Epidemiology
The average age of patients undergoing total knee arthroplasty (TKA) in reports prior to 2000 was 75 years, and in the past decade the age has decreased to 66–69 years of age. Approximately two-thirds of patients are female, and the primary indication for surgery is in 90% of cases osteoarthritis (see Figure 1). Other indications for TKA include rheumatoid arthritis, osteonecrosis, and trauma resulting in deformity and arthrosis. Rheumatoid patients have shown greater improvements in functional status than osteoarthritis, possibly secondary to poorer pre-operative functional scores. Obese patients with a body mass index (BMI) >35 comprise 35–40% of patients undergoing the procedure, and this proportion is rising. However, there is no strong evidence demonstrating that obesity or gender predicts functional outcome.

As more primary TKA surgeries are performed on younger patients, there is a higher demand for fellowship-trained adult reconstructive surgeons. The total volume of TKA is shifting toward these physicians who perform the highest volume of cases. The average caseloads of the top 5% of TKA surgeons in the US has risen from 33 to 86 cases per year from 1990 to 2004. Tertiary care centers have experienced the largest rise in case volume, particularly in revision TKA procedures.

System-wide changes in the medical landscape have led to a push to increase surgical efficiency and decrease costs. The average operative time has decreased by 15%, and despite the increased overall number of patient comorbidities, procedure-related complication rates have decreased and mortality has dropped more than 40%. Overall revision TKA rates have remained stable at approximately 2%, although absolute numbers of revision TKA have clearly risen over the past decade.

Modern Techniques in Primary Total Knee Arthroplasty
The recent trend toward minimally invasive TKA with smaller incisions has met with favorable results; however, there is no established advantage to mini-incision TKA compared with the traditional medial parapatellar approach. Some studies suggest decreased pain and shorter time to perform straight leg raise, as well as shorter length of hospital stay and rehabilitation. The drawback of minimally invasive TKA is that limited bony visualization can lead to tibial component malalignment and higher early failure rate. In some studies, the average time to revision in mini-incision TKA is decreased.

Alternative approaches have also shown some mixed results. The muscle-preserving quadriceps-sparing approach has shown increased potential for malalignment and wound complications, as well as higher operative time; therefore, this approach has fallen out of favor. The midvastus and subvastus approaches have encouraging results but do not demonstrate any distinct advantages to the conventional approach.

Computer-assisted total knee arthroplasty is a novel adjunct used for improving accuracy in alignment during implant placement. Several technologies help guide surgical decision-making, including case-specific cutting jigs and computer navigation. Navigation surgery emphasizes the mechanical axis as the primary predictor for outcomes, and the goal is to reduce deviations that could lead to mechanical
Advances and Controversies In Total Knee Arthroplasty

Figure 1: Anteroposterior and Lateral Radiographs of an Arthritic Knee (A and B) Treated with Primary Total Knee Arthroplasty Using Posterior Stabilized Knee Prostheses (C and D)

Figure 2: Anteroposterior and Lateral Radiographs Demonstrate a Failed Cruciate Retaining Total Knee Arthroplasty with Oversized Femoral Component (A and B). Revision Surgery Was Performed Using Posterior Stabilized Knee System with Long Stems (C and D)

malalignment. Knees found to be within 3–5º of the anatomic mechanical axis had a low failure rate in addition to a functional advantage, whereas outliers in alignment had three to four times higher rate of short-term failure. Computer-assisted TKA has consistently been shown to have more knees within this alignment range than conventional knees; however, computer navigation adds 15–30 minutes of surgical time. The long-term implant survival rates using computer assistance for total knees are yet to be established, and these new methods warrant further study.

Other debates in modern implants include high-flexion versus standard TKA, mobile-bearing versus fixed-bearing TKA, patellar resurfacing, bilateral versus unilateral surgery, and alternative component materials. Randomized controlled trials indicate that high-flexion TKA does not offer any significant short-term benefits in function or range of motion; however, studies with follow-up beyond three years are under way. Mobile-bearing TKA also does not appear to offer any significant benefit compared with fixed-bearing TKA in short- and intermediate-term studies. Implants placed prior to 1995 may have slightly higher rates of bearing complications relative to implants after 1995, possibly from improvements in surgical technique. Patellar resurfacing continues to be debated among reconstructive surgeons. Although the overall rate of anterior knee pain is similar in resurfaced versus non-resurfaced groups, rate of revision TKA appears to be higher in non-resurfaced knees. Another controversial topic over the past decade is the safety of unilateral versus bilateral TKA. A large registry in New Zealand suggested no difference in outcomes between bilateral and unilateral TKA, but other studies describe potentially higher morbidity and mortality in bilateral TKA, particularly within the first three months in patients 70 years or older.
Studies also appear to show that alternative tibial component options, such as all-polyethylene tibial components and uncemented trabecular metal implants, for example, porous tantalum, may have similar short-term outcomes for stability and survival relative to standard tibial components.13,19

