Introduction

Unicompartmental knee arthroplasty has been and remains controversial. Poor results reported in early reviews established the opinion that total knee replacement was a more reliable and durable operation. More recent reports have demonstrated 10-year survivorship after unicompartmental knee replacement that is comparable to total knee arthroplasty [1, 14, 22, 24, 25]. It is generally felt that these reports reflect improved patient selection, surgical technique, component design, and instrumentation. “Unicompartmental knee arthroplasty now is characterized as a procedure with a reliable 8- to 10-year outcome in improperly selected patients with osteoarthritis who receive a skillfully implanted, proper design” [5].

The advantages of unicompartmental knee replacement are well documented. Compared to total knee arthroplasty, unicompartmental knee arthroplasty is less invasive, with less blood loss, less post-operative pain, and a lower infection rate [6]. The range of motion and kinematics are more normal [19, 24, 25]. It is an attractive alternative for patients who seek rapid return of function and normal lifestyle regardless of age [3]. Unicompartmental knee replacement is a bone conserving, soft-tissue-friendly operation that sets the stage for an easier, and more successful revision arthroplasty, making it an important option for the younger, low demand patient who seeks to put off their first total knee replacement [6, 11, 13, 15].

To help guarantee long-term results that are comparable to total knee replacement, it is important to understand the unique elements of unicompartmental knee replacement. Component design and instrumentation for unicompartmental knee replacements allow improved alignment, decreased polyethylene wear, and improved long-term results. Minimally invasive surgical techniques allow easier recovery and less morbidity. But unicompartmental knee replacement is not simply a downsized total knee. Surgeons who rely on their experience in total knee arthroplasty as the foundation for unicompartmental knee arthroplasty will certainly be disappointed, as will their patients. This chapter focuses on essential principles of knee arthroplasty, component design, instrumentation, and surgical techniques that constitute a skillfully implanted, proper unicompartmental knee replacement.

Angular Alignment

Angular alignment directly influences long-term failure rates and is at least as important in unicompartmental knee replacement as it is in total knee replacement. Most surgeons experienced in unicompartmental knee replacement advocate under-correcting the mechanical axis by about 2–3° [2, 4, 5, 21, 25]. Giou et al. reviewed a multi-hospital registry of implant and explant information with emphasis on reasons for revision of unicompartmental knee replacements [7]. The major reasons for revision were opposite side degeneration (51%), aseptic loosening (25%), and polyethylene wear (21%). Over-correction of a varus knee (HKA angle >180°) leads to opposite compartment degeneration [25]. Severe under-correction (HKA <170°) leads to loosening and polyethylene wear. Hernigou’s work demonstrates that angular alignment directly influences these failure modes [8]. Ideal alignment after unicompartmental knee replacement should fall between 179° and 171°. Accurately correcting alignment with unicompartmental knee replacement greatly reduces opposite compartment...
Chapter 9.5.1 - Unicondylar Minimally Invasive degeneration. It also improves patellofemoral mechanics and helps reduce patellofemoral degeneration and pain [4, 14, 25].

Component Design

Component design influences surgical technique and determines long-term results. Early unicondylar designs frequently involved too much constraint, high contact stresses, thin polyethylene, and rudimentary instrumentation [5, 10, 12, 16]. Freehand techniques encouraged poor implant placement, rim loading, impingement, polyethylene wear, loosening, and subsidence [10, 12, 24, 25]. Tibial components with large lugs and deep fixation methods created difficult revisions requiring structural graft, stems, and custom implants [1]. It is no surprise that surgeons eventually opted for the more reliable results of total knee replacement over the less invasive unicondylar knee replacement. However, recent unicondylar design improvements address these issues.

Tibial Component Design: Onlay vs. Inlay

An inlay tibial component is cemented into a defect that is surgically created within the rim of the tibia. Freehand burring techniques are used, and the tibia is simply resurfaced with little emphasis on alignment. The component is placed within the cortical rim of the tibia on denser, subchondral bone. This technique has the theoretic advantage of preserving bone the medial tibial rim [11, 18]. However, the overall position of the tibial component, cement technique, limb alignment, and tibiofemoral kinematics are heavily influence by the native anatomy of the diseased tibia (Fig. 9.42).

