Introduction

The technological advancement in total knee arthroplasty (TKA) of the 1980s and subsequent favorable results [14, 41, 45, 50, 52, 55] led to the recognition of TKA as the ultimate knee-salvage procedure for the treatment of osteoarthritis. When considering treatment options, however, the pathology and progression of the disease must be considered. Past studies examining osteoarthritis of the knee have revealed that the disease is slowly progressive and typically limited to the medial tibiofemoral compartment [1, 7, 19, 61]. Furthermore, the erosion of cartilage in the medial compartment is almost always limited to the anterior half of the medial tibial plateau and the corresponding contact area on the distal portion of the medial femoral condyle [61]. White and colleagues coined the phrase anteromedial osteoarthritis to describe this distinct clinicopathological condition [61]. A sclerotic layer of bone, or medial tibial buttress, is formed in response to this characteristic pattern of cartilage destruction. The widening of the medial tibial plateau and increased bone density compensate for articular cartilage loss. Although this may appear to be an inefficient solution, this layer of sclerotic bone assists the medial compartment in withstanding joint loading, supporting weight, and permitting continued ambulation for 10–19 years after initiation of osteoarthritis [19]. The resulting plastic deformation and ligament imbalance, however, produce pain and loss of function.

The clinical presentation of this early unicompartmental form of osteoarthritis must be differentiated from that of patients with more advanced osteoarthritis. For patients with the tricompartmental variant of the disease, the pain often is so debilitating that activities of daily living are severely restricted, independence is lost, and ambulatory aids, such as crutches, a walker, or wheelchair, are required. In such cases, TKA is the most appropriate surgical option to relieve pain and to restore some degree of independence. Fortunately, however, unicompartmental osteoarthritis is far more prevalent than the more advanced tricompartmental form of the disease, as demonstrated by previous studies [1, 19]. Patients with unicompartmental osteoarthritis usually are not disabled by the disease, but typically are inconvenienced by pain. In general, these patients are more active than their tricompartmental counterparts and, therefore, will not be satisfied with simple pain relief. Because most patients also desire restoration of function and a return to activities of daily living, unicompartmental knee arthroplasty (UKA) is a viable option for many of these patients. Furthermore, when patients exhibiting osteoarthritis limited to one tibiofemoral compartment are presented with a choice between UKA and TKA, they tend to choose the less invasive procedure [48].

Based on this understanding of the disease process, treatments such as UKA that address the single diseased compartment, preserving bone and soft tissue, seem appropriate. Unlike the other conservative treatment options, such as arthroscopic debridement and high tibial osteotomy, UKA specifically addresses the pathology of unicompartmental osteoarthritis by combining realignment, replacement of the single damaged tibiofemoral compartment, and ligamentous balancing [44].

The use of UKA in the United States continues to increase as more orthopedic surgeons become aware of the enhanced low morbidity and rapid rehabilitation associated when a minimally invasive surgical technique is combined with the procedure [44]. The popularity of UKA also is rising in response to patient demand [44]. The conservative nature of this procedure, combined
with the low morbidity, rapid rehabilitation, and desirable level of post-operative function, appeals to many patients suffering from unicompartmental osteoarthritis of the knee. The steadfastness of patient choice regarding UKA use, whether educated through word-of-mouth or through various media sources, should not be underestimated.

**Surgical Technique**

The surgical technique for performing minimally invasive UKA using a resurfacing design has been described previously [43] and is reviewed, focusing on medial implantation, which is the most common indication for UKA. Patient preparation and closure are performed, using standard protocols and, thus, will not be discussed.

Prior to commencing the UKA procedure, diagnostic arthroscopy is performed to corroborate the pre-operative diagnosis of unicompartmental osteoarthritis by verifying that the contralateral compartment is unaffected. The status of the contralateral meniscus also is evaluated, which cannot be accomplished during the open procedure, as the meniscus cannot be visualized through the flexion gap. The UKA procedure itself may proceed, provided that the osteoarthritis is limited to one tibiofemoral compartment and the contralateral meniscus is functional. If, however, the disease is more progressive, the surgeon must be prepared to perform a TKA, of which the potential should be pre-operatively discussed and consented to by the patient.

The following steps summarize the minimally invasive UKA procedure using a resurfacing design as performed by the senior author.

