Chapter 3

Primary Total Knee Arthroplasty: Less Invasive Approaches

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Indications

Both patients and surgeons have shown considerable interest in the so-called minimally invasive surgery (MIS) approaches for total knee arthroplasty (TKA). The exact definition of MIS TKA continues to evolve, but most would agree that it involves a short skin incision, avoids eversion of the patella, and limits the amount of surgical dissection in the suprapatellar pouch, thus minimizing damage to that richly innervated region of the knee. Importantly, the introduction of MIS TKA also has been accompanied by substantial changes in perioperative anesthesia techniques. The goals of MIS, mainly rapid rehabilitation and improved patient function, cannot be achieved without excellent postoperative anesthesia.

The indications for a less invasive TKA are essentially the same as those for a standard TKA—specifically, the presence of disabling pain associated with advanced joint degeneration. The surgeon should be experienced and well-rehearsed with standard TKAs before endeavoring to undertake MIS techniques.

Several different MIS TKA approaches have been described, including the mini-subvastus, mini-midvastus, mini-medial parapatellar, and quadriceps-sparing approaches. The mini-subvastus approach can be used in most patients; it is indicated when earlier return to function of the quadriceps after primary TKA is desired. Historically, the standard subvastus approach was discouraged in obese or muscular patients because everting the patella was either difficult or caused damage to the vastus medialis obliquus (VMO) and the surrounding soft tissues. With the mini-subvastus approach, the patella is not everted, and with minimal release, the patella can be translated relatively easily into the lateral gutter. This makes the mini-subvastus approach applicable to a wider range of patients.

Contraindications

Although the indications for MIS TKA seem to be broad, the complexity of these surgical techniques demands that the contraindications be thoroughly considered. A mini-subvastus approach can be performed on the vast majority of patients undergoing standard TKAs; however, we do not use this approach in patients with substantial patella baja (patella infera) as demonstrated on lateral radiographs or in patients with marked knee stiffness, as it can be very difficult to translate the patella laterally in these situations. Patients with compromised skin (peripheral vascular disease, poorly controlled diabetes mellitus, or chronic corticosteroid use) are poor candidates for any small-incision approach to TKA because substantially more tension is placed on the skin edges during these approaches, and that places patients with compromised skin at risk for wound healing problems. Obesity or muscularity of the patient is not an absolute contraindication to using the mini-subvastus approach, although these conditions add some technical difficulty. Simple maneuvers such as extending the skin incision by 2 or 3 cm often can notably facilitate the mini-subvastus approach in these patients. The knee with inflammatory arthritis may have softer bone surfaces that will collapse slightly with retraction and should be carefully evaluated for suitability of these techniques. Most surgeons should pursue specialized cadaver training before using MIS approaches to TKA in clinical practice.

Dr. Pagnano or an immediate family member has received royalties from DePuy and Zimmer and has received research or institutional support from DePuy, Musculoskeletal Transplant Foundation, National Institutes of Health, Stryker, and Zimmer. Neither Dr. Krych nor any immediate family member has received anything of value from or owns stock in a commercial company or institution related directly or indirectly to the subject of this chapter.

Table 1 Results of Less Invasive Approaches for Total Knee Arthroplasty

Authors (Year)	Study Design	Number of Knees	Approach	Mean Patient Age in Years (Range)	Mean Follow-up	Results
Fauré et al (1993)	Prospective randomized	20	Subvastus vs medial parapatellar	70 (55-81)	3 months	Subvastus had greater strength at 1 week and 1 month; preferred by patients 4:1
Roysam and Oakley (2001)	Prospective randomized	89	Subvastus vs medial parapatellar	Subvastus: 69.8 Medial parapatellar: 70.2	3 months	Subvastus had greater knee flexion, used fewer narcotics at 1 week ($P < 0.001$), had earlier straight-leg raising
Boerger et al (2005)	Matched retrospective	120	Subvastus vs medial parapatellar	Subvastus: 69 (55-82) Medial parapatellar: 68 (59-83)	3 months	Subvastus had less blood loss, less postoperative pain, faster straight-leg raising, better early flexion
Dalury and Dennis (2005)	Retrospective comparative	60	Mini-midvastus vs medial parapatellar	Subvastus: 68.9 Medial parapatellar: 67.4	3 months	Varus malalignment more common in mini-midvastus knees
Aglietti et al (2006)	Prospective randomized	60	Subvastus vs quadriceps-sparing approach	Subvastus: 70 (59-80) Medial parapatellar: 71 (58-84)	3 months	Subvastus had earlier straight-leg raising, better flexion at 10 and 30 days
Schroer et al (2008)	Matched retrospective	300	Subvastus vs medial parapatellar	Subvastus: 70 (44-87) Medial parapatellar: 71 (42-90)	2 years	Subvastus had earlier straight-leg raising, shorter hospital stay, better knee flexion
Jackson et al (2008)	Prospective	209	Quadriceps-sparing	NA	6 months	Increased complication rates compared with standard TKA