An onlay tibial system starts with an L-cut tibial osteotomy that emphasizes a conservative resection, rim purchase, optimal bone coverage, and proper component position and size (Fig. 9.43). Other advantages include thicker polyethylene, instrumentation systems that establish and reproduce proper alignment, and improved cement technique [1, 5, 21]. Extramedullary guide systems can be used to eliminate freehand techniques, and instrumentation is used to achieve ligament balancing, alignment, and kinematics [4].

One of the main reasons for the poor results in early unicondylar knee replacements has been tibial loosen-
Fig. 9.43. The onlay tibial component covers the medial tibial bone with optimal rim purchase. Cement intrudes 2 mm into ideal cancellous bone. Because of the symmetric outer cross-section, the femoral component can be oriented to fit the native femoral anatomy without edge-loading.

Conformity Without Constraint

The tibio-femoral interface of the unicondylar knee replacement sees complex stresses throughout the knee's range of motion. Conformity throughout a range of motion helps avoid edge loading and polyethylene wear. Minimizing constraint helps avoid loosening, and maximizing implant-to-bone contact helps avoid subsidence [16].

The Oxford design utilizes a meniscal-bearing tibial implant that allows increased conformity without increasing constraint [12]. The Oxford experience has shown improved long-term results largely attributed to improve wear characteristics seen in a highly congruous tibio-femoral articulation. However, the implantation of a meniscal-bearing design is technically demanding and unforgiving [24, 25]. Meniscal-bearing designs introduce an additional wear surface and added bone loss. More recent designs achieve conformity without constraint in a fixed bearing design [9].

Femoral Component Design

Modern unicondylar femoral components are designed to be bone-conserving while fully capping the femoral condyle. Ideally, the entire femoral condyle is covered by the implant, and the anterior lip of the component is recessed to avoid patellar impingement. The geometry, shape and size of the implant should match the native femoral condyle. The femoral condyle may be “resurfaced” (burred) or resected (flat-cut), or a combination. In a flat cut system, an oscillating saw is used with cutting jugs. Any error with these systems tends to cause gaps, and it can be difficult to precisely resect bone. A resurfacing system uses high-speed burs that can be used with milling guides. This combination creates a precise and reproducible fit with very little bone resection.

In the EIUS system, a flat-cut resection of the posterior femur is combined with distal femoral burring. The femoral posterior resection is linked to the tibial resection through the use of tensioning blocks combined with femoral cutting jigs. Flexion space tension and tibio-femoral kinematics are addressed systematically. Femoral component shape and sizing insures adequate capping and avoids impingement. The EIUS component designed also includes an I-beam construction with a symmetric outer cross-section. The symmetric outer cross-section enhances tibio-femoral conformity within a 10° variation of positioning. The I-beam construction adds strength to this thin, low-profile component. The beam and the macro-textured surface also add to cement fixation.

or the risk of component dislocation. Adding metal backing will either reduce the polyethylene thickness or increase bone resection. Thinner polyethylene promotes wear, breakage, and subsidence [2, 9]. Deeper bone resections create a larger tibial defect and place the implant on inferior bone. Metal backing also increases shear and tensile stresses at the cement/bone and the cement/implant interfaces [4, 9]. Metal backing also adds cost, and no clinical studies have demonstrated improved results due to metal backing.
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Patient Selection

Minimally invasive surgical techniques begin with patient selection. As medial compartment osteoarthritis becomes progressively severe, the knee develops increasing deformities:
- patello-femoral arthrosis and osteophytes,
- tibial osteophytes,
- medial capsular contracture,
- tibial erosion,
- fixed varus deformity,
- tibio-femoral subluxation,
- posterolateral capsular laxity,
- flexion contracture.

Some of these deformities can be managed within the scope of minimally invasive unicondylar knee replacement. Low-grade patellofemoral arthrosis does not preclude successful unicondylar knee replacement [18, 23, 25]. Still, patellofemoral osteophytes can interfere with exposure and can impinge on the femoral implant. A partial patellar facetectomy and careful sizing and positioning of the femoral component can address both of these issues.

