TIPS AND PEARLS IN REVISION TOTAL KNEE ARTHROPLASTY

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INTRODUCTION

Revision total knee arthroplasty (TKA) tends to be a complex procedure due to the high number of surgical instruments and the lack of standardization in the procedural phases. Revision TKA can be performed based on three fundamental steps: 1) recreation of the tibia platform, 2) recreation of the flexion gap, and 3) recreation of the extension gap [1]. Utilizing these standard guidelines, the surgeon can simplify the procedure by knowing an additional number of technical pitfalls. The purpose of this chapter is to describe some technical and procedural pitfalls in order to show the surgeon a simpler, faster and more-organized manner of performing revision TKA.

SURGICAL TIP NUMBER 1: PRE-OPERATIVE PLANNING AND COUNTDOWN OF INSTRUMENTATION

The surgeon should be familiar with pre-operative planning and revision TKA, starting with obtaining proper x-rays with a magnification that allows measurements for templating devices. From the pre-operative planning, the surgeon will have an idea of the following: implant sizing for the tibia and femur; the need for offset or straight stems; the diameter of the stems; the need for custom-made solutions (Figure 8.1); the need for bone loss solutions, like an augmentation graft; and lastly, the need for alignment restoration for the deformity of the leg. From the pre-operative planning,

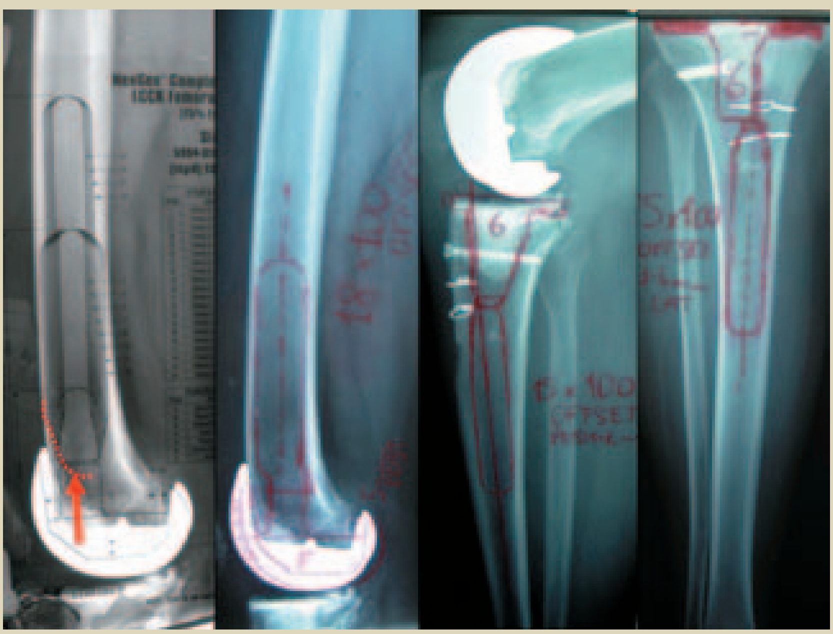


Figure 8.1—Pre-operative planning typically involves implant sizing, assessment of bone defects, and evaluation of meta-diaphyseal mismatch for the tibia and femur.

Figure 8.2 —An example of an back-table is shown with the preassembled trial parts and a simplified number of necessary tools for the procedure.