NA = not available, TKA = total knee arthroplasty.

Alternative Treatments

The preoperative physical examination should be targeted to identify substantial patella baja, knee stiffness, or compromised skin. Most patients with one or more of these issues would be better served with a traditional medial parapatellar approach for the TKA.

Results

Several prospective randomized trials have shown better results with the mini-subvastus approach over other TKA approaches (**Table 1**), including earlier straight-leg raising and better flexion These studies confir an added benefi to the subvastus approach in the early postoperative period. The long-term advantages of this approach have not yet been established. Some studies, however, demonstrate a higher complication rate with MIS TKA approaches. Because of the increased risk of complications and the learning curve associated with MIS, we recommend specialized training before incorporating minimally invasive approaches into clinical practice.

Techniques

Setup/Exposure

The patient is positioned supine with a nonsterile tourniquet placed as far proximal as possible. We prefer not to use any leg positioning devices. Rather, the amount of flexio or extension of the knee can be controlled easily and adjusted frequently throughout the surgery by supporting the foot against the surgeon's hip. The knee is prepared and draped in a standard fashion, with iodine-impregnated drapes on all exposed skin.

A straight, midline, or medially biased incision is made starting at the superior pole of the patella and extending distally to the top of the tibial

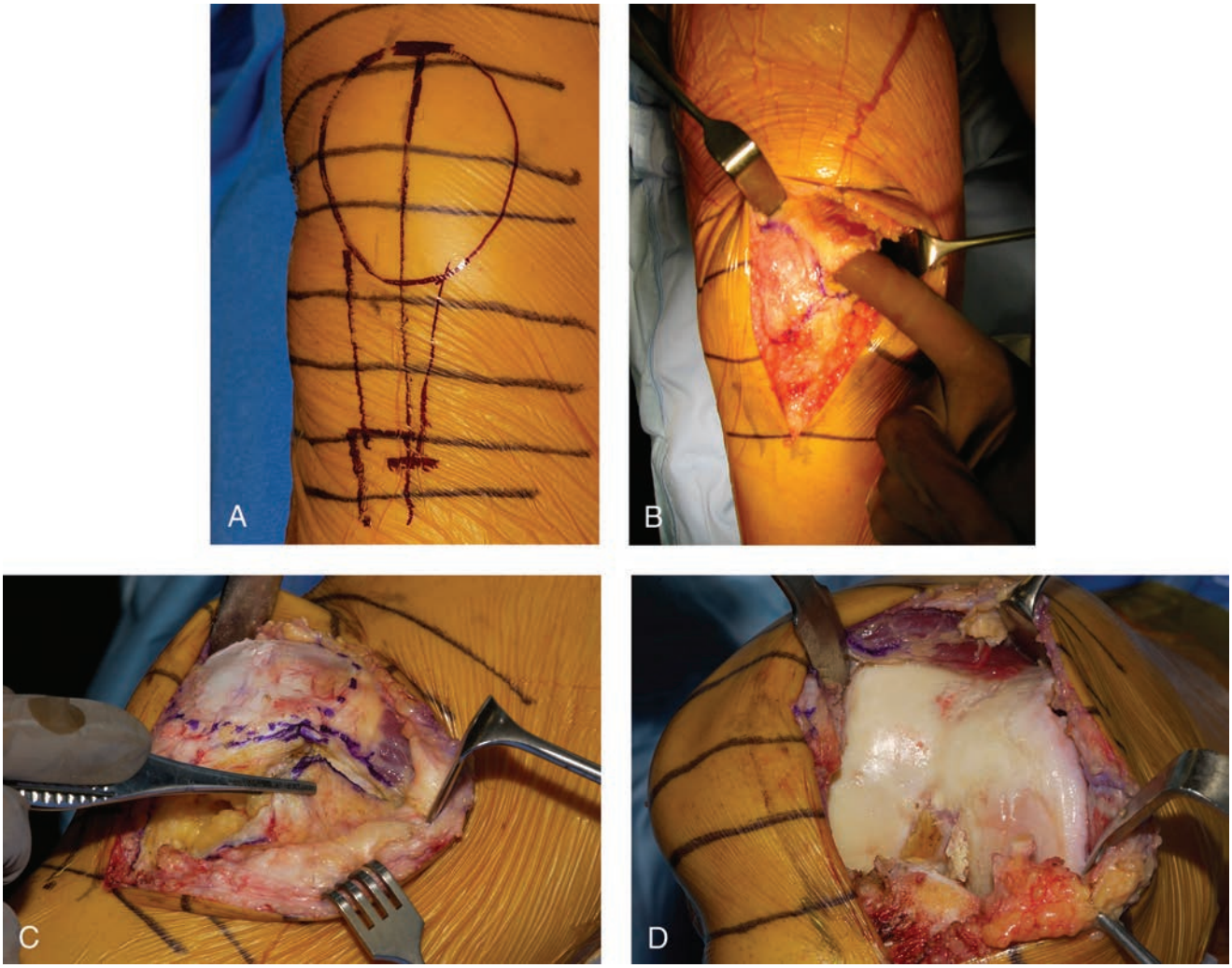

Figure 1 Femoral exposure with the mini-subvastus approach. **A,** The mini-subvastus skin incision extends from the superior pole of the patella to the top of the tibial tubercle. This shows the straight midline incision. **B,** The inferior border of the VMO muscle belly is identified. The surgeon can place a finger beneath this muscle belly, but on top of the synovial capsule and out of the knee joint, to faciliate leaving a thin edge of myofascial tissue attached to the inferior border of the VMO when making the arthrotomy. **C,** The arthrotomy for the mini-subvastus exposure follows the inferior border of the VMO, intersects the patella, and then turns distally to parallel the medial edge of the patellar tendon to the medial margin of the tibial tubercle. **D,** The patella is retracted into the gutter with relatively little tension on the VMO. A second 90° bent Hohmann retractor is placed medially to visualize the distal femur.

