SURGICAL TECHNIQUES IN THE PERFORMANCE OF UNICOMPARTMENTAL ARTHROPLASTIES

PETER A. KEBLISH, JR, MD

The technical principles of unicompartmental knee arthroplasty (UKA) are similar to but subtly different from total knee arthroplasty (TKA). Reestablishing the joint line of the diseased compartment and restoring the altered anterior cruciate ligament, posterior cruciate ligament, and collateral (medial and lateral) kinematics are the goals of surgery. When proper indications exist, normal knee function is possible. Instrumentation systems plus surgical expertise must provide for accurate compartment resurfacing of the femoral condyle and tibial plateau. Technical errors of malposition (rotational, varus-valgus, flexion-extension) and gap imbalance (depth of resection) will negatively affect stability, mobility, wear, and fixation with less than satisfactory clinical outcomes. Because few UKAs are performed, even by so-called experts, more attention to detail is required. Excellent long-term results can be appreciated when patient selection, prosthetic design, and surgical technique are optimal. This section addresses the key technical aspects of UKA that will affect clinical results.

KEY WORDS: arthroplasty, knee prosthesis, prosthesis design

Unicompartmental knee arthroplasty (UKA) provides an alternative to high tibial osteotomy (HTO) and total knee arthroplasty (TKA) for angular knee deformity. Criteria and selection factors in the literature to date have been conservative.[1-4] The procedure is usually recommended for relatively inactive, elderly patients. An increasing number of patients, however, are more youthful, more active, will live longer, and desire to maintain an active lifestyle, including recreational athletics, such as tennis, skiing, and so on. These patients may be too young for TKA and may not meet the treatment criteria for HTO or newer approaches, such as autologous cartilage autotransplantation and allograft (bone, cartilage, meniscal) transplantation.[5] Improvement in prosthetic design, materials, instrumentation, and surgical technique have renewed interest in UKA for this patient group.

The philosophy of UKA is to realign minimal, correctable angular deformity while preserving normal kinematics. The procedure entails a resurfacing to reestablish the normal ligament environment (cruciates and collaterals) and the mechanical axis to the premorbid alignment, which is dictated by collateral ligament tension. Flexion-extension balancing must be accomplished without lengthening releases, subtle elevation of the joint line, overloading the opposite compartment, overcorrection, or creating patellofemoral impingement.

Patient selection remains the most important factor if early failures are to be avoided. All investigators have stressed that UKA patient selection is most important, including proper diagnosis, age, activity level, weight, and appropriate imaging studies (magnetic resonance imaging, computed tomography scans) to confirm noninflammatory single compartment disease. Most agree that the patient should have a correctable deformity, an intact anterior cruciate ligament (ACL), no or minimal opposite compartment, or no patellofemoral involvement (Fig 1). The patient should be well motivated with a good understanding of the philosophy of the procedure. Many patients have had previous arthroscopic surgery with well-documented compartment pathology and overall joint assessment. However, conversion to TKA at surgery, if indicated, must be agreed upon by the patient because more extensive disease may be present than had been anticipated.

Prosthetic design, the second major factor in successful UKA, must allow for unconstrained motion without mechanical (translational or rotational) blocks.[6] Designs that have attempted to introduce increased stability without allowing for mobility have resulted in premature mechanical failures,[7,8] whereas designs with high contact stress have led to failures secondary to polyethylene wear.[8-11] The two basic designs that have stood the test of time (Fig 2) are round-on-flat fixed bearing and meniscal bearing with more congruent geometry. Fixed-bearing designs include all polyethylene tibial components (Marmor prototype; Richards, Memphis, TN) or metallic-backed polyethylene tibial components (Brigham prototype; Johnson and Johnson, New Brunswick, NJ), which have been modified to allow for cementless fixation and modularity. Meniscal-bearing designs include the Oxford (Biomet, Warsaw, IN) (Goodfellow-O'Connor) cemented straight track constant radius and the low contact stress (LCS; De Puy, Leeds, UK) radial track with decreasing radius of curvature. The LCS provides the option of cementless fixation. Fixed and meniscal-bearing knees have been used successfully for over 20 years and provide options for the orthopaedic

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From the Division of Orthopaedic Surgery, Lehigh Valley Hospital, Allentown, PA; and the Penn State University College of Medicine, Hershey, PA.