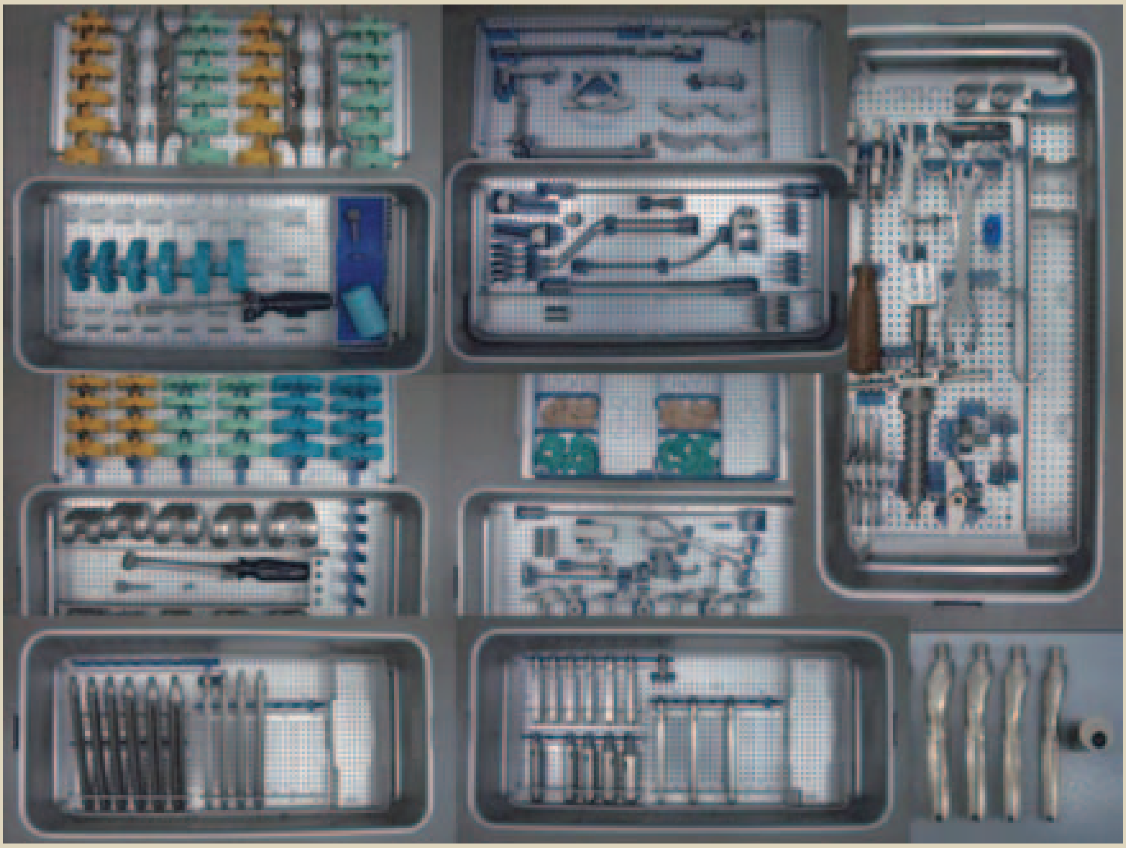


Figure 8.3 —Part of the large number of cassettes containing set of instruments for a typical revision total knee arthroplasty.

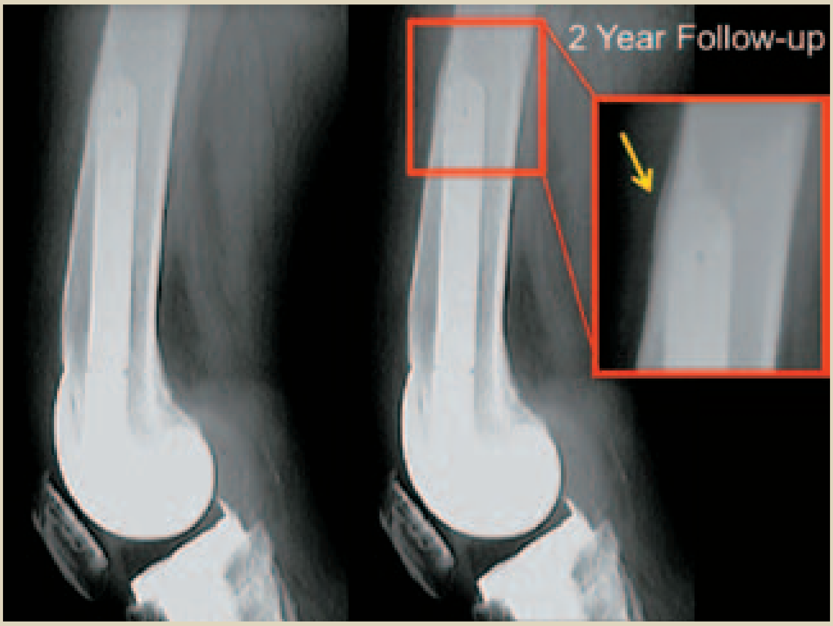


Figure 8.4—The low entry point in the femoral canal is shown in preoperative sagittal x-rays (note the contact between the tip of the stem and the anterior femoral cortex and the undersized final stem diameter).

the surgeon and the surgical team, including the scrub nurse, should review the steps of the procedure before starting the revision TKA, facilitating a more efficient procedure and a more knowledgeable team. With a careful plan the scrub nurse will be able to preassemble parts from the main charts of instruments (Figure 8.2), allowing a fast and smooth transition between the surgical phases (Figure 8.3). Also, the surgeon should be able to identify the proper entry point for the femoral and tibial canal, by analyzing landmarks on the previous implant or bone (Figure 8.4). These landmarks should be marked and memorized on the x-ray in a way that can be adopted as intraoperative feedback when the surgical reconstruction starts.

