Principles of knee arthroplasty

Total Knee Arthroplasty (TKA) aims to relief pain and restore function in patients with severe knee joint degeneration (OA, RA).

Indications	Contraindications
Pain and functional limitation of the knee due to osteoarthritis Failed conservative therapies	Absolute: Active infection Medically unfit Absence of extensor mech Relative: Neuropathic joint Peripheral vascular disease Class III Obesity

Surgical goals

Remove diseased bone and replace with internal prosthesis while:

- Not causing contamination / infection
- Restoring the soft tissue (ligament and capsule) tension
- Distributing potential loads evenly
- Optimising extensor mechanism function

Strategies to achieve:

Strict aseptic technique, minimal soft tissue manipulation

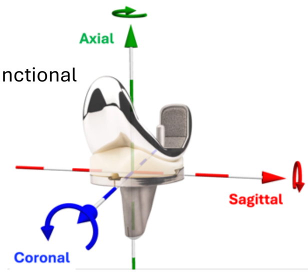
Good visualization, minimise injury to quads, patella, tendon

Equal (rectangular) gaps at 0° and 90°

Optimal alignment desired alignment philosophies has evolved – mechanical, anatomical, kinematic, functional

Good positioning of implants (coronal, sagittal and axial planes)

a.k.a. maintain joint line, restore Q angle



Pre-op planning:

Radiographs:

See areas of disease (cartilage loss, ligament tension and integrity)

Tight – anticipate release   Loose – constraint / adjust cuts

Plan implant positioning, need for graft / augments

Femur   LDFA, difference between AA and MA, entry point of femur

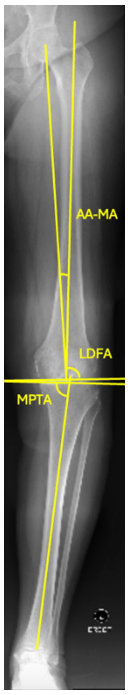
Tibia   MPTA, PTS, entry point (if IM jig)

Intraop:

Approach: medial parapatellar (option to extend) or quadriceps sparing approaches

Need to visualize whole of distal femur, proximal tibia, patella

Challenges: posterior osteophytes, scarring (revision, infection), short patella tendon



Cuts: based on planning

If axes used as guide: centre of femoral head > centre of knee > centre of ankle in line (true mechanical alignment create a joint line parallel to floor i.e. 90° to axes)

Distal Femur: intramedullary jig, adjust cut angle according to measured AA-MA

Remove similar thickness to prosthesis (usu 10mm)

Tibia: IM or EM jig, follow MA

centre of prox tibia = medial 3rd tibial tubercle

centre of ankle = between malleoli

Resultant gap = extension gap

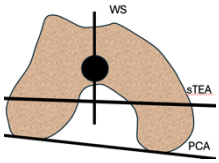
In normal tension, target MCL and LCL same length i.e. thickness of prosthesis

Trapezoidal gap usu MCL tighter → Check alignment → If tibia too valgus (splaying of saw)– recut bones

→ If alignment good, consider release

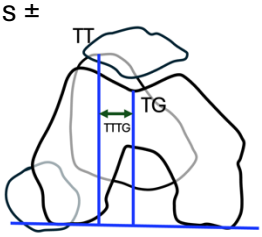
Posterior femur variables: size, AP position, rotation

Size	Based on AP dimension of femur	Ideally remove 10mm post condyle, trochlea same thickness as prosthesis
	Possible problems	ML dimension mismatch (use narrow options) In between sizes (troubleshoot based on referencing tech) Ant ref: ↓size (risks overcut post cond = loose flexion gap) Post ref: ↓size (overcut trochlea = notching)
AP position		Adjust acc to flexion gap
Rotation	Measured resection landmarks	Parallel to sTEA Perpendicular to Whiteside line 3° ER to PCA
	Gap balancing landmarks: proximal tibia cut	Rotation of femur based on equal tension of MCL and LCL in flexion
	Also influences patella tracking	



Poor sizing – mismatch between extension gap and flexion gaps (use McPherson's rule to troubleshoot), generally symmetric rectangular gap problem – adjust tibia
asymmetric rectangular gap problem – adjust femur
test: POLO test

Poor rotation – trapezoidal flexion gap, address with position adjustment, releases ± thicker insert



<u>Optimal extensor mechanism function:</u>

1. Restore patella-trochlea gap (tendency is to overstuff)
2. Align quad pull to patella tendon (TT-TG distance, Q angle)
- Internal rotation (axial malalignment) and/or overmedialisation of femoral comp and/or tibia comp increases TT-TG
- Intra-op tests: no thumb, towel clip, vertical patella test
- Corrective procedures: facetectomy, lateral release (inside out or outside in)

3. Distalise joint i.e. iatrogenic patella alta = late engagement of patella on trochlea, may cause maltracking

Lustig S, Servien E, Batailler C. How to optimize patellar tracking in knee arthroplasty? Orthop Traumatol Surg Res. 2023 Feb;109(1S):103458. doi: 10.1016/j.otsr.2022.103458. Epub 2022 Oct 24. PMID: 36302447.

<u>Bone defects:</u> Causes abnormal loading of the prosthesis leading to early failure.
Commonly in the medial tibial plateau in varus knees
Aim: create a flat surface for equal compressive load from prosthesis to tibial surface
Strategies:

translate component away from defect: smaller tibia maximises contact, excess medial tibia may be osteotomized, beware allowance of size mismatch between femur and tibia. Too small tibial component may only rest on cancellous bone, which can lead to subsidence

lower tibia cut: also means smaller surface, limited to gerdy's tubercle.

fill with cement: not ideal as cement weak in shear, more for elderly patients

graft with bone cuts / allograft: easier in contained defects, need fixation with screws or wires

augments / custom implants: most common strategy, best results.

**** if large defect present, also best strengthen fixation with tibial stem

Reasons for failed knee arthroplasty & how to avoid:

Infection:	see prevention of PJI
PFJ issues:	optimal patella tracking, avoid overstuffing, change joint line patelloplasty, denervation, resurfacing
Instability:	balance tension of collaterals, post capsule
Aseptic Loosening:	avoid excess tension, good cementing, remove all possible sources of third body wear
Wear:	more dependent on technology – better PE, better tibial trays
Stiffness:	prehab, balanced soft tissue, optimal tracking, post-op rehab
Fractures:	avoid notching, screen for osteoporosis, falls prevention
Pain:	optimal component sizing, proper component placement, restore kinematics

Further reading:

Thomas Parker Vail and Jason E. Lang*, Surgical Techniques and Instrumentation in Total Knee Arthroplasty, chapter 150* in Insall & Scott Surgery of the Knee (2018), 1665-1720.

Edward J. McPherson, James A. Browne, and Stephen R. Thompson, *Adult Reconstruction, chapter 5* in Miller Review of Orthopaedics (2016), 403-481

Scott, R. D. (2015). Total Knee Arthroplasty. Elsevier.

Inui, H., Yamagami, R., Kono, K., & Kawaguchi, K. (2023). What are the causes of failure after total knee arthroplasty?. Journal of Joint Surgery and Research, 1(1), 32-40.