Address reprint requests to Peter Keblish, MD, 1243 S. Cedar Crest Blvd, Suite 2500, Allentown, PA 18103.

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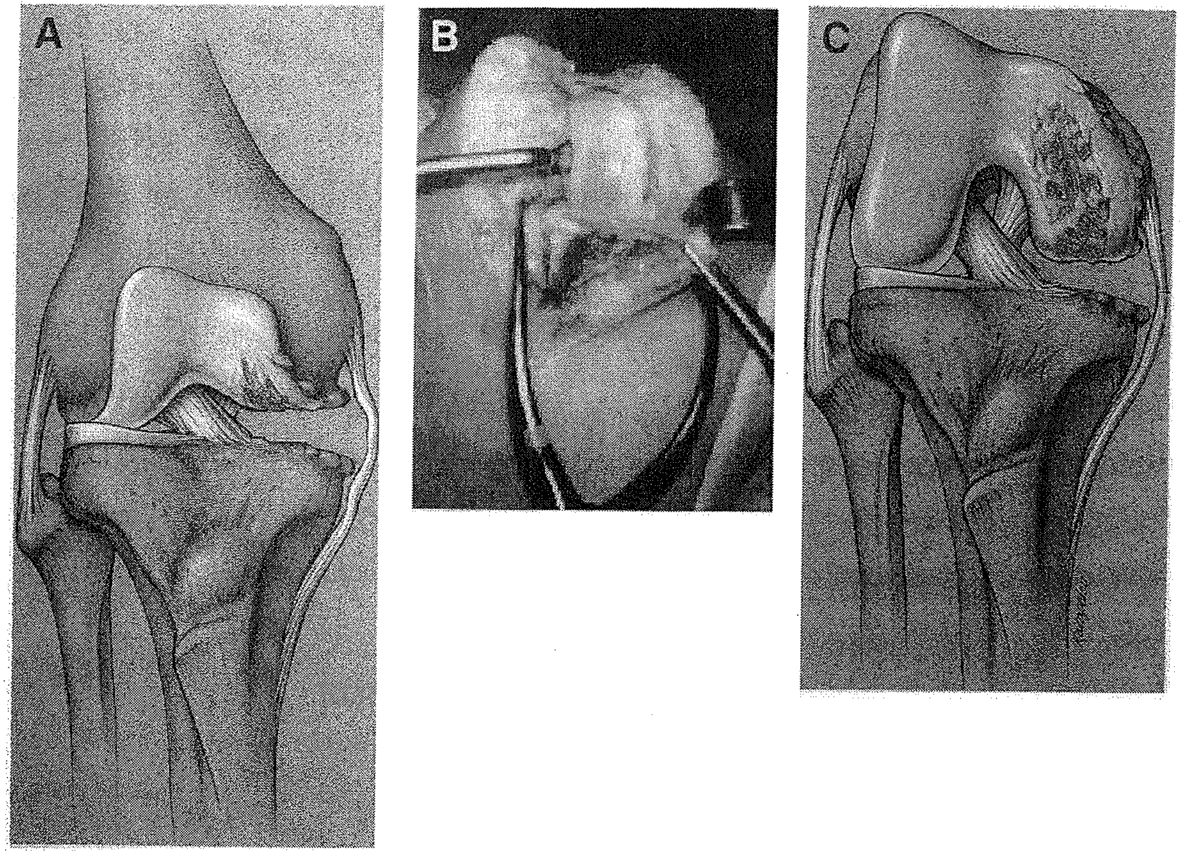

Fig 1. Ideal candidate for UKA. Typical medial compartment arthrosis with correctable deformity and intact ACL (cartilage loss instability). Illustrations (A) in extension and (C) in flexion. (B) Intraoperative view in flexion.

surgeon who believes in the concept of UKA. Both fixed and meniscal-bearing knees present the surgeon with the challenge of proper implantation. Basic surgical principles apply to all design systems but variations exist.