SURGICAL TIP NUMBER 2: EXPOSURE WITHOUT EXTENSILE APPROACHES

When the surgeon faces a revision knee with a limited range of motion and stiffness reduces the possibility to gain exposure to the components for removal and reconstruction, there is a general low threshold for the surgeon to perform an extensile approach, such as a tibial tubercle osteotomy, or a proximal exposure, such as a V-Y turndown. Proximal or distal extensile approaches are inherently more invasive. They may limit the postoperative rehabilitation protocol, and they have a finite rate of possible complications.[2-3] In the case of a stiff joint, the surgeon should limit the performance of these extensile approaches by manipulating the extensor mechanism in extension with the removal of synovial adhesions of the medial and lateral patellofemoral gutters, opening the supra-patellar pouch and removing all the adhesions between the rectus muscle and the bony aspect of the femur. After having performed this proximal internal arthrolysis of the medial, lateral, and superior aspect of the distal femur, the surgeon can displace the extensor mechanism laterally through a long standard medial parapatellar approach, which extends proximally to the fibers of the rectus muscle. At this point, the surgeon can utilize some maneuvers adopted from minimally invasive techniques in primary TKA, which generally requires working at lower degrees of flexion in the first surgical phases. With the foot of the patient held in the externally rotated position and a pin placed on the insertion of the patellar tendon on the tubercle, additional dangerous tension can be kept under the surgeon control. Then, the component removal has a particular sequence starting from the polyethylene, which creates some additional space, followed by the femoral component, which does not need much flexion. Removing the poly and the femoral component automatically creates extra space, resulting in the possibility of gaining further flexion for the exposure and safe removal of the tibial component as well. If there continues to be difficulty in obtaining flexion and an adequate exposure to perform the procedure, the surgeon should selectively lengthen the extensor mechanism by performing 10 to 12 pie-crustings with a number 15 blade over the quadriceps tendon at different levels, which can be slightly manipulated to gain an additional 10 to 15 degrees of flexion without traumatic disruptions.

SURGICAL TIP NUMBER 3: COMPONENTS REMOVAL

Components removal in revision arthroplasty should be expeditious and without additional bone loss from iatrogenic maneuvers. Well-fixed femoral and tibial components can be challenging to remove. The surgeon should plan maneuvers and things to do, regarding the quick and safe removal of these components, without creating damages, and without adopting an extensile approach if possible. There is a rationale to remove the polyethylene first in extension, creating more space and facilitating motion in the case of a stiff joint. This mild flexion that the surgeon is able to obtain will guarantee exposure to all the interfaces of the femoral component. The femoral component interface - both medial and lateral - can be accessed with sharp, thin instruments. The use of a reciprocating saw blade is generally very useful because it is a powerful instrument with limited thickness, and enables the surgeon to rapidly work at the interface between the femur and cement (in the case of cemented implants). Also, it can easily be used at the level of the interface of the trochlea, the chamfers, and the distal condyle. In regards to the posterior condyle's aspect, the surgeon should work at the interface using a narrow osteotome - straight or angulated - in order to prevent damaging of the collateral ligaments insertion and the bone. In cruciate-retaining (CR) implants, the saw blade should go underneath the trochlea from the box area. The extraction of the femoral component should avoid following a pathway in flexion because the femoral condyles, while coming out, can bend and sink into the bone of the posterior femoral condyles. As a result, the assistant should hammer at the trochlear level while the surgeon maintains the femoral component with an extraction device in a parallel position to the distal femur, avoiding flexion while extraction.

This extraction is also applicable to cementless femoral components. When the tibial component is cemented, it is relatively easy to work on the medial aspect because the exposure should uncover the medial aspect of the tibial base plate. Additional flexion in the case of a stiff knee can be reached because the polyethylene components have been removed, allowing more space. Then, using the same oscillating saw blade, the surgeon can go posterior to the base plate, maintaining protection of the posterior arterial vessels. With the saw blade, it is also possible to go posteriorly from medial to lateral and anteriorly if the patella is not everted; however, a common scenario is to have a limited access to the antero-lateral tibial plateau because of the short, contracted patellar tendon, which is often in the way. As a result, the surgeon with the knife can create a small longitudinal split of the fibers laterally to the patellar tendon. Then, a blunt instrument can enter through the split, and the tibia can be impacted laterally using the mallet, while controlling the base plate from the medial side. The lateral impaction at the less-exposed tibial plateau prevents the base plate from sinking at that level while removing it. In the case of the well-fixed, cementless tibial base components, the central keel, which is not accessible from the surface, is often integrated to the bone, leading to a difficult extraction procedure. As a result, there may be a need to create a frontal window in the cortical bone of the anterior aspect of the tibia to access the keel and prevent bone loss while removing it. Alternatively, some central bone loss in the metaphyseal medullary area can be tolerable because it generally will not harm the reconstruction. Special care should be dedicated to those cementless components with the keel adjacent to the posterior tibial cortical wall, because a vertical pullout can create an extensive bone interruption at that level.

