Primary Total Knee Arthroplasty

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Cover Illustration by Vanessa Ray
I. INTRODUCTION

A. Total knee arthroplasty (TKA) is a reliable and reproducible procedure for properly selected patients.

B. TKA has been facilitated by advances in instrumentation, prosthetic design, and surgical technique.

C. The implant survival rate of TKA is 91% to 98% 10 to 15 years after the operation (Table 1).

II. PATIENT SELECTION

A. Indications. The following are the general indications for TKA. The indications have been expanded to include patients younger than 55 years.\(^1\) Results for specific diagnoses are presented in Table 2.

1. Daily pain unresponsive to trial of conservative management

2. Knee pain that limits activities of daily living

3. Radiographic evidence of marked degenerative changes and loss of joint space in the medial and/or lateral tibiofemoral compartment and in the patellofemoral compartment

B. Contraindications

1. Ongoing infection

2. Disruption of the extensor mechanism

3. Complete ankylosis or arthrodesis of the knee

4. Marked neurologic deficit in the lower extremity

5. Inability of patient to work hard after surgery to regain full knee extension and maximal knee flexion

C. Risk factors for complications and poor results.

Patients with the following disorders are at risk of less than ideal results after TKA. They are at higher risk of complications and poor functional results despite adequate pain relief than are other patients.

1. Marked obesity

2. Diabetes mellitus
3. Parkinson’s disease
4. Rheumatoid arthritis
5. Previous osteomyelitis around the knee
6. Marked bone deformity before TKA

III. SURGICAL APPROACH

A. **Most common approach.** A midline incision and medial parapatellar arthrotomy are commonly used for TKA (Figure 1).

B. **Other approaches** (see Figure 1)
   1. **Modified parapatellar approach** described by Insall. This is a straight arthrotomy carried over the medial border of the patellar bone itself.
   2. **Midvastus approach.** This approach entails splitting the vastus medialis muscle in line with its muscle fibers beginning at the superior pole of the patella. Use of this approach leaves more of the extensor mechanism intact than do the medial and modified parapatellar approaches and may lower the lateral release rate.
   3. **Subvastus approach.** This approach leaves the entire vastus medialis muscle intact. It may result in a lower rate of performing lateral release and may be less painful in the first day.
<table>
<thead>
<tr>
<th>Clinical Setting</th>
<th>Percentage of Good to Excellent Results</th>
<th>Implant Survival Rate (%) and Follow-up Period</th>
<th>Comments</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior infection</td>
<td>70</td>
<td>No data</td>
<td>15% infection rate if osteomyelitis was present</td>
<td>Jerry GJ, Rand JA, Istrup D: O ld sepsis prior to total knee arthroplasty. Clin Orthop 1988;236:135–140.</td>
</tr>
</tbody>
</table>

TKA = total knee arthroplasty.
or two after surgery. It is difficult to use in operations on obese patients.

4. **Lateral parapatellar approach.** This approach may be useful in operations for valgus knee, but it is not widely used.

C. **Extensile approaches.** Operations on stiff knees may have to be performed with an extensile approach.

1. **Quadriceps snip.** This approach is versatile and requires no change in postoperative care.

2. **V–Y turndown (Figure 2).** Although it provides good exposure in operations on very stiff knees, this approach essentially transects the quadriceps tendon.
   a. Careful repair and postoperative protection are needed.
   b. Limited weightbearing is necessary until healing is complete.

3. **Tibial tubercle osteotomy.** This approach is useful in operations on markedly stiff knees of selected patients. It allows bone-to-bone healing but still requires protected weight-bearing in the initial phase of recovery.

IV. **SOFT-TISSUE BALANCING**

A. Accurate soft-tissue balancing is an integral part of TKA.

B. **Collateral ligaments.** These must be balanced with symmetric tension both in full extension and at 90 degrees of flexion.
   1. In full extension 1 to 2 mm of laxity is appropriate and should be symmetric on both the medial and lateral aspects of the joint.
   2. Mild laxity of both the medial and lateral collateral ligaments is expected at 30 degrees of flexion.
   3. At 90 degrees of flexion, the flexion space should be rectangular and match the extension gap (Figure 3).