tubercle (**Figure 1**, *A*). A medial full-thickness skin fla is raised to clearly identify the distal border and insertion of the VMO while preserving its overlying fascia. It is helpful to establish a plane between the undersurface of the VMO and the capsule before making the arthrotomy. This can be accomplished by incising the overlying fascia of the VMO and bluntly freeing the muscle belly from the underlying synovial layer (**Figure 1**, *B*). This will preserve a myofascial band of tissue at the inferior border of the VMO, which the retractor will rest against later in the procedure. If the tendon is not preserved, the retractor will move proximally and tear or macerate the VMO muscle fibers causing unwanted damage and bleeding. The arthrotomy starts along the inferior border of the VMO, extends laterally to the midpole of the patella, and then turns distally to parallel the medial border of the patellar tendon to the level of the tibial tubercle (**Figure 1**, *C*).

After the arthrotomy is completed, the medial soft-tissue sleeve along the proximal tibia can be elevated in a standard fashion with subperiosteal elevation of the deep medial collateral ligament. A Kocher clamp can be placed on the capsule above the level of the medial meniscus to assist with medial tibial exposure throughout the surgery. After ensuring sufficien patellar mobility, a 90° bent Hohmann retractor is placed in the lateral gutter to rest against the tendon edge of the

Figure 2 Intraoperative photograph demonstrates the insertion of the VMO onto the patella. Note that the VMO inserts distally at the midpole of the patella at a 50° angle relative to the long axis of the femur.

VMO that was carefully preserved during the exposure. The patella is subluxated (not everted) into the lateral gutter with relatively little tension on the VMO, and the fat pad can be excised or preserved according to surgeon preference. The knee is then flexe to 90°, providing good exposure of both femoral condyles (**Figure 1**, *D*). Before cutting the distal femur, the anterior cruciate ligament is released from the proximal tibia. If a cruciate-substituting TKA is being performed, the posterior cruciate ligament is released from the proximal tibia in full flexion and the posterior horns of the medial and lateral menisci also are released. This will facilitate subluxation of the tibia anteriorly, which will aid visualization for proximal tibial resection.