SURGICAL TIP NUMBER 4: GAPS ASSESSMENT

Before starting the reconstruction, the surgeon should measure the gaps in extension and in flexion, using spacer blocks or calibrated laminar spreaders (Figure 8.5). These instruments provide the surgeon with an idea of the dimension of both the gaps and the presence of ligament imbalance, such as an asymmetric gaps scenario where one side opens more than the other. Knowing whether the gap is balanced or imbalanced from the beginning of the procedure allows the surgeon and the surgical team to understand future passages. Then, the surgeon can measure distances from the medial and lateral epicondyle to the joint line, providing

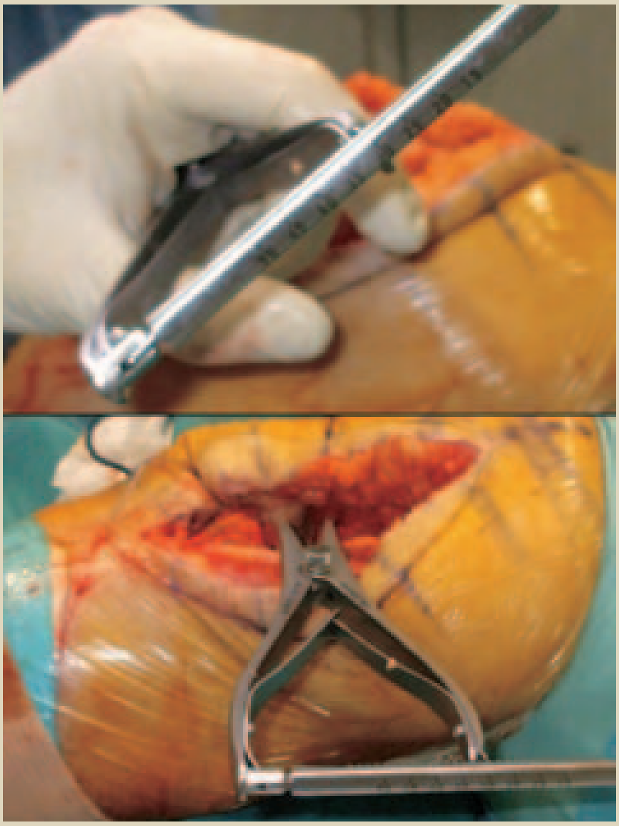


Figure 8.5 —Flexion and extension gap measurement using calibrated laminar spreaders.

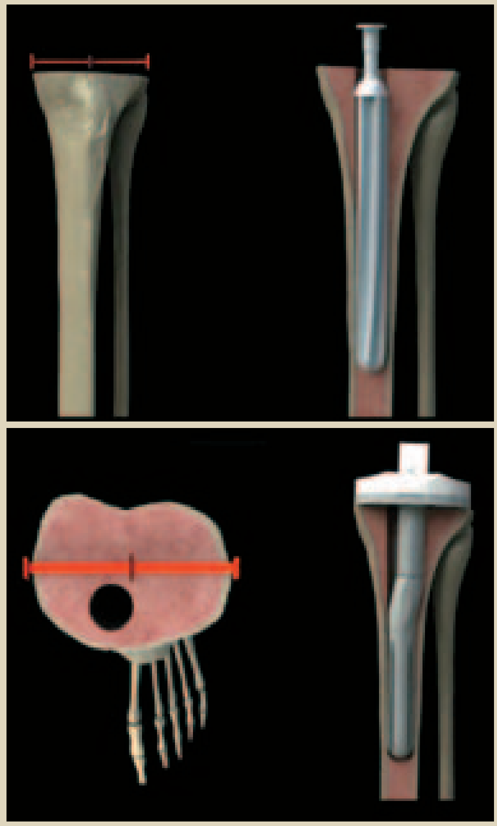


Figure 8.6 —A) The natural offset between tibial metaphysis and diaphysis with a medial entry point. B) Offset stem needed for centering the tibial platform on the tibial plateau.

the surgeon with which the direction the joint line should be built and whether the presence of bone loss exists. The build-up should be made from the femoral side relative to either the distal or the posterior joint line or both. In case of a low tibial resection, the surgeon should be able to identify the proper level of the tibial platform by measuring the distance from the tibia tubercle, the tip of the fibular head, or using the remnant of the meniscus scar as a landmark.