C. **Varus deformity** is present in most knees on which TKA is performed.
   1. It is most often corrected with subperiosteal release of the superficial medial collateral ligament.
   2. The semimembranosus tendon may have to be released if residual tightness is present.
   3. When varus deformity is severe, some surgeons perform osteotomy of the medial femoral epicondyle.

D. **Valgus deformity** is less common than varus deformity.
1. Extensive soft-tissue releases in valgus knees have been associated with instability.
2. Intra-articular lengthening of the lateral aspect in full extension may minimize problems with instability. An incision is made in the posterolateral joint capsule between the lateral collateral ligament and the popliteal muscle. Multiple punctures are made in the iliotibial band and sometimes the lateral collateral ligament.

E. Flexion contracture often can be addressed with resection of additional distal femoral bone, usually 2 mm. The posterior capsule is released from the femur subperiosteally.

F. Posterior cruciate ligament (PCL). When the PCL is retained, the ligament must be balanced.
   1. The POLO test (pull out, lift off) is useful to determine whether the PCL is too loose, too tight, or just right.
   2. With trial components in place and the knee at 90 degrees of flexion, a stemless tibial trial component with tibial insert should not be pulled out (too loose) or be lifted off the tibia as the knee is flexed (too tight).

V. LIMB ALIGNMENT

A. Neutral mechanical axis. Most authors suggest that a neutral mechanical axis be reproduced with TKA (Figure 4). A varus mechanical axis and placement of tibial components in marked varus have been associated with higher rates of failure of TKA.
   2. A tibiofemoral angle of 5 to 7 degrees most often produces a neutral mechanical axis. Patients with marked coxa vara or coxa valga deformity at the femoral head may need a different tibiofemoral angle.

B. Technique. Most surgeons cut the distal femur in 5 to 7 degrees of valgus and cut the proximal tibia perpendicularly to the long axis of the bone (0 degrees). The result is a tibiofemoral angle of 5 to 7 degrees and a neutral mechanical axis.
   1. Femoral cutting. Most femoral cutting guides have an intramedullary alignment rod.
a. A template of the femur made before the operation shows the proper entrance point for the intramedullary guide rod. That point is often medial to the center of the knee to avoid a distal femoral cut in excessive valgus.

b. Intramedullary femoral guides have proved to be more accurate (within 2 degrees) than most extramedullary guides.

2. **Tibial cutting.** The tibia can be cut equally well with extramedullary and intramedullary guides. To limit fat embolism from instrumentation of 4 long bones, extramedullary guides are favored when the tibia is bowed and when bilateral simultaneous TKA is performed.

### VI. ROTATION OF THE FEMORAL COMPONENT

A. **General considerations.** The proper rotational position of the femoral component must be achieved. Internal rotation of the femoral component can disturb knee kinematics and cause patellofemoral problems such as pain and poor tracking.

B. **Techniques for determining proper rotation** *(Figure 5).* The true flexion-extension axis of the knee passes through the femoral epicondyles and is represented by the transepicondylar axis (TE axis). The femoral component should be rotated parallel to the TE axis. The following 4 methods for determining femoral rotation are well established, and each can be useful in selected circumstances.

1. **Direct referencing of the TE axis** requires identification of the medial epicondylar sulcus and the lateral epicondylar high point. The medial sulcus sometimes is difficult to locate with precision.

2. The **posterior-condylar axis** (PC axis) is the line tangent to the posterior femoral condyles. On average the TE axis is 3 degrees externally rotated relative to the PC axis. Many knee instrumentation systems reference the posterior condyles and then build in 3 degrees of external rotation. For a valgus knee or a knee with marked intrinsic tibial varus, the TE axis may be rotated as much as 10 degrees relative to the PC axis.

3. The **anterior-posterior axis** (AP axis) is the line connecting the center of the intercondylar notch with the low point in the femoral trochlea. The AP axis typically is perpendicular to the TE axis. Deformity of the trochlea can make the AP axis unreliable.