**Exposure with Posterior Femoral Condyle Resection (Fig. 9.33)**

A 3- to 4-inch incision is created from the superomedial edge of the patella to the proximal tibial region. A subcutaneous dissection producing a 1- to 2-inch skin flap surrounding the entire incision improves skin mobility and visualization. A medial parapatellar capsular incision from the superior pole of the patella to the tibia is produced. A one-inch transverse release of the vastus medialis tendon is performed to further aid in visualization.

Avoiding patellar dislocation is critical to the minimally invasive technique, as the suprapatellar pouch must remain intact. The suprapatellar pouch is a unique structure that unfolds four times in length when the knee is flexed 90° [24]. When the patella is dislocated, as is performed in traditional open TKA and UKA procedures, the suprapatellar pouch is damaged. Extensive physical therapy then is required to reverse the iatrogenic damage to this structure.

Next, the posterior femoral condyle is resected 5–8 mm. This resection is necessary to create space in the flexion gap to accommodate the UKA prosthesis, as medial compartmental osteoarthritis is an extension gap disease (Fig. 9.34). The articular defect is located at the distal femur and the anterior tibia. When the knee is flexed 90°, the femur rolls back onto the tibia to an area of preserved articular cartilage. Because there is no defect present in the flexion gap, the joint line in the area of retained articular cartilage is an excellent reference point for reconstruction.

**Distraction with Tibial Inlay Preparation and Resection (Fig. 9.35)**

To improve tibial visualization, curved distractor pins are placed at the femoral and tibial levels and are attached to a joint laminar distractor. Approximately 10 mm space must be created in the flexion gap to accommodate the UKA prosthesis. Because 5–8 mm has been resected previously from the posterior
Medial unicompartmental osteoarthritis is an extension gap disease. a There is no articular surface loss in the flexion gap. b In contrast, a loss of approximately 5 mm is present in the extension gap. This narrowing of the medial compartment joint space is evident on radiographic evaluation and is responsible for ACL and MCL laxity, the lateral tibial thrust, or varus deformity, present in the extension gap, and the absence of deformity in the flexion gap, which are all clinical observations characteristic of medial unicompartmental osteoarthritis (From [44]).

This resurfacing inlay technique preserves the layer of sclerotic bone to provide a stable platform for the component and to minimize medial tibial bone loss, which is a major cause of UKA revision [3, 38]. The importance of protecting this medial tibial buttress may be likened to the preservation of the posterior acetabular rim in total hip arthroplasty in that, when lost, future reconstruction is severely compromised. Unlike other UKA designs, the resurfacing, inlay tibial component preserves the medial tibial buttress. The amount of bone resected for UKA implantation of resurfacing UKA designs compared to that resected for saw-cut UKA designs is depicted in Fig. 9.36. Because the medial
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AP weight-bearing post-operative radiographs of knee joints exhibiting Ahlback III osteoarthritis with complete loss of medial joint space. a Limited bone resection and preservation of the medial tibial buttress associated with the use of the inlay all-polyethylene tibial component. b More aggressive bone resection and corresponding medial tibial buttress sacrifice required with the use of saw-cut metal-backed designs.

Limited bone resection and preservation of the medial tibial buttress, the senior author considers resurfacing UKA as the last reconstruction procedure for a patient, but classifies any technique in which the medial tibial buttress is sacrificed, whether it may be other UKA techniques or TKA, as the first salvage procedure.

Femoral Preparation and Resection (Fig. 9.37)

At the femoral level, the 5.5 mm round burr is used to drill to a depth of 3 mm into the femoral extension gap surface, which serves as a depth gauge. An additional full-burr depth (5 mm) is created at the junction of the previous saw cut and the distal femoral surface, which allows the curved portion of the femoral prosthesis to set midway between the flexion and extension gaps (45° flexion position). Bone bulk is removed with the burr. This resection permits adequate spacing of the femoral component, while preventing settling.

Femoral-Tibial Alignment (Fig. 9.38)

Methylene blue marks are used to indicate the desired center of rotation, or contact point, of the femoral component in relation to the tibial component and to indicate the desired center point of the femoral component. A femoral drill guide, manufactured with a large central slot to visualize component alignment, is inserted.
to assist aligning the femoral contact with adequate tibial support. A sagittal saw or side-cutting burr may be used to create a keel-slot for the fin of the femoral component. Femoral preparation is concluded by inserting the trial femoral component using the femoral inserter.

