERAL SURFACE OF MEDIAL FEMORAL CONDYLE**
- **PREVENTS HYPER FLEXION OF KNEE**
- **CRUCIAL FOR ROLLBACK**

PCL ANATOMY

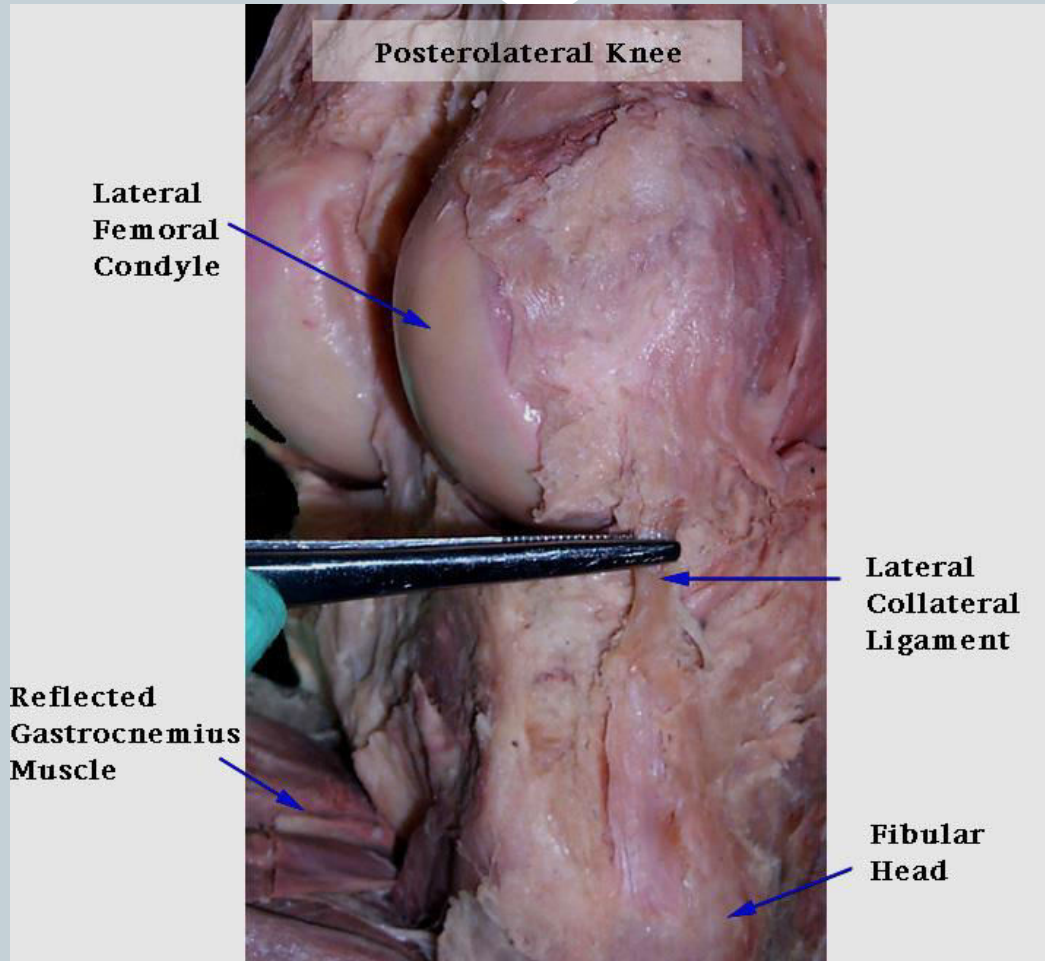


LATERAL COLLATERAL LIGAMENT



- **ORIGIN FROM LATERAL EPICONDYLE**
- **INSERTED ON LATERAL ASPECT OF FIBULAR HEAD**
- **RESISTS VARUS FORCE**

LCL ANATOMY



KINETICS

THE EXTENSOR MECHANISM

- MADE UP BY THE **QUADRICEPS** AND THE **PATELLA**
- THE PATELLA **INCREASES** THE MECHANICAL **EFFICIENCY** OF THE QUADS AND **GUIDES** THE **PULL** OF THE QUADS
- IN THE ABSENCE OF A PATELLA, THE EFFICIENCY OF THE QUADS IS DRAMATICALLY REDUCED

KINETICS JOINT FORCES



- **TIBIOFEMORAL JOINT**
- **PATELLOFEMORAL JOINT**

TIBIOFEMORAL JOINT



- ▶ **JOINT SURFACE LOADS ARE EQUIVALENT TO 3 TIMES BODY WEIGHT ON LEVEL WALKING AND UPTO 4 TIMES ON STAIRS**
- ▶ **MENISCI HELP WITH LOAD TRANSMISSION**