More precise instrumentation and improved prosthetic design have enhanced the surgeon's ability to achieve a better outcome. The initial technique was principally an "eyeballing," which has proven to be less than satisfactory and is reflected in literature reports.[12] Surgical technique and principles of accurate surgical alignment in UKA are important factors that are basic to satisfactory outcomes. The technique of UKA is more challenging, and experience with operative techniques is frequently limited in residencies and/or fellowships. This paper addresses the technical aspects of surgery required to achieve reproducible alignment while avoiding the multiple pitfalls inherent in the procedure.

SURGICAL APPROACH

Medial UKA

A midline anterior skin incision is preferred. The incision is angled distally to the medial side of the tibial tubercle. Minimal undermining is required. The arthrotomy incision can be performed through the standard parapatellar, subvastus, or the midvastus variation, which is the current approach of choice. The midvastus approach, popularized by Engh et al,[13] splits the medial quadriceps and capsule from the anteromedial attachment of the patella proximally along a natural cleavage plane. The distal retinaculum (with the vastus medialis obliquus) is grasped with a tenaculum and turned down, exposing the medial condyle. A limited medial sleeve release of the upper tibia enhances the exposure. The status of the lateral and patellar femoral compartments can be assessed without everting the patella. Patella eversion and extensive exposure are not required in UKA. However, if the surgeon is more comfortable with a more extensive exposure, it is easily accomplished with the midvastus approach. The advantages of patella translocation include minimizing the external tibial rotation and protecting the normal articular cartilage. Maintaining the bulk of the medial quadriceps to the central tendon allows for better patella control intraoperatively, less postoperative pain, and more rapid rehabilitation.

Lateral UKA

Lateral compartment replacement for valgus instability is best performed through the direct lateral approach,[14-16] which accomplishes the lateral release with the exposure. The skin incision is proximal midline ending distally at a point between Gerdy's tubercle and the tibial tubercle. The arthrotomy incision splits the retinaculum (superficial layer) at the medial border of Gerdy's tubercle and extends proximally, 1 to 2 cm lateral to the patella. The deep capsular layer is released from the patellar rim. The

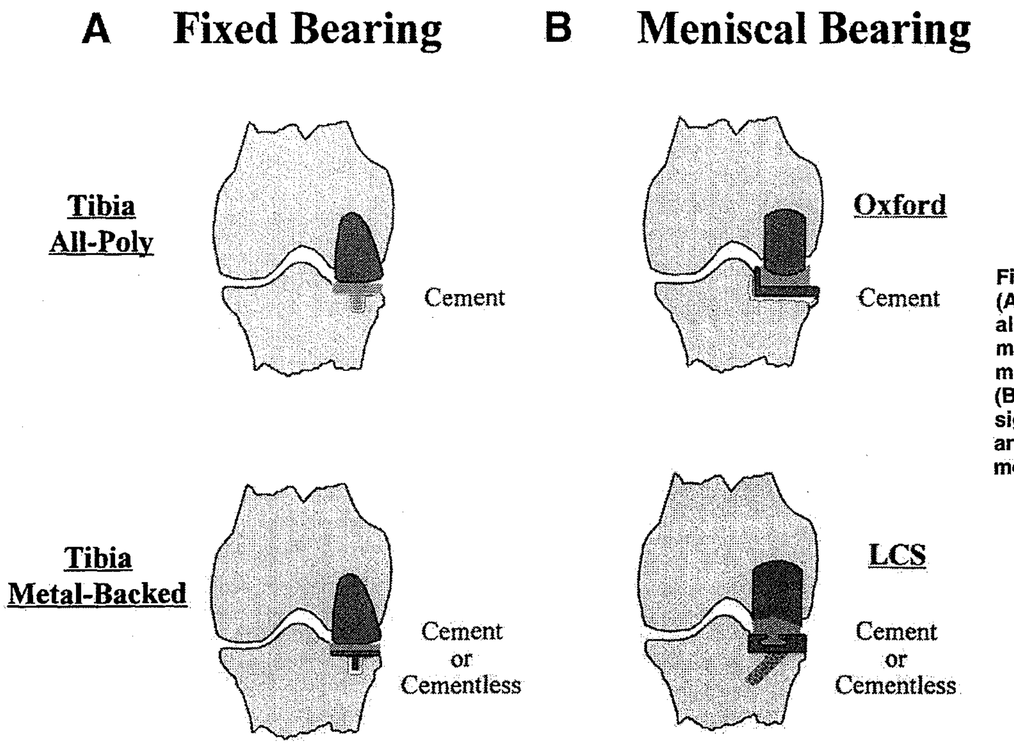

Fig 2. UKA prototypes. (A) Fixed-bearing design, all polyethylene and metal-backed tibia, cemented or cementless. (B) Meniscal bearing design, Oxford (cemented) and LCS (cemented or cementless).