To some extent, varus deformity, medial contracture, and flexion contracture can be addressed by removing tibial osteophytes and releasing the coronary ligament [5]. However, varus deformities of greater than 10° from neutral can make unicondylar knee replacement complicated. Flexion contractures of greater than 10–15° are difficult to manage without removing excessive amounts of tibial bone. This places the tibial implant on weaker bone with poor load carrying capabilities and can create difficult revision situations. Tibio-femoral subluxation and posterolateral laxity cannot be addressed with unicondylar knee arthroplasty.

Minimally Invasive Surgical Techniques for Unicondylar Knee Replacement

Minimally invasive surgical techniques for unicondylar knee replacement are well established [4, 17, 19]. These techniques utilize a small incision and avoid eversion of the extensor mechanism. This allows less post-operative pain, early return of function (stair climbing and straight-leg raising), more normal range of motion, and the potential for outpatient surgery. Modern unicondy-
postero-medially along the tibia. Releasing the coronary ligament and placing an angled Hohmann's retractor exposes tibial osteophytes. This step corrects medial contracture and aids in the removal of the tibial bone after tibial osteotomy. With his type of exposure, a modified Hohmann's can be placed along the medial tibial bone, protecting the medial collateral ligament and retracting the soft tissues out of the way during the transverse tibial osteotomy.

**Tibial Osteotomy**

The tibial osteotomy is one of the pivotal steps in unicompartmental knee arthroplasty. It determines tibial slope, angular alignment, tibiofemoral mechanics, flexion and extension gaps, range of motion, and stability. It is important to take all of these elements into consideration as the osteotomy is performed. The osteotomy is begun by localizing the most deficient part of the diseased tibial condyle and placing an external tibial guide system. The surgeon needs to consider axial alignment, rotational alignment, the position of the tibial tubercle, and tibial slope. For a medial unicompartmental tibial implant, the proper rotation can be referenced from tibial flare of the spine and the lateral side of the medial femoral condyle. A reciprocating saw is used to perform a the sagittal osteotomy. That saw blade can be left in place to prevent undercutting of the tibial spine during the transverse osteotomy (Fig. 9.45).

Once tibial alignment, slope, and rotation have been set, the tibial osteotomy is done using the most conservative resection possible. The difference between the thickness of the tibial bone resected and the thickness of an onlay tibial insert determines angular alignment. Varus knees that can be corrected with a valgus stress and have a full range of motion will need very little bone...
resected. Knees with a fixed varus deformity and a fixed flexion contracture will require more bone resection in order to accommodate an 8-mm polyethylene insert. It is difficult to accurately estimate the ideal amount of tibial bone to be resected based on standard bony landmarks. After an initial, 2-mm resection, a tensor block is combined with alignment rods to evaluate ligament balancing and alignment in flexion and extension. With the knee in full extension, increasing thickness of the tensor block creates a more valgus alignment, and the alignment rod projects further and further away from the femoral head (Fig. 9.46).

Fitting the Femoral Component

Preparing the femoral condyle and placing a unicompact femoral component differs greatly from total knee arthroplasty. Sizing and positioning of the femoral component begins with identifying the tidemark and the medial-to-lateral width and contour of the femoral condyle. Since the fit is very precise, removing all osteophytes helps to avoid over-sizing and medial overhang. The femoral cutting guide can be combined with a flexion space tensioner. This instrumentation “links” the femoral posterior resection to the tibial cut and ensures appropriate ligament balancing. The positioning of the instrumentation needs to be evaluated for flexion space tensioning, femoral sizing, and femoral fit (Fig. 9.47).

Unicompact knee replacements preserve native femoral anatomy, and the femoral component is essentially fitted to that anatomy. Angular alignment is determined by the tibial osteotomy and thickness of the tibial component. Conversely, the coronal rotation and placement of the femoral component has little impact on angular alignment. Fortunately, the femoral component is designed to allow 10° of variation in the varus/valgus plane without edge-loading. Therefore, femoral component positioning can be determined according to the shape of the femur. Femoral component design and instrumentation allows for small adjustments in the sagittal, coronal, and axial planes in order to achieve maximum capping without medial overhang or lateral impingement. Once the position of the posterior resection has been linked to the tibial cut, it is appropriate to make minor adjustments in the axial rotation in order to optimize the fit. After the posterior resection is completed, a tensioner can be used to confirm the accuracy of the cut and flexion space balancing.
Placement of the distal femoral bur guide is another pivotal step in a resurfacing, unicompartmental knee replacement. It determines coronal rotation of the implant and the depth and completeness of the distal femoral resection. There is significant variation in shape from one normal femoral condyle to the next, and these variations need to be considered as the bur guide is placed. Errors in this step can lead to medial overhang, lateral impingement, and incomplete distal resections.