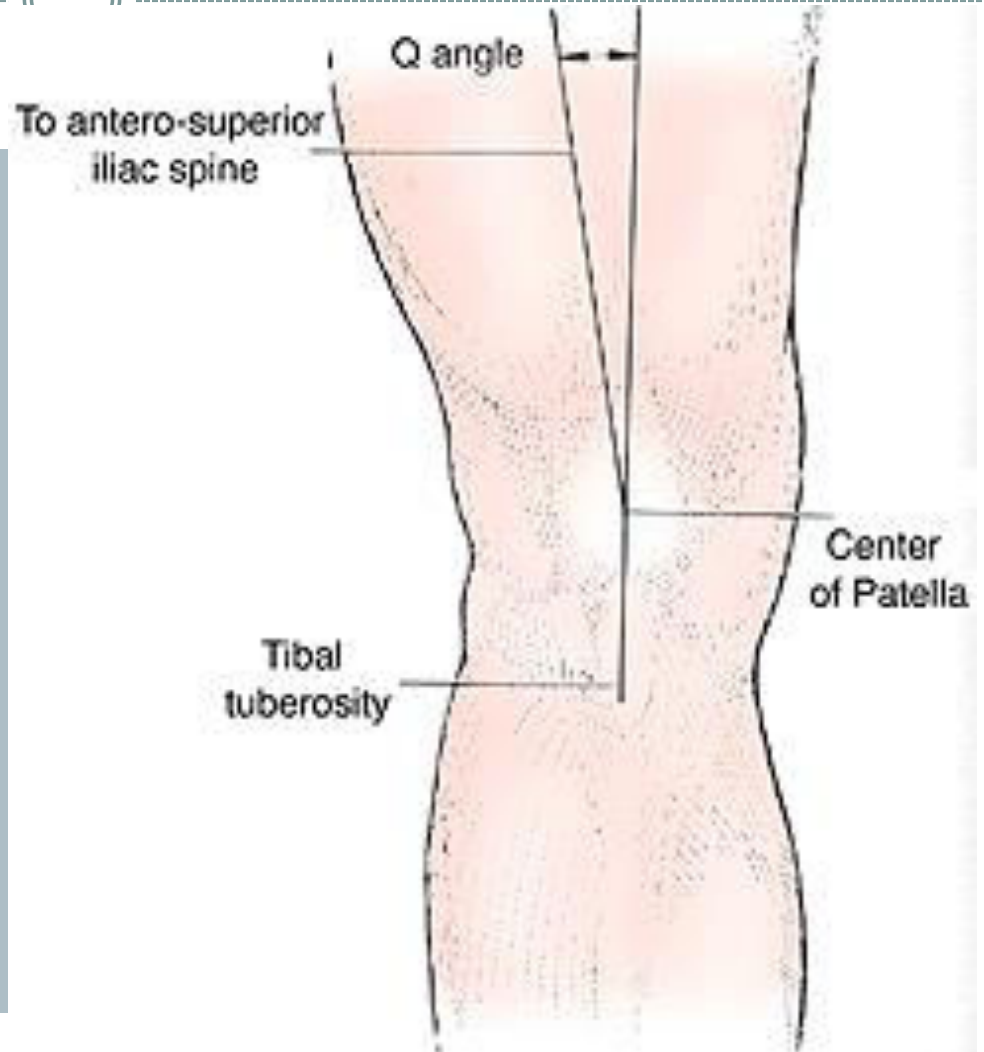
PATELLOFEMORAL JOINT



- ▶ VITAL TO THE FUNCTION OF THE KNEE
- ▶ SUSTAINS HIGH LOADS, THICKEST CARTILAGE IN THE BODY
- ▶ DURING TKR, FOLLOWING MEASURES IMPROVE TRACKING
 - ▶ EXT ROT OF FEMORAL COMP
 - ▶ LATERAL PLACEMENT OF FEM AND TIB COMP
 - ▶ MEDIAL PLACEMENT OF PAT COMP
 - ▶ AVOID INT ROT OF TIB COMP

THE 'Q' ANGLE

- ▶ THE 'Q' ANGLE IS NORMALLY 15°
- ▶ ANY INCREASE IN THE 'Q' ANGLE WILL PREDISPOSE PATELLA INSTABILITY



TYPES OF KNEE REPLACEMENT PROSTHESIS



- **3 BROAD TYPES**
 - UNCONSTRAINED
 - ✦ CRUCIATE SACRIFICING
 - ✦ CRUCIATE RETAINING
 - SEMICONSTRAINED
 - FULLY CONSTRAINED

CRUCIATE RETAINING



- MOST OF THE CASES IDEALLY
- CONTRAINDICATED IN PATIENTS WITH INFLAMMATORY ARTHRITIS, VALGUS KNEES AND SEVERE FFD AND SEVERE VARUS
- FEMORAL ROLLBACK APPARENTLY PRESERVED {ROLLBACK NEEDS BOTH ACL AND PCL}
- BOX CUT NOT DONE
- CLINICAL EVIDENCE IN FAVOUR
 - JBJS 2011 INCREASED LONGTERM SURVIVAL OF POST CRUCIATE RETAINING VERSUS POST CRUCIATE STAB TKRS.
[B MORREY ET ALL]

CRUCIATE RETAINING



- **ADVANTAGES**

- MAINTAINENCE OF LIGAMENT'S PROPRIOCEPTIVE AND LOAD TRANSFER ABILITIES
- ALLOWS STRESS SHARING
- AP STABILITY

- **DISADVANTAGES**

- DIFFICULT TO ADEQUATELY EXPOSE TIBIA
- LIGAMENT BALANCING DIFFICULT
- INCREASED POLY WEAR?