proximal arthrotomy can be completed by splitting the vastus lateralis or a limited lateral parapatellar incision made obliquely through the central tendon. The iliotibial band is released in sleeve fashion from the upper tibia (as required) to enhance exposure of the posterolateral corner. Closure in flexion allows for precise soft-tissue adjustment of the prepared layers.

The direct lateral approach allows for direct soft tissue release, adequate exposure without everting the patella, improved patellofemoral tracking, minimal soft tissue trauma, and rapid rehabilitation. The approach can be extended if TKA is required. The standard medial approach can be used but has many disadvantages in lateral UKA, including (1) a required extensive approach; (2) accentuated external tibial rotation, which may influence technique and instrumentation; (3) limited component visualization during trial reduction; and (4) less than optimal patella tracking, necessitating a lateral release.

BONE RESECTIONS

Position and Orientation Variables

Effective instrumentation should reliably establish the correct size, position, and orientation of the femoral and tibial components. The variables of axial rotation, varus-valgus tilt, flexion-extension orientation, anteroposterior (AP) position, and joint line level must be correctly defined by the surgeon by using instruments designed for these purposes. Proper flexion-extension gap balancing should allow for unimpeded motion with normal kinematic control. Bone resections are the key element in preparing implantation surfaces and dictate final positioning. The potential for malresection exists on both femoral and tibial sides (Fig 3) and will be described later in more detail.

Errors are compounded if instrument malposition (malresection) is made on both sides and are more common with anatomic variations, such as flared femoral condyles, which may be a contradiction to UKA.

Tibial first or femoral first approaches can be used, depending on the UKA system[17,18] and instrumentation philosophy/rationale. Most implantation systems, however, have similar guidelines, including (1) referencing off the subchondral bone, which is more consistent, or a fixed point such as the ACL insertion; (2) correct tibial rotation to reproduce a perpendicular mediolateral plane with a 7° to 10° posterior slope; (3) extramedullary instrumentation for the tibial resection; and (4) mating the femoral resection to the tibial resection plane with appropriate resection blocks. Femoral orientation can include either extramedullary or intramedullary instrumentation. An intramedullary system requires a more extensive approach and violation of the femoral canal, both potential disadvantages.

The principles of bone resection are similar for fixed and mobile bearing systems. The following description is for the LCS mobile bearing UKA system, which I have used for the past 17 years. The approach is tibia first. Illustrations are for a medial compartment replacement (left), because medial compartment replacement represents 90% to 95% of UKAs.

Bone Surface Preparation

Exposure of the tibial plateau is enhanced by a sleeve elevation that is adequate enough to allow for exposure and removal of peripheral osteophytes to normal anatomy. Preservation of the outer meniscal rim is recommended to maintain the integrity of the medial sleeve, preserve optimal stability, and avoid geniculate vessels.