4. The **measured flexion gap method** of determining femoral rotation requires soft-tissue balancing of the knee before the bone cuts are made. The tibia is cut perpendicularly to its long axis, and the knee is brought to 90 degrees of flexion. The femoral component is rotated parallel to the tibia. This technique is particularly useful when post-traumatic femoral deformity is present.

### VII. PREPARATION OF THE PATELLA

A. **General considerations.** Most complications and poor results of TKA are caused by problems with the patella. Metal-backed patellar components have largely been eliminated because of problems with accelerated polyethylene wear and metal-on-metal articulation at the patellofemoral joint.

B. **Technique-related problems.** The following problems cause poor patellar tracking or anterior knee pain.

1. "**Overstuffed knee,**" which causes excess tightness in the lateral retinaculum. A femoral component that is too large or malpositioned...
in the AP plane or a resurfaced patella that exceeds the original patellar height produces an overstuffed patellofemoral joint.

2. Internal rotation of a femoral or tibial component, which increases the Q angle

3. Positioning the patellar button lateral to the native high point of the patella

4. Unintentional asymmetric resurfacing of the patella. This is most often caused by under-resection of bone on the medial aspect and over-resection of bone on the lateral aspect.

C. Lateral retinacular release is often performed to correct a patellar tracking problem found intraoperatively. Lateral release, however, has been associated with a higher incidence of postoperative complications, including hematoma, wound healing problems, pain, and patellar fracture.

1. Preservation of the superior lateral geniculate artery during lateral retinacular release does not appear to influence rates of patellar fracture or loosening.

2. The necessity of performing a lateral release can be minimized with use of surgical techniques in which the femur is rotated parallel to the TE axis, internal rotation of the tibial component is avoided, the femoral component is lateralized slightly, and the original patellar height and patellar high point location are reproduced accurately.

D. Patellar resurfacing. Most surgeons routinely resurface the patella.

1. Resurfacing is clearly indicated in operations on patients with inflammatory arthritis.

2. For selected patients with noninflammatory arthritis, the native patella may be left in place if the femoral component is of a so-called “trochlea-friendly” design.

3. Not resurfacing the patella avoids the complications of loosening and wear of the patellar button. However, the patella may be more prone to anterior knee pain, and a reoperation for patellar resurfacing may become necessary.

In some cases it is reasonable to resect 1 to 3 mm of additional tibia to eliminate the defect. In other cases the defect should be filled. The choice of cement, graft, or metal wedge is based on the patient’s age and the size of the defect.

1. Very small defects (less than 5 mm deep). These defects often can be eliminated by means of resection of slightly more proximal tibial bone. The typical resection depth is 8 to 10 mm measured from the intact lateral plateau in a varus knee. An extra 2- to 3-mm resection can eliminate many defects that would otherwise necessitate use of a small bone graft, metal wedge, or cement filling.

2. Small wedge-shaped defects (5 to 10 mm deep)
   a. The defect can be easily converted into a step-shaped defect and filled with cement or cement and screws, particularly for older patients. Step-shaped defects are subject to compressive loads, and cement works well in compression.
   b. The defect can be filled with a small modular metal wedge, which has excellent results in primary TKA, particularly in older patients.
   c. Autogenous bone graft is often used, particularly in younger patients.

3. Large wedge-shaped defects (10 to 20 mm deep)
   a. The defect can be filled with a large metal wedge. This option is quick and reliable and may be favored for older patients.
   b. The defect can be filled with autologous bone shaped to fit the defect. This option may be favored for younger patients to preserve bone stock.

4. Massive defects
   a. Allograft bone or custom implants must be used.
   b. The defect should be bypassed with a stemmed tibial component.

B. Femoral bone loss. Femoral defects are rare in primary TKA. Trauma or marked valgus deformity may cause femoral bone loss that requires augmentation.

1. Modular metal wedges can be used on the femoral side.

2. Care must be taken to ensure proper rotation of the femoral component in the presence of marked bone loss.
3. The defect can be bypassed with an intramedullary stem if rotational stability of the femoral component against host bone cannot be obtained.