CRUCIATE RETAINING

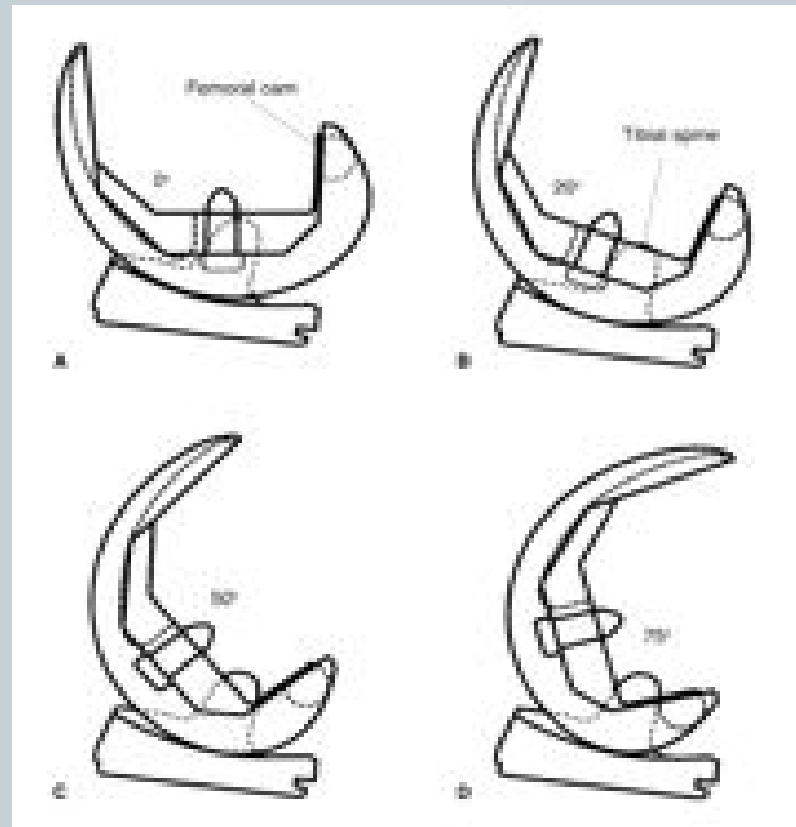


CRUCIATE SACRIFICING



- **MOST OF THE CASES IN INDIA WHY?**
- **INSERT CAM ENGAGES IN THE SLOT**
- **SPECIFIC INDICATIONS**
 - PREVIOUS PATELLECTOMY
 - INFLAMMATORY ARTHRITIS
 - TRAUMA TO PCL
- **BEWARE OF DISTAL FEMORAL FRACTURES**

CRUCIATE SACRIFICING



CRUCIATE SACRIFICING



SEMICONSTRAINED



- REVISION /COMPLEX PRIMARY PROSTHESIS
- SEMICONSTRAINED NONHINGED IMPLANT WITH LARGE CENTRAL POST THAT SUBSTITUTES MCL OR LCL FUNCTION
- INDICATIONS
 - MCL/LCL ATTENUATION
 - FLEXION GAP LAXITY
- STEMS
- AUGMENTS

SEMICONSTRAINED



FULLY CONSTRAINED



- **HINGED KNEE PROSTHESIS WITH A ROTATING PLATFORM**
- **FEMUR AND TIBIA ARE MECHANICALLY LINKED WITH A CONNECTING BAR AND BEARING**
- **TIBIAL COMPONENT ALLOWED TO ROTATE WITHIN A YOKE**
- **ROTATING PLATFORM REDUCES STRESS ON PROSTHESIS BONE INTERFACE**

FULLY CONSTRAINED



- **INDICATIONS**
 - GLOBAL LIGAMENT DEFICIENCY
 - ✦ TRAUMA
 - ✦ MULTIPLE REVISIONS
 - HYPEREXTENSION INSTABILITY {POLIO}
 - TUMOUR
 - INFECTION

FULLY CONSTRAINED



Hinged Knee
Replacement



SPECIAL POINTS



- **IN CONSTRAINED DEVICE ,ALWAYS USE STEMS**
- **CAVITARY DEFECTS**
 - CONTAINED DEFECTS LESS THAN 1 CM –FILL WITH CEMENT
 - SEGMENTAL DEFECTS-AUGMENTS/BONE GRAFTS
- **METAPHYSEAL DEFECTS**
 - TRABECULAR METAL CONES

SUMMARY



- BIOMECHANICS BORING BUT VERY IMP
- RANGE OF IMPLANTS FROM UNCONSTRAINED TO FULLY CONSTRAINED
- UNDERSTAND INDICATIONS FOR EACH

THANK YOU