Instruments/Equipment/ Implants Required

Most manufacturers have introduced modifie low-profil instruments designed specificall for MIS TKA. These instruments are more easily placed into smaller incisions and into an ideal position during surgery. We highly recommend two 90° bent Hohmann retractors for this procedure. The tapered tip effectively slides into place to protect the collateral ligaments during bone cuts, and it is also very useful for retracting the quadriceps and patella laterally. The 90° bend also aids visualization of the small surgical fiel by keeping the assistant's hands out of the surgeon's visual path. In addition, a large Kocher clamp placed at the time of exposure on the medial soft tissues just superior to the medial meniscus will facilitate visualization of the medial tibial side during the surgery.

Mini-Subvastus Approach

The mini-subvastus approach to the knee is a reliable, reproducible, and safe way to access the knee joint. In addition, the mini-subvastus is the only approach that maintains the integrity of the entire extensor mechanism. The VMO inserts at a 50° angle relative to the long axis of the femur, and the distal-most attachment is at the midpole of the patella on the medial side. It is important to identify the inferior aspect of this insertion, as it tends to be more distal than expected (**Figure 2**). Therefore, any approach that extends proximally to the midpoint of the patella violates a portion of the quadriceps tendon and should not be considered "quadriceps sparing."

Procedure

The distal femur is resected with a low-profil intramedullary resection guide. Two key maneuvers can aid in visualization of the distal femur during critical steps such as placing the intramedullary guide, femoral sizing, anterior resection, and cementation. The firs is bringing the knee into more extension, which decreases tension on the extensor mechanism and allows more of the distal femur to be visualized. The second is placing a small knee retractor to slightly elevate the extensor mechanism from the distal femur.

The proximal tibia is resected next. This creates more space for femoral sizing and rotation, the most difficul portion of any MIS TKA technique. Exposure of the tibia is performed by placing a bent Hohmann medially and laterally against the tibia to protect the collateral ligaments, and then placing a "pickle-fork" retractor posteriorly around the posterior cruciate ligament attachment, levering the tibia forward (**Figure 3**, *A*). The tibial resection is performed using an extramedullary guide designed for MIS. With subluxation of the patella into the lateral gutter, the patellar tendon tends to push the tibial resection block medially. As a result, it is critical to keep the distal guide toward the medial malleolus to compensate for this position and avoid a varus resection of the tibia.

Femoral rotation can be assessed accurately by referencing the transepicondylar axis, the Whiteside line, or the posterior condyles, according to the surgeon's preference. The femur is then sized precisely, and the anterior, posterior, and chamfer cuts are made