C. Patellar bone loss
1. The patellar bone remaining after TKA should be at least 10 to 12 mm thick. One author has suggested 15 mm.  
2. Thin patellae may be better suited to resurfacing with a biconvex inset patellar button, which leaves more native patellar bone intact.
3. Very thin patellae may not be suitable for use of an onset resurfacing patellar button. These may be best managed by leaving them unresurfaced, gently shaping them to accommodate the trochlea (patelloplasty), and balancing them to track centrally.
   a. Pain relief with this treatment may be incomplete.
   b. If bone stock is compromised, complications with this technique are less likely than with resurfacing.

X. POLYETHYLENE WEAR

A. Polyethylene wear in TKA tends to be less of a problem than polyethylene wear in total hip arthroplasty. Results of most wear simulation studies suggest tenfold less wear in the knee than in the hip after comparable follow-up periods.

B. Causes of marked polyethylene wear in TKA
   1. Liner problems. Very thin modular liners, heat pressed liners, and flat-on-flat articulation between the femoral component and tibial liner have caused complications.
   2. Oxidation of polyethylene
      a. Gamma sterilization of polyethylene in air and prolonged storage of polyethylene before implantation have been linked to marked oxidation of liners and subsequent wear.
      b. Wear and fatigue failure of oxidized polyethylene can be rapid.
      c. Polyethylene liners should be sterilized or stored in an inert environment to minimize oxidation.

C. Other factors. Poor postoperative limb alignment (typically a varus mechanical axis), younger age, male sex, and higher patient weight may contribute to higher rates of polyethylene wear.

XI. RANGE OF MOTION AFTER TOTAL KNEE ARTHROPLASTY

A. Average flexion after TKA is 105 to 115 degrees. TKA with a posterior stabilized design appears to provide slightly better flexion than does TKA with a cruciate-retaining design.

B. Postoperative range of motion correlates with preoperative range of motion.
   1. Knees with more than 125 degrees of flexion before TKA tend to lose a slight amount of flexion after TKA.
   2. Knees with less than 90 degrees of flexion before TKA tend to gain a slight amount of flexion after TKA.
C. Use of **continuous passive motion machines** after TKA may lead to better flexion soon after the operation and may decrease the need for manipulation; however, they probably do not influence the final range of motion for many patients.

D. **Closure of the knee capsule in 90 degrees of flexion** has been shown to improve early motion in some but not all studies.

### XII. Complications

#### A. Fat embolism

1. Transesophageal echocardiography has been used to document marked embolic events during knee and hip arthroplasty.

2. **Intramedullary instrumentation** of the femoral and tibial canals is the likely source of most but not all emboli. Venous emboli may be generated from a tourniquet or from the stasis induced by knee hyperflexion during the procedure.

3. Bilateral simultaneous TKA, particularly for patients with a history of cardiac problems, may be best performed with extramedullary alignment guides for the tibias to avoid instrumentation of 4 long bones.

#### B. Neurovascular injury

1. **Arterial injury.** Direct arterial injury during TKA is rare. The rate of occurrence is less than 0.2%.
   a. The popliteal artery usually is slightly lateral to the midline at the level of the knee joint. Care must be taken when removing osteophytes and loose bodies in the posterior recesses of the knee.
   b. Marked calcification of the arteries predisposes them to injury.
   c. Careful documentation of the preoperative and postoperative vascular status of the patient allows timely diagnosis of vascular insufficiency.

2. **Neurologic injury.** Neurologic injury after TKA typically involves the peroneal nerve and may occur in 0.5% of operations.
   a. Predisposing factors for peroneal palsy include postoperative epidural anesthesia, prior lumbar laminectomy, and preoperative valgus and flexion deformity.
   b. Management of peroneal palsy is largely supportive. It consists of loosening constrictive dressings and flexing the knee slightly. If a large hematoma is found around the nerve, early exploration may be reasonable but is not supported scientifically at this time.