**Trial Reduction and Local Anesthetic Injection (Fig. 9.39)**

Trial reduction is performed by implanting the trial components to evaluate range of motion through 115° of flexion and to assess soft-tissue balance. Ligament balancing is achieved primarily by the insertion of a properly sized and fitted implant. If the ligaments are tight in only the extension gap, tension may be adjusted by further bone removal at the distal femoral level. If, however, tension exists in both the flexion and extension gaps, tibial bone resection as previously described should be repeated in 1 mm increments. The round femoral surface permits easy adjustment.

Once range of motion and soft-tissue balancing are satisfactory, the trial components are removed, the joint is irrigated thoroughly, and a dry field is established. The femoral and tibial preparations will be visible. Prior to component insertion, all incised tissues are infiltrated with anesthesia (0.25% bupivacaine and 0.5% epinephrine solution) for post-operative pain relief and hemostasis.

**Component Insertion and Final Preparation (Fig. 9.40)**

All components are inserted using methylnethacrylate cement. After insertion of each component, excess cement is removed with a dental pick. Range of motion should be performed a final time to evaluate the flexion-extension gaps. The cement is cured with the knee in full extension. Once the cement mantle is hardened, it may be necessary to remove any remaining osteophytes, contour the patella, or perform notch plasty. The procedure is completed by irrigating the joint with sterile saline. A tube drain then is inserted into the contralateral compartment via a stab wound. Sterile dressing, a circumferential ice cuff, a pneumatic compression device, and an immobilizer are placed on the knee prior to exiting the operating room.

**Potential Pitfalls**

The 3-inch minimally invasive surgical approach described above provides appropriate visualization to effectively perform UKA. If, however, visualization or technique is compromised at any point in the technique, it may be converted to an open procedure, with full dislocation of the patella, at which time the procedure would not be considered minimally invasive.

Although many UKA failures may be attributed to implant design, technical errors are often a result of human judgment. Over-correction may lead to aseptic
loosening and/or subsidence, as well as secondary degeneration of the contralateral compartment. These failure modes stress the importance of proper training, experience, and strong surgical technique. Because of the steep learning curve associated with developing accurate surgical technique [5, 6, 27, 31, 32, 35, 37, 44, 59], instructional training is highly advised to avoid the early failure that may result if UKA is attempted without proper training.

Christensen emphasized the need for such training by contending that TKA systems with good instrumentation may be implanted using only written instructions, while UKA technique is best taught in the operating room [13]. In addition, Robertsson et al. stressed that skill, patient-selection decisions, and operative routine are assumed to be influenced by the number of procedures performed by the surgeon [47]. Indeed, centers performing UKA on a regular basis demonstrate better results than those centers where the procedure is occasionally performed [32, 46]. To successfully perform UKA, orthopedic surgeons, therefore, must seek appropriate instructional training prior to attempting UKA and be cognizant of the learning curve that must be overcome to avoid the technical errors that are well-established failure modes of UKA.

Results

A retrospective study comprised of 136 UKA cases conducted by the senior author using broad selection criteria demonstrated an overall 7% revision rate requiring TKA among Ahlback stage-2, -3, and -4 patients at 8 years [48]. Among the 20 Ahlback stage-4 cases, 5 (25%) required revision at 8 years [48]. The Repicci II unicompartmental knee system (Biomet, Inc., Warsaw, IN) was utilized in all cases. Within 4 h after surgery, all patients ambulated with a walker and most (98%) were discharged from the hospital within 23 h [48]. Most patients, however, ambulated with a walker within 2 h post-operatively and are discharged home within 4–6 h. Hospitalization for 48 h was required for refractory nausea in one case and telemetry observation for new onset atrial fibrillation in another case [48]. In the 8 cases requiring revision to TKA, primary designs were utilized with good (25%) or excellent (75%) Knee Society clinical ratings at follow-up [48]. The results from this study highlight the safety and efficacy of the minimally invasive surgical technique, demonstrate the decreased recovery and rehabilitation time, and support the relative ease of conversion to TKA, if required, of this particular UKA device.