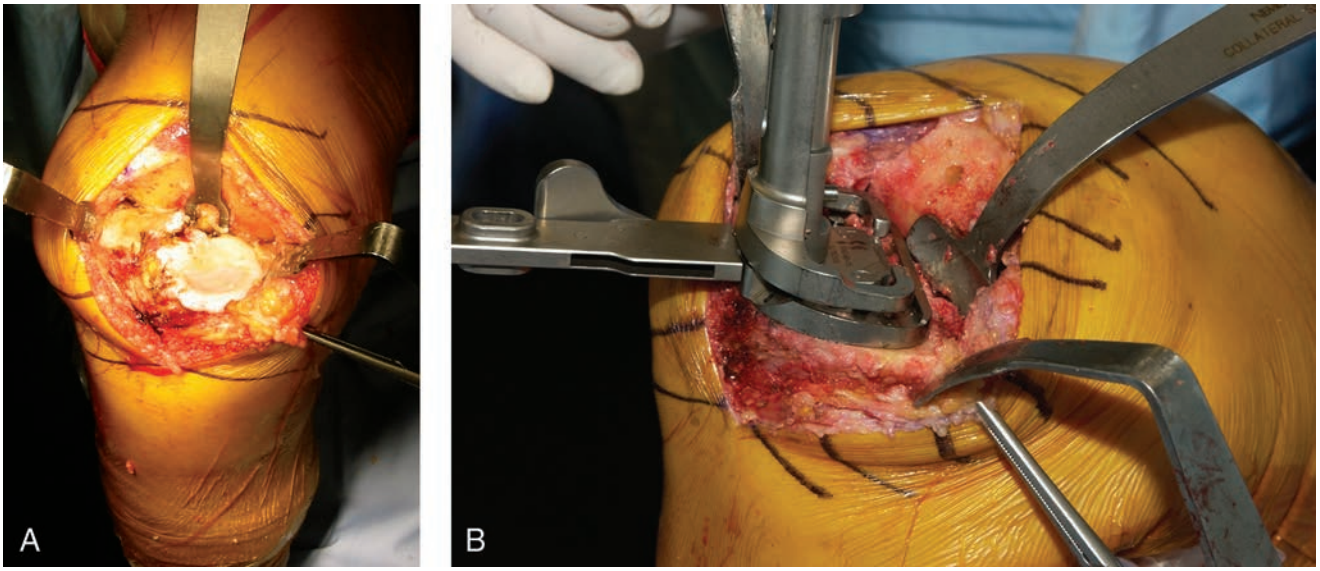

Figure 3 Tibial exposure with the mini-subvastus approach. **A,** For initial exposure, a pickle-fork retractor is placed posteriorly to provide an anterior drawer, and two bent Hohmann retractors are placed medially and laterally to both protect the collateral ligaments and define the edges of the tibial bone. **B,** Tibial exposure for final preparation is obtained by using the same three retractors as for initial exposure. This excellent visualization avoids placing the tibial component in internal rotation.

with a 4-in-one finishin guide. After the femoral cuts are made, a laminar spreader is introduced into the flexio space, and the notch osteophytes, any remaining cruciate ligament(s), medial and lateral menisci, and posterior osteophytes can be excised under direct visualization. The fina ligament releases are performed, and flexio and extension gaps are checked according to the surgeon's preference. The fina preparation of the tibia is performed (**Figure 3**, *B*).

The patella is then resurfaced (if desired) by turning it 90°, but not everting it. The patella can be resected freehand from medial to lateral or by using a patellar resection guide (**Figure 4**). Resecting the patella at the end of the procedure avoids inadvertent damage to the resected surface during the remainder of the surgery. A trial reduction can then be performed and patellar tracking tested with the trials in place. The patella should track centrally with a "no-thumbs" test and should contact the medial and lateral femoral condyles equally at 90° of flex ion.

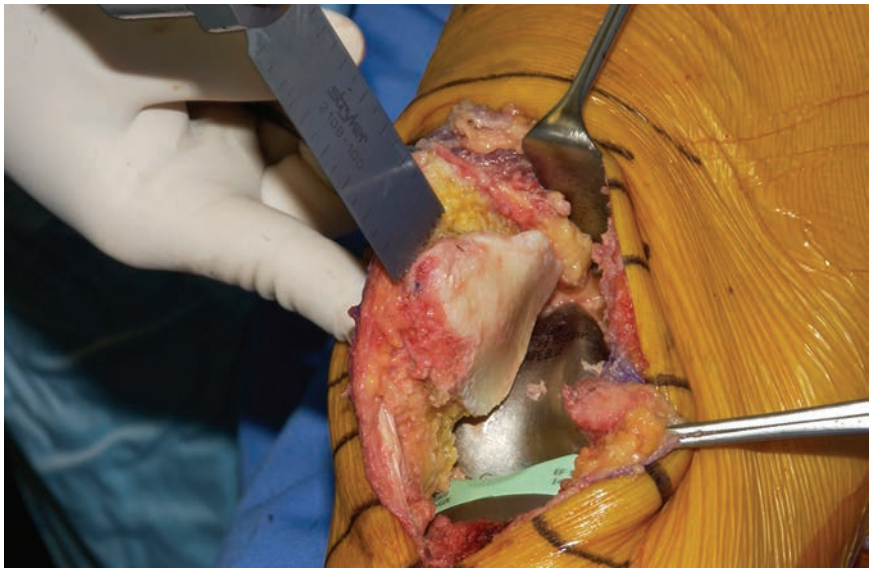

Figure 4 To resect the patella, it is turned 90° but not everted. Resection can be done freehand, cutting from medial to lateral.

The modular tibial tray is cemented first followed by the femur and then the patella. Attention is paid to removing excess cement from the posterolateral corner of the tibia and the distal lateral surface of the femur, as these areas are obscured by a laterally subluxated patella.