Tibial and femoral osteophytes are best removed with a

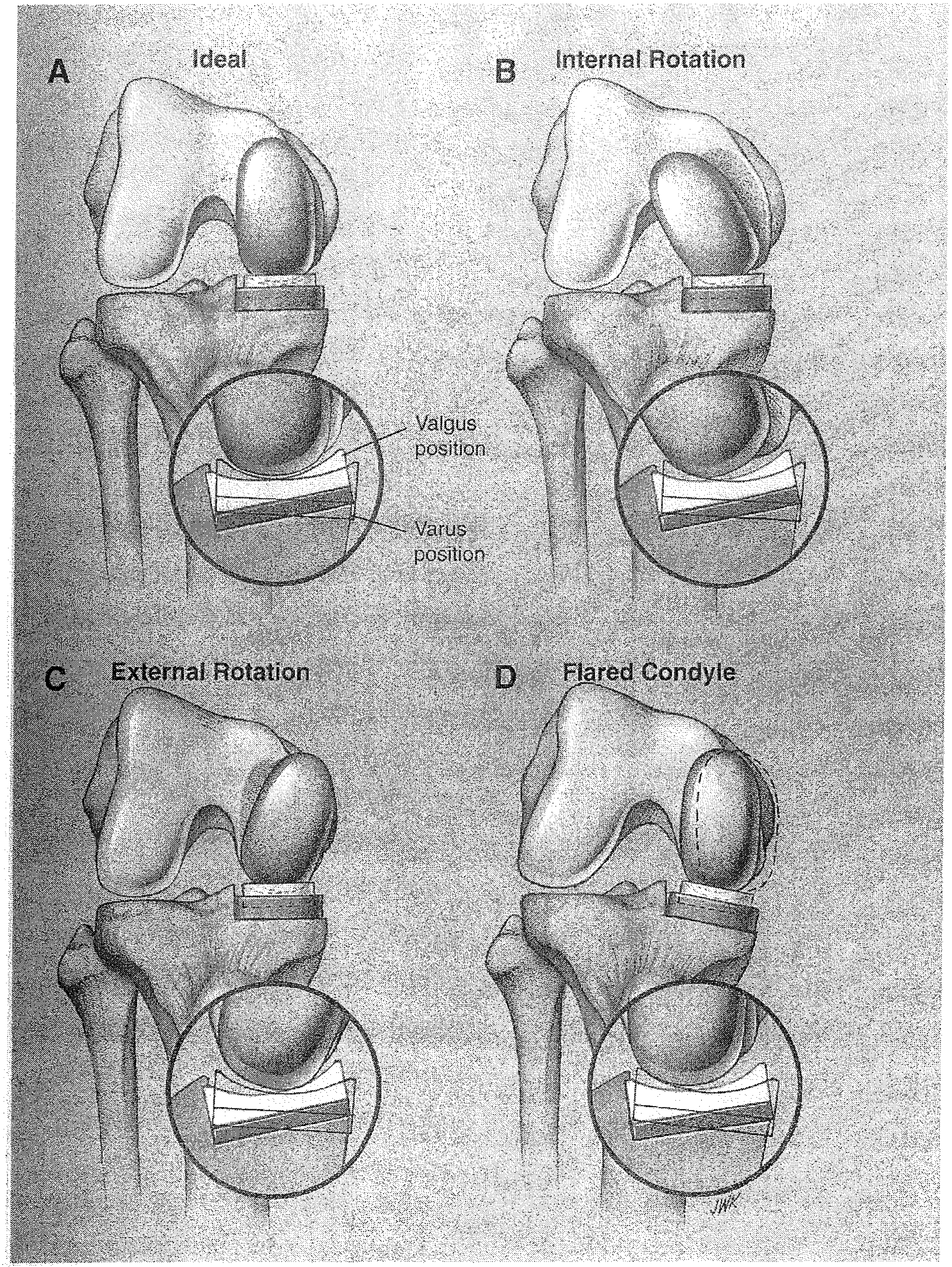

Fig 3. Bone resection (prosthetic position) variables in flexion. Malresections are compounded if AP or sagittal plane rotation cuts are less than ideal, if femoral geometry is atypical (ie, flared), or gaps unequal. (A) Ideal; (B) internal rotation of the femoral component; (C) external rotation of the femoral component; and (D) flared condyle with component position variables. Circular insets illustrate tibial varus-valgus malposition.

reciprocating saw and/or rongeurs to reestablish premorbid anatomy. External tibial rotation will improve access to the posterior corner. Loose bodies or remaining posterior osteophytes are removed. Anatomic variants, pathological erosions, the tibial slope, and bone quality are assessed. Articular (cartilage and bone) high points or irregularities should be removed to subchondral bone because referencing is more accurate and the bone surfaces are more accessible for instrumentation.