Discussion

Although recognized as a safe and efficacious procedure for the treatment of osteoarthritis, TKA has a finite longevity. An effective procedure, such as UKA, is needed to address treatment of the earlier, non-advanced cases of osteoarthritis, postponing or delaying the need for TKA. Given the slow, progressive nature of osteoarthritis [1, 7, 19, 61], UKA, which addresses the single-diseased compartment and preserves bone and soft tissue, is an appropriate treatment option for the unicompartmental form of the disease. Not only is there a clinical need for such a treatment, but also patient demand for such a procedure is quite strong [44, 48].

The senior author uses UKA under broad selection criteria to supplement TKA, extending the spectrum of knee prosthetic survivability and decreasing the likelihood that a complex revision procedure will be required in a patient's lifetime. As previously summarized [44, 48], all patients between 50 and 90 years, of age diagnosed with osteoarthritis of the knee limited to a single tibiofemoral compartment who have failed non-operative treatment, are considered for UKA if presenting with weight-bearing pain that significantly impairs quality of life. Patients with Ahlback stage 2, 3, or 4 [1] are candidates if range of motion is at least 10–90°.
Although an attenuated or ruptured anterior cruciate ligament (ACL) is an absolute contra-indication to lateral UKA, instability, including a compromised ACL, is a relative contra-indication to medial UKA [12, 13, 22, 53, 54, 56]. When presented with a choice between UKA and TKA, UKA candidates tend to choose the less invasive procedure [48].

Combining a minimally invasive surgical technique with UKA is appealing to both surgeons and patients, as morbidity and rehabilitation time are reduced [44]. A successful minimally invasive technique, regardless of its application, must meet the following goals:

- minimal physiologic disruption;
- minimal interference in patient lifestyle;
- minimal hindrance to future treatment options.

In 1992, the senior author implemented a minimally invasive UKA program [43] that is significantly different from simply the use of a small skin incision or implementation of only a minimally invasive surgical approach. The following concepts, which are all minimally invasive by nature, were combined into a single program to meet the above goals:

- minimally invasive surgical approach avoiding patellar dislocation;
- adjunct use of arthroscopy;
- resurfacing UKA design with an inlay tibial component;
- pain management with local anesthetic and without the use of narcotics.

The utilization of arthroscopy in conjunction with UKA reduces the morbidity of the procedure and enhances survivorship by identifying patients with advanced osteoarthritic involvement and/or a compromised meniscus in the contralateral compartment whom otherwise may not have been excluded based on pre-operative radiograph evaluation and traditional surgical inspection alone. The pre-planned UKA procedure should be abandoned for these patients in favor of TKA, the procedure of choice for more advanced cases of osteoarthritis. A fully functioning, intact contralateral meniscus, which cannot be verified through traditional surgical exposure, is a significant factor affecting UKA survivability, as the surface area of load bearing and the stability of the knee joint are enhanced by intact menisci [16, 18, 20, 23, 28, 51, 57]. When the menisci are intact, the average surface contact area of the tibia is 765–1150 mm²; however, the tibial contact with the femur is reduced to approximately 520 mm² when the menisci are removed [17, 25, 29]. Based on these findings, Kuster et al. concluded that a contact area of approximately 400 mm² is required to avoid polyethylene stress and to prevent cold flow in knee prostheses [29]. Although a certain amount of cold flow is expected in UKA designs, due to lower tibiofemoral contact surface area compared to TKA designs, an absent contralateral meniscus will result in an inadequate amount of tibiofemoral contact. This lack of tibiofemoral contact, coupled with the concurrent continued osteoarthritic process, may hasten the rate of degeneration of the untreated contralateral side and may also lead to early failure of the UKA device [33]. Therefore, although eliminating over-correction has reduced the incidence of UKA failures in recent years [2, 4, 8, 10–12, 15, 18, 34, 49, 53, 58, 60], contralateral compartment degeneration and early UKA failure remain a concern if the status of the contralateral meniscus is not assessed.