Wound Closure

The tourniquet is deflate and care is taken to identify any small bleeding vessels under the VMO muscle belly. If hemostasis in that area is a concern, a drain can be placed. The arthrotomy closure begins at the midpole of the patella, reapproximating the corner of

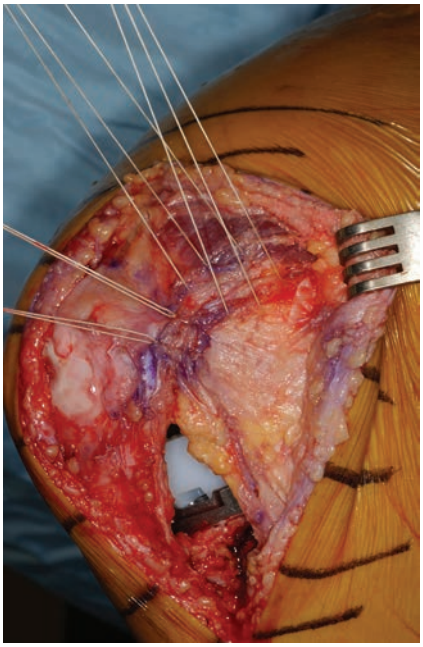

Figure 5 The mini-subvastus arthrotomy is closed by first reapproximating the corner of capsule at the midpole of the patella with two No. 0 nonabsorbable braided sutures. Three or four interrupted sutures are then placed through the synovium to close the knee joint itself and are tied in 90° of flexion to avoid creating patella baja.

the capsule to the extensor mechanism. Next, interrupted nonabsorbable braided sutures are placed deep to the VMO muscle belly (not in the muscle belly itself) in the myofascial sleeve define at the time of exposure and reapproximated to the medial retinacular tissue (**Figure 5**). The distal vertical limb is closed by suturing the medial retinacular tissue to the medial edge of the patellar tendon with interrupted nonabsorbable braided suture. The skin and subcutaneous tissue are closed in layers.

AVOIDING PITFALLS AND COMPLICATIONS

The complication unique to the mini-subvastus approach is a subvastus hematoma. This occurs when the blood vessels that course through the adductor canal and branch through the VMO are torn with excessive retraction. This is minimized by translating the patella and not everting it, as this decreases the tension on this area. Before the arthrotomy is closed, the tourniquet is released, the area is examined for possible bleeding, and any bleeding vessels are cauterized. If the surgeon is concerned about continued oozing after closure, a deep drain can be placed in this area.

We recommend that surgeons begin performing this procedure with a traditional skin incision and then shorten the incision as they become more comfortable with this approach. The main benefi of this exposure is that it is truly quadriceps-sparing, not that the incision is shorter. Therefore, while females with more mobile soft tissues may be operated on through a 3.5-in or shorter incision, in more muscular males, a longer incision may be required for adequate visualization.

The medial skin fla must be elevated far enough to clearly identify the inferior border of the VMO. The arthrotomy should never extend proximal to the midpole of the patella, as this will tear, split, or macerate the VMO muscle fiber during the remainder of the operation. After making the arthrotomy, the surgeon must make certain the patella is mobile by translating the patella into the lateral gutter while the knee is extended. If difficult is encountered, the release of the medial patellofemoral ligament and any soft-tissue attachments overlying the quadriceps must be ensured to assist with patellar mobility.

Mini-Midvastus Approach

The mini-midvastus surgical approach has no absolute contraindications, but relative contraindications include the significantl obese patient (body mass index >40), men with large quadriceps muscle mass, patella baja, and substantial deformity.