SURGICAL TIP NUMBER 5: CANAL REAMING

Both canals have special features in reaming. The tibial canal usually has a medial entry point at the metaphyseal level because there is a natural offset of the metaphysis related to the diaphysis, which should be recognized on the pre-operative [4] (Figure 8.6). In some cases, there is not an offset due to a pre-operative deformity of the metaphyseal varus, exposing the lateral tibial spine to the center of the diaphysis. In the other cases, the center of the diaphyseal canal corresponds to the medial aspect of the tibial plateau (i.e., valgus bow of the tibia). When the canal is entered through the proper entry point, the surgeon should aim for a proper direction of reaming. There is a tendency toward posterior reaming of the tibial canal and consequently, posterior positioning of the tibial implant because the density of the medullary bone of the tibial side in the sagittal plane is greater in the anterior aspect with respect to the posterior aspect, pushing the reamer in the posterior direction. The surgeon should counteract this tendency by applying a force in the anterior direction. Sclerotic areas at the metaphyseal level can be accessed with sharp instruments or high-speed bars in order to push the reamer in

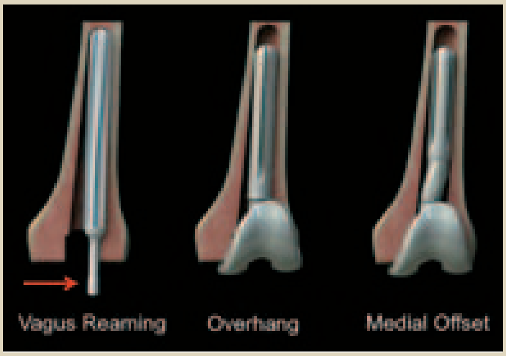


Figure 8.7—Femoral reaming against the lateral cortex leads to lateral overhang requiring a medial femoral offset stem. With this technique the surgeon is able to obtain 2-3° of additional femoral valgus alignment.

the proper anterior and medial direction. The surgeon should not allow sclerotic bone to direct reaming toward the undesired direction.

Femur reaming requires attention to both coronal and sagittal planes. Regarding the coronal reaming, the surgeon should have an idea of the amount of valgus or varus degree of correction relative to the mechanical axis from the pre-operative planning. Typically, six degrees of fixed valgus are present in modern revision implants. However, this may not be enough in the case of the femoral bow on the coronal plane with the varus effect or the valgus effect. In cases where valgus is greater than six degrees, the surgeon should ream in the coronal plane toward the lateral cortex, allowing a few degrees of valgus that will add further correction to the pre-operative deformity (Figure 8.7). In case of a valgus diaphysis, the surgeon may reduce the malalignment by directing the reaming of the canal towards the medial aspect of the knee. In summary, reaming medially goes in the varus direction while reaming laterally goes in the valgus direction.[5] On the sagittal plane, there is a tendency to have a low entry point due to the fear of disrupting the anterior bone bridge, which is usually weak in revision TKA. The surgeon should use a low entry point, reaming toward the anterior bow of the femur. This will lead to a smaller diameter of the femur stem, which will impinge at the apex to the anterior aspect of the femur cortex (Figure 8.4). In order to avoid this, the surgeon should use a higher entry point with the first reamer, raising his/her hand until the reaming is contacting the entire anterior cortex of the femur (Figure 8.8). Then, the surgeon will use the other diameter-enlargement reamer, enlarging the canal and producing the correct stem size and stem distribution of forces in the canal. The longer the stem, the more difficult to direct the reaming because the stem engages the central part of the diaphysis, which has a cylindrical shape, pushing toward a definite direction of the surgeon's hand. With shorter stems up to 150-160 mm of combined length, the tip of the stem engages the cylindrical part of the diaphysis while the rest of the stem is still in the trumpet zone of the meta-diaphyseal transition, enabling the surgeon to play with the canal direction.

In order to direct canal reaming in the femur and tibia, power reaming is suggested because it conserves the energy of turning the reamer, allowing the surgeon's force to be applied in the desired direction of the reaming. Typically, reamers are blunt at the heads, so the diaphysis can be relatively protected against perforation until the cortex is reached. If cementless stem extensions are utilized, the surgeon should search for cortical contact without forcing it.