### Options in Revision Total Knee Arthroplasty

Difficult revision TKA commonly necessitates an extended exposure, particularly in cases of significant cavitary bone loss in tibial and/or femoral components. Proximal extension of the medial parapatellar arthrotomy can be accomplished with a rectus snip or V-Y quadriceps transdow as needed. Adequate distal exposure can be accomplished with a tibial tubercle osteotomy.

Bony defects can be reconstructed with morcellized or structural allograft, synthetic bone-graft substitutes, cement, porous-coated or cemented metal augments, or a combination of these methods. For contained defects with intact cortical support, cancellous bone grafts tend to revascularize more rapidly. Uncontained defects with complete loss of cortical structural bone often require metal augments or structural allograft. Porous tantalum is now also an excellent option, allowing metaphyseal fixation in regions of aseptic bone loss.

Stem fixation for improving implant stability is necessary when metaphyseal fixation is compromised by bone loss (see Figure 2). Varus-valgus constrained and hinged knee implants can be utilized at the surgeon’s discretion in cases of mediolateral instability, flexion instability, or extensor mechanism failure. For extensor mechanism insufficiency, mesh allografts with either quadriceps tendon-patella-patellar tendon-tibial tubercle graft or Achilles tendon graft have shown good results.13

Problems associated with revision TKA surgery include higher incidence of post-operative pain and stiffness, infection, skin necrosis, and neurovascular injury. Patients undergoing revision surgery tend to be older and have more medical comorbidities. Pain relief and knee function after revision TKA are less favorable than after primary TKA, but patient satisfaction still remains high after revision surgery. Factors that affect outcomes in revision TKA include extent of surgical reconstruction required, pre-operative range of motion, extensor mechanism function, collateral ligament support, quality of skin and soft tissues, and remaining bone stock.1 Salvage procedures after failed revision TKA include knee arthrodesis and above-knee amputation.

### Complications

The primary causes of implant failure in TKA are infection and osteolysis from ultra-high-molecular-weight polyethylene (UHMWPE) wear. Tibial component osteolysis is generally easier to recognize on plain radiographs than femoral osteolysis. Oblique posterior femoral condylar radiographs allow detection of radiolucencies more consistently than true lateral views, but up to 80% of osteolytic lesions are missed with plain radiographs compared with computed tomography.14 Contributing factors to osteolysis include sterilization with irradiation in air causing oxygen radicals, presence of third-body debris, as well as motion between the tibial insert and metal tray that causes backside wear. Modern implants have undergone improvements in processing of the UHMWPE, which have reduced the risk of wear and osteolysis.

Infection in TKA has a rate of 0.7–1.0% overall. High-risk factors include obesity (BMI >50), rheumatoid arthritis, male sex, younger age, diabetes, and constrained or hinged implants. Two-stage revision is recommended for infected TKA, particularly in cases of methicillin-resistant *Staphylococcus aureus* (MRSA) infections. MRSA osteomyelitis tends to behave aggressively near knee implants, often causing large cavitary bone defects. Stage I involves removal of implants and placement of an antibiotic-impregnated spacer, followed by six to eight weeks of parenteral antibiotic therapy. Inflammatory laboratory values are followed and the knee is aspirated to rule out persistent infection prior to stage II, when the knee is revised with new implants. Gram staining prior to stage II has high specificity but low sensitivity; therefore, the aspirate culture must be followed before the placement of clean implants. Mobilization is encouraged after stage I to avoid arthrofibrosis, and articulating antibiotic spacers are now commonly used to improve range of motion.15 Antibiotic-impregnated cement offers lower rates of re-infection relative to cement without antibiotics, but long-term and larger-scale studies are needed.