PROCEDURE

A midline incision is made from the superior pole of the patella to the midpoint of the tibial tubercle distally. A medial arthrotomy is begun distally 5 mm medial to the tibial tubercle and extended proximally just medial to the patellar border. At the superomedial corner of the patella, the arthrotomy is turned proximal-medially and a 2-cm split is made in line with the muscle fiber of the VMO. The patella is subluxated (but not everted) laterally with a bent Hohmann retractor around the margin of the lateral femoral condyle. The fat pad is then excised and the anterior horns of the medial and lateral menisci are incised. The distal femur is resected with the knee in 70° of flexion Depending on surgeon preference, the remainder of the femoral cuts can either be made next or after the tibial resection. The anterior-posterior axis of the knee is used to assess femoral rotation. The intramedullary distal cutting guide is placed, and the cut is made. The femur is then sized, with variations in knee flexio angle needed to accommodate the guide, and the finishin cuts are made. The knee is then flexe to 90°, the tibia is exposed with bent Hohmann retractors placed medially and laterally at the tibial margins, and a posterior pickle-fork retractor is used to lever the tibia anteriorly. A modifie tibial cutting guide specificall designed for small-incision surgery can be of great assistance. After removing the proximal tibial fragment, a laminar spreader can be placed in the flex ion space firs medially and then laterally. This facilitates removal of the osteophytes, cruciate ligaments, and posterior menisci under direct vision. The trial components are assembled and the knee reduced. The patella is prepared last. The sequence for cementation is the tibia first followed by the femur and then the patella.

WOUND CLOSURE

The arthrotomy incision is closed with either multiple interrupted sutures or a running suture, at the discretion of the surgeon. Care should be taken not to strangulate the muscle of the VMO

with the proximal sutures. Many surgeons choose to close the arthrotomy in flexio to avoid overtightening the medial side. The subcutaneous tissue and skin are closed in layers.

AVOIDING PITFALLS AND COMPLICATIONS

It is important to remember that the VMO is innervated by the terminal branches of the femoral nerve, and it can be safely dissected 4.5 cm from the patellar insertion without risk of denervation to the distal muscle. Deflating the tourniquet before polyethylene insertion allows for better visualization of bleeding vessels at the back of the knee and more thorough hemostasis.

Mini–Medial Parapatellar Approach

The mini–medial parapatellar approach is the most popular MIS TKA approach because it is simple and is familiar to most surgeons. It also has the advantage of being easily extended to a standard medial parapatellar approach at any time. The indications are similar to the other MIS TKA approaches, with the benefi being limited damage of knee structures, not necessarily a shortened incision length.

PROCEDURE

A midline or slightly medially biased incision is made from just above the superior pole of the patella to the top of the tibial tubercle. Because of the elasticity of skin, the incision can stretch, creating a mobile window that can be used throughout the procedure to gain an additional 2 to 4 cm of visualization. The medial parapatellar arthrotomy is performed like the standard medial parapatellar approach (see chapter 1), except that the proximal extent of the quadriceps tendon incision is only 2 to 4 cm. If difficult is encountered in subluxating the patella laterally, then the success of the procedure will depend on extending the arthrotomy more proximally. Modifie instruments, including alignment guides and cutting blocks that are reduced in size with contoured geometry, facilitate placement in a smaller soft-tissue window. The sequence of bone cuts can be made according to the surgeon's preference, but some favor cutting the tibia firs because this increases the size of the flexio and extension space in which to perform the remainder of the operation. Placing a pickle-fork retractor posteriorly and bent Hohmann retractors medially and laterally to protect the collateral ligaments provides adequate exposure to safely cut the tibia. Next, the distal femur is cut, followed by femoral sizing and femoral finishin cuts. Adequate exposure exists to reference the anterior-posterior axis and the posterior condyles for rotational positioning of the femur. The epicondylar axis can be identifie after appropriate retractor placement, moving the mobile window medially for medial visualization and moving it laterally for lateral visualization to avoid overtensioning soft tissues. Soft-tissue balancing is performed appropriately and the trial components are assembled. The patella can be prepared by either turning the patella up 90° and cutting from medial to lateral or everting the patella with the knee in full extension after the trial components have been removed. The fina components are cemented with the tibia first followed by the femur and patella. As in other MIS approaches, the surgeon should specificall assess for excess cement laterally around both the femoral and tibial components before closing because that location often is obscured when the patella is subluxated and not everted.

WOUND CLOSURE

The arthrotomy incision is closed with either multiple interrupted sutures or a running suture, at the discretion of the surgeon. Many surgeons choose to close the arthrotomy in flexio to avoid overtightening the medial side. The subcutaneous tissue and skin are closed in layers.

AVOIDING PITFALLS AND COMPLICATIONS

In male patients with large femurs, the knee is particularly difficul to expose with this approach because the wider the femur (as measured by epicondylar width), the greater the exposure needed to implant a larger femoral component. In addition, a patient with a deformity greater than 15° of varus or valgus or a flexio contracture greater than 10° will require more extensive soft-tissue dissection to release and correct the deformity, which will limit the ability to make a small incision. As in all MIS TKA approaches, a shortened patellar tendon will make it more difficul to subluxate the patella laterally and will require a longer incision.