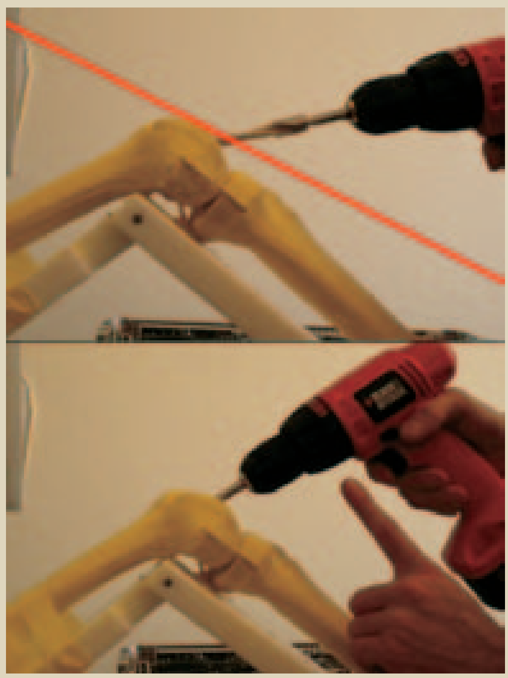


Figure 8.8—Femoral reaming from a sagittal view: reaming with a low entry point leads to divergence between the direction of the reamer and the canal itself.

SURGICAL TIP NUMBER 6: TIBIAL ROTATIONAL ALIGNMENT

Malrotation of the tibial component is a common feature that a surgeon faces in revision TKA due to a difficulty in identifying reproducible bony landmarks in the setting of primary TKA for tibial rotational alignment (Figure 8.9). In coupled-component alignment for primary TKA, there is a tendency for internal rotation of the tibial component. The surgeon should be able to properly rotate the implant, referring to the anterior cortex of the tibial plateau, if it is not damaged by bone loss. In a recent MRI study, we demonstrated that the tibial cortex is the most accurate landmark, providing a good coupling in extension with femoral rotation both in reference to the epicondylar axis and to the extensor mechanism of the knee. [6] The final rotation should match the curve of a symmetric tibial component to the curve of the anterior tibial cortex, which leaves some bone of the posterior medial aspect of the tibia exposed. The size of the tibial base plate should be chosen from the dimension of the lateral plateau, which is smaller than the medial plateau (Figure 8.10). A double check of the component rotation should be performed, referring to a point on the medial third to the mid third of the tibial tubercle. This represents the anterior landmark while the back of the component should face toward the PCL insertion, which represents the second posterior landmark. When a fixed-bearing semi-constrained implant is chosen, rotation of the tibial component is crucial to the proper positioning of the leg with respect to the thigh in order to have a proper tracking of the extensor mechanism.

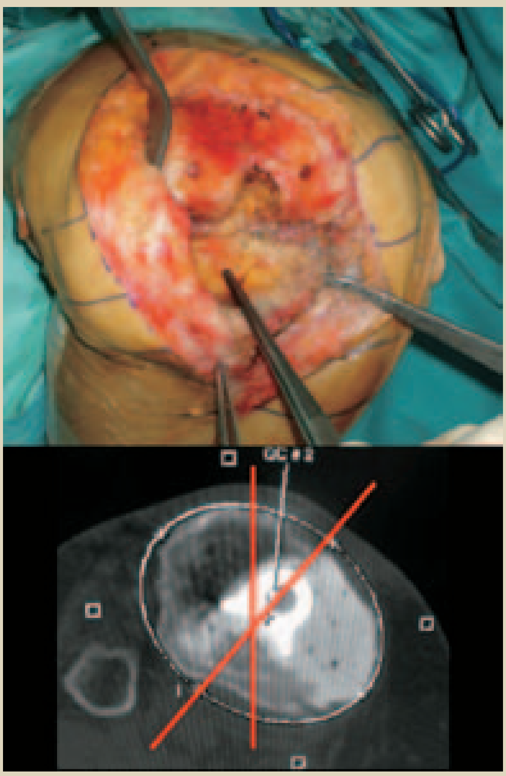


Figure 8.9—Malrotation of tibial component (CT scan with the intraoperative finding of internal rotation of the tibial component with respect to the tibial tubercle).

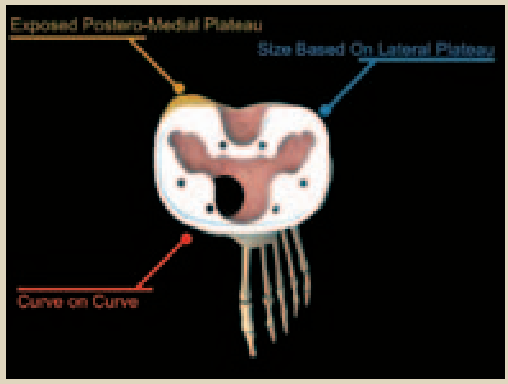


Figure 8.10—The bony landmarks for a proper tibial rotation (anterior cortex and posteromedial plateau) and sizing (lateral plateau coverage).