Early loosening is more commonly seen in cementless TKA, and cemented fixation is used in the vast majority of primary TKA in the US. Malalignment of components leads to asymmetric loading of the knee, resulting in loosening, more common in varus than valgus malalignment.

Mediolateral instability may occur from either intraoperative collateral ligament laceration or post-surgical trauma; revision in such a situation requires a constrained implant for stability during varus/valgus stress. Flexion instability may occur when soft tissue laxity develops post-operatively. This can result in paradoxical motion, with anterior subluxation of the femur on the tibia. Extensor mechanism failure is another complication that often necessitates revision surgery with a more constrained implant and/or allograft.

Other less common complications include fracture, early arthrofibrosis, heterotopic ossification, patellar maltracking, patellar clunk syndrome, component breakage, and neurovascular injury. Late arthrofibrosis with persistent pain following TKA is a difficult problem to treat, but revision surgery improves range of motion 20–35° in two-thirds of patients.16 Uncontrolled diabetics tend to have higher rates of wound infection and dehiscence, aside from the higher risk of postoperative bleeding, need for transfusion, urinary tract infection, and stroke.

### Peri-operative Care

A variety of modern pain management protocols have been developed for total knee procedures, which include peripheral nerve blocks, intraoperative capsular local anesthetic administration, and post-operative narcotic regimens. Localization of the femoral nerve for catheter placement has been described in the anesthetic literature to be more consistent and safer than the sciatic nerve; therefore, femoral nerve catheters are more commonly used in conjunction with posterior capsular intraoperative injection. Both femoral and sciatic nerve catheters have the potential for intra-neural injection and nerve injury. There is short-term reduction in pain the first 12–24 hours post-operatively and decrease in total narcotic usage; however, overall there is not a clinical difference beyond 24 hours after surgery.7 Periarticular local anesthetic injections have been beneficial for...
pain control without significant risk for systemic toxicity. Periarticular steroid injections may also be used but may have a higher risk of deep wound infection. Other approaches for pain control include intrathecal baclofen or intrathecal narcotics.17

The ongoing controversy of venous thromboembolism (VTE) prophylaxis is yet to be resolved. There is no definitive evidence favoring one type of prophylaxis (aspirin versus low-molecular-weight-heparin (LMWH) versus fondaparinux versus warfarin versus mechanical prophylaxis alone), but it is evident that without any prophylaxis, rates of deep vein thrombosis approach 60–80% in total knee replacement, even higher in total hips. Reports from the American Academy of Orthopaedic Surgeons (AAOS) describe no significant difference in symptomatic pulmonary embolism in the use of LMWH versus warfarin versus aspirin with sequential compression devices alone.7 Risk of hematomata formation and major hemarthrosis events after TKA are a concern with the use of LMWH and warfarin, and these should be taken into account according to surgeon preference. Fondaparinux and LMWH after total joint replacements appear to be cost-effective for VTE prevention,14 but well-designed large scale randomized controlled trials comparing prophylactic methods are pending. Despite the recommendations in thromboprophylaxis and increased use, the rate of pulmonary embolism surprisingly increased from 0.29 to 0.52% from 2000 to 2004. VTE thromboprophylaxis will evidently be an area of further research in the coming decade.

Conclusion
TKA has undergone many technical advances over the last 20 years. Revision surgery rates remain low. Improvements in surgical techniques and materials have consistently led to reliable pain relief for patients, with implant survival greater than 90–95% at 10 years and approximately 80% at 20-year follow-up. As the absolute number of revision TKA surgeries will certainly rise over the coming years, it is essential to understand the modes of prosthetic failure and the methods for reconstruction in failed knees.

3. Memtsoudis SG, Della Valle AG, Besculides MC, et al., Trends in the use of LMWH versus warfarin versus aspirin with sequential compression devices alone.7 Risk of hematoma formation and major hemarthrosis events after TKA are a concern with the use of LMWH and warfarin, and these should be taken into account according to surgeon preference. Fondaparinux and LMWH after total joint replacements appear to be cost-effective for VTE prevention,14 but well-designed large scale randomized controlled trials comparing prophylactic methods are pending. Despite the recommendations in thromboprophylaxis and increased use, the rate of pulmonary embolism surprisingly increased from 0.29 to 0.52% from 2000 to 2004. VTE thromboprophylaxis will evidently be an area of further research in the coming decade.

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