The minimally invasive surgical approach utilized by the senior author must be differentiated from a “mini incision,” which is merely a small hole. The use of a “mini incision” may cause significant distortion of soft tissue. This minimally invasive surgical approach preserves tissue and maintains the function of the suprapatellar synovial pouch, the quadriceps tendon, and the patella. Traditional TKA and UKA surgical techniques, on the other hand, involve dislocation of the patella, which, in turn, destroys the suprapatellar pouch and requires extensive physical therapy. The advantages of this minimally invasive approach include reduction in post-operative morbidity, reduction in post-operative pain, decreased rehabilitation time without the need for formal physical therapy, and the ability to perform the procedure on a same-day or short-day basis [9, 15, 26, 36, 40, 43, 48]. Several studies have demonstrated a faster rate of recovery, defined as the time required to achieve straight leg raises, knee flexion, and independent stair climbing, and discharge in minimally invasive UKA, when the patella is not dislocated and when the suprapatellar pouch remains intact, compared to traditional open UKA or TKA [36, 39, 40]. In addition, studies have documented that UKA may be performed as reliably with a minimally invasive approach as through a wide incision, without compromising proper component placement or long-term results [9, 26, 36, 40]. The preservation of the quadriceps tendon and suprapatellar pouch, rather
than the short skin incision itself, is most likely responsible for the diminished post-operative pain and decreased rehabilitation time associated with the minimally invasive surgical technique [40].

Because medial tibial bone loss is a major problem in converting a UKA to TKA [3, 38], a significant advantage of using an inlay all-polyethylene tibial component compared to modular components requiring a saw-cut tibial technique is that such resurfacing designs require less bone resection and preserve the medial tibial buttress, increasing the likelihood that conversion to TKA may be more easily accomplished with less bone resection should future revision become necessary, as illustrated in Fig. 9.41. Modular saw-cut tibial components are much thicker than their inlay counterparts and require sacrifice of the medial tibial buttress. In addition, resection designs often require full exposure of the joint for jig instrumentation and involve resection of larger amounts of bone. Such saw-cut components frequently utilize peg or fin fixation, which further compromises tibial bone upon implant removal and may require the use of bone grafts, special custom devices, or metal-wedge tibial trays to stabilize the tibia if conversion is necessary, further complicating the revision surgery [3, 21, 30, 38, 42].

Outpatient status requires a structured pain-management program. Spinal or general anesthesia is used in all cases. Patient education, avoidance of cerebral-depressing injectable narcotics, infiltration of all incised tissues with long-acting local anesthetics, and the preemptive use of scheduled oral 400 mg ibuprofen every 4 h and oral 500 mg acetaminophen/5 mg hydrocodone bitartrate every 4 h for the first 3 days post-operatively, all aid in controlling pain. In addition, 30 mg ketorolac tromethamine (15 mg for patients over 65 years of age) is administered either intramuscularly or intravenously during surgery and is repeated after 5 h in patients with normal renal function. This pain-management program results in fully alert patients in the recovery room with no local knee pain. When pain is absent, patients are able to perform straight leg raises and to actively participate in their post-operative rehabilitation process. In addition to the minimally invasive surgical approach, the use of the local anesthetic and avoidance of narcotics are credited for shortening the recovery and rehabilitation time, permitting the procedure to be performed on an outpatient basis.

In summary, by utilizing arthroscopy, patients with more advanced stages of osteoarthritis are excluded from UKA and, instead, may receive the more appropriate TKA. The use of arthroscopy to assist in proper patient selection reduces morbidity and increases survivorship. By avoiding patellar dislocation and non-essential tissue dissection, interference in physiology is avoided and lower morbidity and rapid rehabilitation are achieved. The minimally invasive surgical approach, combined with the specific pain-management program, allows UKA to be performed on an outpatient basis, with full independence achieved by 4 h post-operatively. This rapid rehabilitation and return to activities of daily living addresses patient satisfaction regarding minimizing interference of lifestyle. The use of a resurfacing UKA design diminishes bone resection compared to other UKA designs. Consequently, future treatment options are not interfered with and UKA use is permitted in a broader range of patients, including younger, heavier or active patients. These individual concepts, combined by the senior author into a multi-pronged minimally invasive program, work in unison to meet the goals of a minimally invasive technique: minimal interference in physiology, lifestyle, and future treatment options.

Finally, whereas TKA marks the end of a disease process and the beginning of a new predictable construct, UKA is implanted into the middle of a less predictable disease process and is considered an extension...
of conservative management. Long-term survivorship of UKA is affected by many factors, including the stage of the disease at insertion, limited tibial bone support, and material limitations, such as polyethylene deformity and wear. A minimally invasive surgical technique adds a significant variable; therefore, surgeons who choose to utilize this technique would greatly benefit from instructional training. In this context, UKA is feasible as a minimally invasive, bone-sparing outpatient procedure with low morbidity.

References


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