SURGICAL TIP NUMBER 7: CORRECTION OF FEMORAL INTER-MALROTATION

Pre-operatively, the surgeon should identify potential femoral-component malrotation by utilizing either x-rays with particular positioning as described by Kanekasu *et al.* [7] and Takai *et al.* [8] or by analyzing the knee joint with a CT-scan applying the Berger *et al.* [9] protocol. With this radiographic analysis, the surgeon will start the procedure knowing exactly how many degrees the femoral component is malrotated relative to the surgical epicondylar line. During the procedure after removing the components and after having recreated the tibial platform, the surgeon will manage the feature of malrotation

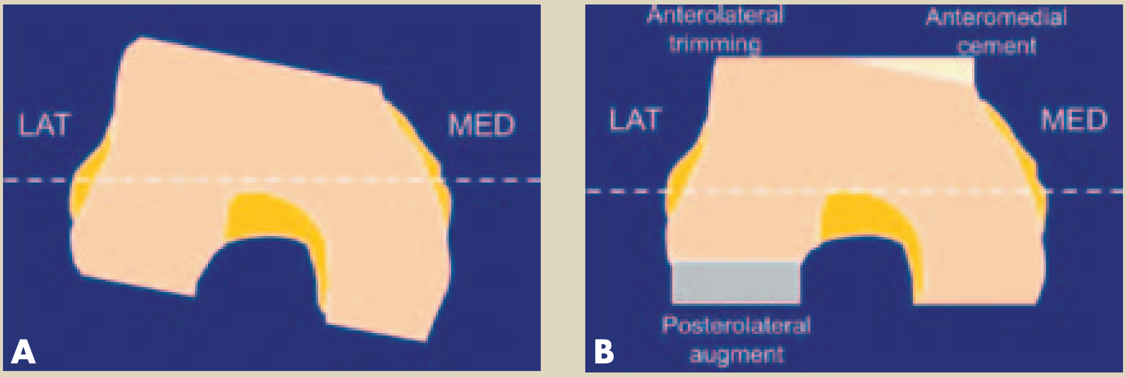
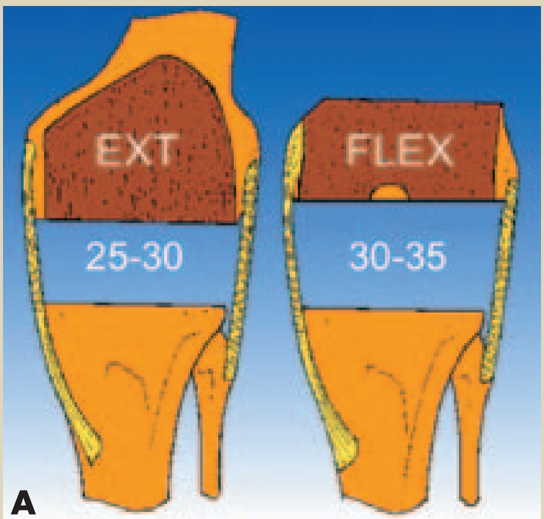


Figure 8.11—A) Femoral internal rotation scenario with a deficient posterolateral condyle. B) "Automatic" solution for femoral internal rotation correction (postero-lateral augmentation, anterolateral cortex trimming, and anteromedial cement wedge).



B

FLEXION \ EXTENSION	Tight	OK	Loose
Tight	1	2	3
OK	4	5	6
Loose	7	8	9

Figure 8.12—The imbalanced gap: the flexion gap tends to be larger than the extension gap. Average distances in millimeter are reported according to a previous study from our group.10 In the flexion-extension knee algorithm, configuration number 8 is the most frequent in revision TKA.

and choose and memorize the automatic solution, adding augments in the postero-lateral aspect of the knee in order to recreate the column of the lateral femoral condyle, which has been sacrificed due to malrotation. Then, the surgeon should trim the antero-lateral cortex. Drawing the transepicondylar axis (TEA) intra-operatively and making the resection parallel to the TEA can help identify the degree of the trimming. When internal malrotation is present, the final aspect of the femoral reconstruction is the postero-lateral augment with some trimming on the antero-lateral cortex and postero-medial condyle. The surgeon should expect to put a small wedge of cement on the antero-medial aspect of the femur as a final configuration (Figure 8.11).