THE TIBIAL "L" RESECTION

General Principles

Accuracy of the tibial resection is critical and is determined by proper instrument positioning for variables of rotation (coronal plane), varus-valgus tilt, flexion extension (AP slope), horizontal limit (sizing), and depth of resection. Rotational orientation influences varus-valgus and the AP positions (posterior slope) and therefore should be established first. Malposition of the rotational setting can lead to subtle or obvious changes in the varus-valgus and AP slope cuts, which may lead to less than ideal resections. Malresections will result in higher contact stress at the articulating surface and increased torque forces at the bone (cement) prosthetic interface, especially in fixed bearings with round-on-flat or dished geometries.

Tibial Resection Guide Positioning

Extramedullary guide systems are the norm because ACL preservation is a requirement for UKA. Standard TKA alignment systems can be used, but extensive exposure is required. Lower profile UKA tibial resection guides, as used in the LCS system, allow for instrumentation with more limited compartment exposure as recommended. The resection guide should allow for small adjustments of the alignment rod to fine tune rotation and the varus-valgus and AP positions. The guide should allow for an adjustable resection block to accommodate the depth of resection changes (Fig 4).

Rotation Alignment

The sagittal plane of the "L" resection dictates the rotational orientation of the tibial component; therefore, this setting is primary. The alignment rod (with resection block) is fixed to the tibial spine proximally and to the ankle positioning clamp distally. The rod is set over the tibial crest or proximally at the medial border of the tibial tubercle, which are the most consistent rotational landmarks. More medial rod alignment will result in an internally rotated tibial component, whereas more lateral rod alignment will result in an externally rotated component. Both errors will result in rotational malalignment that will be accentuated with the knee in extension.

Varus-Valgus Alignment

The mediolateral resection should be made perpendicular to the anatomic (mechanical) axis of the tibia. The alignment rod is best referenced distally (ankle level) to the tibialis anterior tendon. The lateral border of the tibialis anterior tendon is easily palpable and centers over the midpoint of the talus. This point is slightly medial to the midpoint of the malleus and centers over the second metatarsal when the foot is normal. Medial rod placement will result in a valgus position, and lateral rod placement, which is more common, will result in a varus position. An ideal (perpendicular) resection is critical, therefore the alignment rod should be rechecked before final resection.

Flexion-Extension (AP) Alignment

Reproducing the patient's normal posterior slope (5° to 10°) is the goal and is important for restoration of normal kinematics of the ACL/posterior cruciate ligament (PCL) and the so-called four-bar linkage. Alignment systems should allow for AP adjustment. The LCS resection block is set for a 7° posterior resection when the alignment rod is parallel to the tibial crest and/or fibular shaft as viewed from the lateral side. Anterior placement of the rod will increase the posterior slope whereas posterior rod alignment will decrease the posterior slope. Some "eyeballing" may be required if external landmarks are obscured. Remember that a neutral or decreased posterior slope will limit rollback and flexion, increase contact stress on the posterior bearing surface, increase polyethylene wear, and increase the potential for prosthetic lift off and prosthetic fixation failure.

Depth of Resection

The depth of resection is best determined after having confirmed the other variables. The goal is to resect enough bone to allow space for the "total tibial prosthetic thickness" without elevating the joint line (femoral-tibial articulating surface). The most consistent landmarks for establishing the proper depth of resection are the ACL insertion and the upper slope of the tibial spine. The final joint line (articulating interface) should be located at this level to allow for optimal kinematics. The tibial resection block is adjusted to a level that accommodates the prosthetic space requirement. The level is estimated with a stylus or, preferably, an accurately sized tibial drill guide/template (Fig 5). The minimal resection approach is frequently recommended and has resulted in failures secondary to overcorrection, joint line elevation, increased polyethylene wear, fixation, patella impingement, etc, and should be avoided. The space is more finite in UKA (ACL-PCL controlled) and relates most critically to the normal opposite compartment.

The "L" resection is completed after all of the variables have been checked and fine tuned. Minor malalignments can be acceptable, especially in round-on-flat, fixed-bearing systems that usually "trough out" the polyethylene along the rotational arc (from flexion to extension) over time.[17,18] Final selection of the tibial component size is determined after the "L" resection. Optimal peripheral bony rim contact should be obtained with abutment of the sagittal tibial surface against the vertical arm of the "L" resection (Fig 6). Minor adjustments can be made if the depth of resection changes. The ACL insertion must be preserved and the final tibial articulating surface adjusted

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