A unicompartmental femoral component resurfaces the femur distal and posterior and does not capture the femur anterior the way total knee femoral components do. Unicompartmental femoral components cannot allow any gaps. Gaps, especially posterior, will create tension forces on the component/cement interface and ultimately lead to failure. Femoral cutting jigs, milling guides, and tensor blocks can be sequenced and utilized so that gaps are not created. The distal femoral bone in the knee with medial compartment osteoarthritis is typically deficient. If the bur guide is positioned appropriately on the posterior resection, this femoral deficiency creates an apparent gap distal. If the gap is eliminated by simply impacting the guide, a posterior gap is created. Therefore, the distal gap should be managed by systematically improving the fit of the bur guide. This is done by eliminating the apex of the bone between the posterior resection and the distal femoral condyle and the removing anterior osteophytes using the high-speed bur (Fig. 9.48). Finally, it is very helpful to overstuff the flexion space with tensioning blocks as the bur guide is positioned and impacted (Fig. 9.49). Eliminating posterior gapping and managing the fit distally creates a precise and accurate fit between the femoral component and host bone. Since unicompartmental femoral components are not captured, this is a critically important nuance of unicompartmental technique.

### Cement Technique in Unicompartmental Knee Replacement

Cementing techniques for unicompartmental knee replacement are different from those of total knee replacement. The main differences stem from bone quality, the more limited exposure of unicompartmental knee replacement, and the potential to develop retained cement posterior. Bone resections on the tibial and femoral side are quite conservative, leaving dense, sclerotic bone for cement surfaces. A bur can be used to penetrate sclerotic bone, and applying cement before it begins to set up helps as well. It is critical to avoid excess cement. Using an implant to pressurize mounded-up cement leads to extrusion.
and poor penetration of cement into bone. Intrusion without extrusion is achieved by using a cement tool to pressurize small amounts of cement. Excess cement can easily be removed, and additional increments of cement can be pressurized until the bone surface is fully impregnated. Once this process of intrusion without extrusion is completed, cement is evenly pressurized over the entire cancellous bed and little or no cement is seen above the bone surface.

Cement is then thoroughly but carefully preloaded onto the implant. In the case of the tibial implant, cement is carefully packed into the dovetail insets. Again, little or no excess cement is used. The cement is already pressurized, and any mounded cement only serves to create extrusion. The tibial component can be seated in an a posteriori-to-anterior direction, forcing extruded cement anterior. A soap sponge can be packed into the popliteal space prior to cementing. This restricts cement that may extrude. Excess cement can be removed as the sponge is removed. This same basic technique is useful for the femoral side. It is easy to safely preload femoral bone over the distal femoral condyle. The posterior femoral resection should be preloaded carefully and conservatively with a cement tool. Any preloading posterior must leave the cement flush with bone so that cement is not piled posterior as the implant is placed. Instead, preload cement on the implant. This will help keep extruded cement out of the popliteal space.

Conclusions

Unicondylar knee replacement can be much more than a minimally invasive resurfacing of worn out tibial and femoral joint surfaces. This procedure can and should adhere to the basic principles that have established total knee replacements as one of the most successful, reliable and durable operations available. Authors have shown that results of unicondylar knee replacement can be comparable to those of total knee replacement. However, other reports have shown that poor implant design, surgical technique, and patient selection can lead to disappointing results [20]. The use of one or two tibial component enables precise management of component position, flexion and extension spaces, alignment, and tibio-femoral kinematics. Modern component design combined with precise and conservative bone resections provides stable, reliable, and durable fixation. Instrumentation and surgical techniques that enable accurate restoration of ideal alignment will help prevent opposite-compartment degeneration, polyethylene wear, loosening, and subsidence. In an era when total knee replacement is becoming less invasive and more reliable, unicondylar knee replacement must achieve comparably reliable, long-term results.

References