When one or both epicondyles are not present, the surgeon cannot use the TEA as a rotational landmark for femoral component alignment. Instead, the tibial plateau can be used. The surgeon should position the femoral component parallel to the tibial plateau without using the tension of the ligaments, so the components are facing each other at 90 degrees of flexion. The new rotation of the leg and thigh should be neutral. The surgeon can obtain a satisfactory rotational alignment of the femoral component by assessing the following positions. Firstly, tibial platform should be parallel to the floor

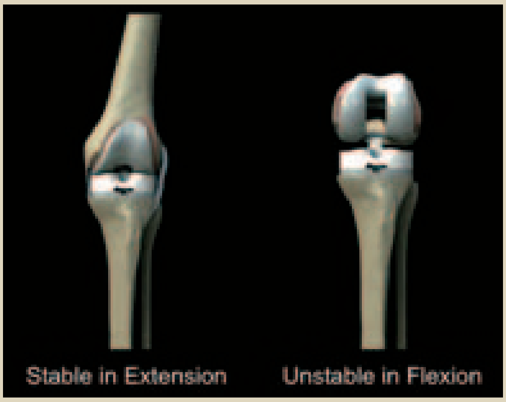


Figure 8.13—Typical revision TKA scenario with stability achieved in extension with the implant in place, but still unstable in flexion. With damaged or deficient collateral ligaments, the posterior capsule maintains an important role for stability in extension (stable), but it is less competent in flexion (unstable).

with the vertical leg. Secondly, the femoral component should rest on the tibial plateau. Lastly, the rotation of the femur should be neutral at the hip. The surgeon can insure a neutral rotation of the hip by assessing the position of the greater trochanter posterior to the midline on the coronal plane. This position is at 90 degrees of flexion of the knee.

SURGICAL TIP NUMBER 8: BALANCED FLEXION GAP

The flexion gap in a revision knee tends to be larger than the extension gap due to a damaged collateral ligament [10] (Figure 8.12). The stability of the gap is mainly supported by the posterior capsule, which is holding the gap configuration in extension. In flexion, the capsule is more redundant, and it is recruited later than in extension (Figure 8.13). When the flexion gap is larger, the surgeons need to fill it by moving the femoral component posteriorly. This can be achieved by increasing the size of the femoral component, which is growing selectively in the posterior aspect of the femur relative to the stem. When the size is large enough to not overhang the medial-lateral dimension of the femur if the sizes are at the limit of the bone - medial to lateral - and the flexion gap is still unbalanced and large, the surgeon has the possibility to obtain further posterior translation of the same size femoral component by using an off system in the femoral canal, and the stem is offset in the posterior direction. This will add another 4.5 mm gap, filling in the flexion space [11] (Figure 8.14). The surgeon should selectively fill the flexion gap and not overhang the bone. If the knee is still unbalanced and the flexion gap is still large, the ligaments and the posterior capsule could be severely damaged. This will

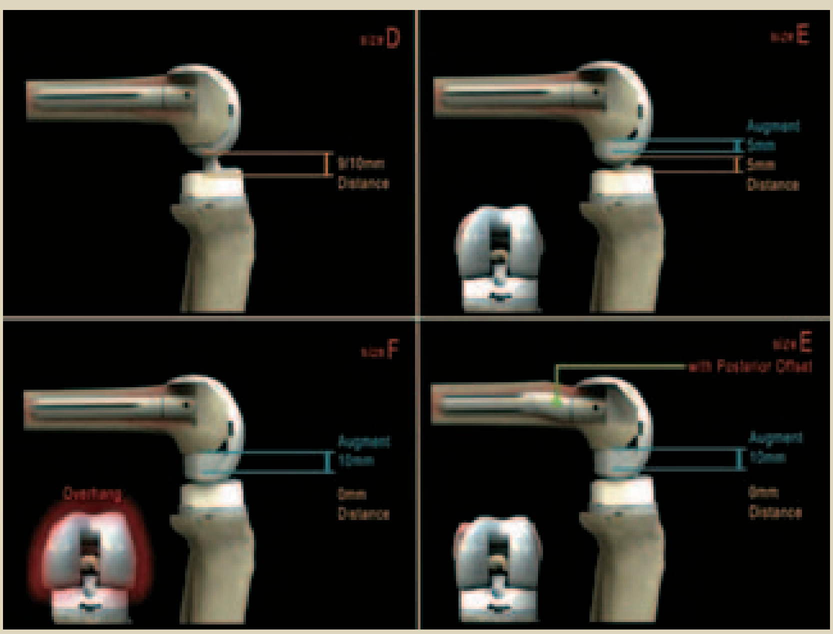


Figure 8.14—In order to fill the flexion gap the combined use of a larger femoral size with a posterior offset stem is described. This will enable the surgeon to obtain the stabilizing effect of a larger size avoiding medial-lateral implant overhang.

require leaving the gap partially unbalanced and changing the implant using a rotating hinge.

CONCLUSIONS

Familiarity with a number of surgical pitfalls is mandatory for the surgeon who is approaching revision TKA procedures. An organized approach to revision starts from the understanding of the failure mechanism and diagnosis, and is followed by a surgical technique based on solid principles. In addition to this, the experienced surgeon will enrich and simultaneously simplify the procedure thanks to the knowledge of multiple surgical technical details.

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