#### C. Periprosthetic fracture. Fracture of the femur, tibia, or patella can occur during or after TKA.

1. **Intraoperative fractures** typically occur during trial or final insertion of components.
   a. Fractures of the femoral condyle can occur during insertion of a posterior stabilized component if the intercondylar bone is not carefully resected flush with the cutting guides. Such fractures often can be stabilized by means of removal of the component before the cement has hardened, internal fixation of the fracture, and recementing the component in place with or without an intramedullary stem. The technique used depends on the extent of the fracture.
   b. **Tibial fractures** can occur if the component is impacted too vigorously. Stable, metaphyseal fractures can be managed with protected weightbearing. Unstable or diaphyseal fractures may necessitate adjunctive fixation.

2. **Postoperative fractures** can be caused by trauma, loosening, or osteolysis.
   a. Supracondylar fractures of the femur are classified and fracture management is summarized in Table 3.
   b. Tibial fractures are classified according to the Mayo system. (Figure 6).

   1) Anatomic fracture types
   a) Type I: tibial metaphyseal
   b) Type II: metaphyseal-diaphyseal
   c) Type III: diaphyseal below stem
   d) Type IV: tibial tubercle

   2) Subclassification
   a) A: stable prosthesis
   b) B: unstable prosthesis
   c) C: intraoperative fracture

   3) Management
   a) Fractures associated with a loose implant are best treated with component revision.
   b) Fractures associated with well-fixed implants are managed with the usual principles of tibial fracture care.

   c. Patellar fractures. Management of patellar fractures depends on the integrity of the extensor mechanism. Displaced fractures
that disrupt the extensor mechanism necessitate internal fixation.

D. **Disruption of the extensor mechanism.** This complication can occur either intraoperatively or postoperatively and may involve either the quadriceps or the patellar tendon.

1. **Intraoperative avulsion of the patellar tendon** is rare in primary TKA.
   a. Preoperative stiffness or patella baja may predispose a patient to this problem.
   b. Primary repair can be performed with Krackow sutures placed through drill holes in the tubercle and supplementation of the repair with autogenous tissue such as pes tendon or with wire to protect the repair.

2. **Late patellar tendon rupture** is a rare problem.
   a. Direct repair alone has a poor rate of success.
   b. Repair and supplementation with autologous pes tendon or allograft tissue is needed.
   c. The joint must be protected for 6 to 12 weeks.
   d. Allografts of the entire extensor mechanism have mixed results. Management is maximum tension in full extension and protection for 6 weeks with a cast. The tendon can be expected to stretch over time.

3. **Quadriceps tendon tear** can occur postoperatively.

E. **Heterotopic ossification**

1. Marked heterotopic bone formation is much less common after TKA than after total hip arthroplasty.
2. Heterotopic bone around the implant typically is immediately superior to the anterior flange of the femoral component.
   a. Extensive heterotopic bone sometimes is present in the quadriceps tendon.
   b. Heterotopic bone formation may be minimized with limitation of periosteal stripping of the anterior femur.

F. **Hemarthrosis.** Hemarthrosis can occur and recur after TKA.

1. In most instances the cause is unclear. Possible causes include entrapment of synovial tissue and flexion instability.
2. Nonoperative management is indicated in most instances. Open synovectomy is reserved for recurrent, symptomatic cases.
3. For patients with symptomatic flexion instability after cruciate-retaining TKA, revision to a posterior stabilized implant may be needed.

G. **Wound healing problems.** Most wound healing problems can be avoided with careful preoperative evaluation.

1. **Risk factors.** Patients with multiple prior incisions, impaired vascularity, diabetes, or...
steroid-dependent inflammatory arthritis are at risk.

2. Prevention in high-risk patients. If a patient has had multiple incisions, the most anterior and lateral incision should be used for TKA. When there are multiple crossing incisions or densely adherent skin, preoperative use of soft-tissue expanders should be considered.

3. Management. If a wound problem develops, aggressive early management is appropriate to save the prosthesis.
   a. Wound healing takes priority over motion.
   b. Early débridement and early flap coverage of full-thickness defects are needed.

REFERENCES


SUGGESTED READINGS