Quadriceps-Sparing Approach

The so-called quadriceps-sparing TKA has an even more limited medial parapatellar exposure than the mini–medial parapatellar approach, with the arthrotomy stopping at the superior pole of the patella. This approach is similar to the old open medial meniscectomy approach, and it affords the poorest visualization of any of the MIS TKA approaches. Whether this approach is completely quadriceps sparing is controversial in the literature. It has been shown that the VMO tendon inserts along the medial patella from the superior pole distally to the midpole. When the arthrotomy is carried to the superior pole of the patella, however, it does involve detachment of the VMO along the upper half of the medial border of the patella.

PROCEDURE

The skin incision can be curved around the medial aspect of the patella, or a straight incision can be made just medial to the patella. The

arthrotomy is from the superior pole of the patella to 2 cm below the tibial joint line, just medial to the tibial tubercle. If the patella will be resurfaced, initial resection of the patellar surface will facilitate the exposure for the remaining procedure. This has the drawback of inadvertent damage to the cut patellar surface from poorly placed retractors. The cruciate ligaments are then excised, an intramedullary femoral guide is placed, and the distal femur is cut. Because of the limited visualization, the procedure must be performed with instruments that cut from medial to lateral and demands partial cuts through resection guides followed by freehand finishin cuts. The extramedullary tibial guide is placed, and the tibia is cut from medial to lateral with great care to avoid injury to the posterior neurovascular structures. Once these cuts have been made, a spacer block is placed to check overall alignment, match flex ion and extension gaps, and balance the soft tissues. The rotation of the femur is then determined using a femoral tower, and sized with a modifie tower attachment. The finishin guide is then placed in extension, the knee flexe to 90°, and the finishin cuts completed. Once the trial components are placed and patellar tracking and balancing have been tested, the fina components are cemented into place with the tibia first followed by the femur and patella. The tibial component is difficul to insert because of the intramedullary stem, and special components without a stem or with shortened or modular stems are used by some surgeons.

WOUND CLOSURE

The arthrotomy incision is closed with either multiple interrupted sutures or a running suture, at the discretion of the surgeon. Many surgeons choose to close the arthrotomy in flexio to avoid overtightening the medial side. The subcutaneous tissue and skin are closed in layers.

AVOIDING PITFALLS AND COMPLICATIONS

In the more muscular male with a VMO that inserts low on the mid patella, this approach is very difficult if not impossible, to perform without detaching a portion of the VMO. As in all MIS TKA approaches, the knee with patella baja would be better served with a traditional approach. This exposure requires custom instruments, and it is important for the operating surgeon to become thoroughly familiar with them to avoid inaccurate cuts.

Postoperative Regimen

The postoperative regimen for any of the MIS TKA approaches is the same. The importance of a multimodal analgesia regimen cannot be overemphasized to allow for early mobilization and to minimize side effects of narcotic pain medications. Patients receive thromboembolism prophylaxis in accordance with the surgeon's best judgment concerning the optimal regimen. The patient is up to the edge of bed the day of surgery. The following morning, a physical therapist assists with mobilization, with weight bearing as tolerated. Almost all patients require a walker or crutches for several days and later progress to a cane. Most patients are discharged from the hospital on postoperative day 2, or when they can ambulate more than 150 feet, navigate stairs, and have pain controlled with oral pain medications. Patients may return to driving after they can ambulate with a cane and they are off all daytime narcotics. Patients are given a telephone call at 2 weeks to check on their progress and return to clinic at 2 months for formal evaluation with full-length, weight-bearing radiographs. We recommend instructing patients in the use of a compression bandage at the time of discharge from the hospital. With this surgical approach, patients are quick to regain quadriceps function and often return to more vigorous activities at 7 to 14 days after surgery. This can cause excessive swelling in the knee, which can be limited by use of the compression wrap.

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Coding

CPT Codes		Corresponding ICD-9 Codes	
Total Knee Arthroplasty			
27447	Arthroplasty, knee, condyle and plateau; medial AND lateral compartments with or without patella resurfacing (total knee arthroplasty)	715 715.80	715.16 715.89