INSTRUMENTATION OVERVIEW

The ATTUNE® Knee INTUITION™ Instruments were designed to allow surgeons to perform precise Total Knee Arthroplasty (TKA). Each instrument allows the surgeon to control the angle and depth of bone resection with carefully designed alignment and cutting guides. Designed to accommodate different surgical philosophies and techniques, the workflow can be performed through femur or tibia first options, while femoral preparation can be driven by anterior-down, posterior-up or balanced resection techniques.

Achieving proper balance of flexion and extension spaces has proven to be a critical success factor in total knee arthroplasty. To aid in proper ligament tension, Spacer Blocks are provided that assist the surgeon in attaining ligament balancing in flexion and extension while performing the procedure. Tibial slope can be easily adjusted for cruciate retaining (5 – 7 degrees) and posterior stabilized options (3 degrees). Composite materials have been incorporated into the instrument design to reduce the weight of the instruments by 51%1 (Image 1) and allow the introduction of high contrast markings that are easy to read versus the predicate option of etching on stainless steel. Modular Tibial Trials were created to streamline the surgical process as well as decrease the number of instruments required (78 trials vs. 240 Solid Trials). The flexibility of the trialing system provides for an easy exchange of bearing options (rotating platform or fixed) and bearing thicknesses, including 1 mm increments to allow precise ligament balancing.

In my practice, I do a combination of rotating platform (RP) and fixed bearing (FB) knees, with the majority of these cruciate retaining. The following paper describes the approaches I use for these implants, and how I determine femoral rotation with a modified measured resection technique.
MEASURED RESECTION WORKFLOW CONCEPTS

The femoral measured resection technique is a method of bone preparation that has been used for many years in total knee arthroplasty. It allows for controlled resection of bone with reference to the bony anatomy of the femur. Conventional knee surgery corrects the natural varus angle of the tibia by approximately 3 degrees, and this, along with deformities or ligament imbalance requires correction at the femoral side.

One way to overcome the discrepancy is to allow for positioning of the femoral component in some degree of external rotation to correctly match the flexion and extension gaps. Three (3) degrees of femoral external rotation has been held as a standard practice, but often is inadequate to balance the flexion space. The INTUITION Instruments allow adjustment of femoral external rotation by 0, 3, 5 and 7 degrees on the Measured Sizer and infinite adjustability on the Balanced Sizer, thereby squaring up the flexion space with the tibial position. This technique can be used with a cruciate retaining (CR), cruciate sacrificing (CS), or posterior stabilized (PS) technique.

My workflow is as follows. I create a trivector arthrotomy for exposure (Image 2). For varus knees I do an initial release of the anterior horn of the medial meniscus, the menisco-tibial ligament and remove any medial osteophytes, with a deep medial collateral ligament (MCL) release until I can correct the varus deformity to neutral. If there is a combined flexion deformity, I may extend the release around the postero-medial corner of the exposed tibia. After resection of part of the fat pad, I will then evert and resect the patella with the knee flexed 45 degrees. Once the patella is resected, I will ever the patella and sublux it laterally. The ACL and lateral meniscus are divided and the tibia subluxed forward for the proximal tibial resection. This is performed with a 5-7 degree posterior slope for a cruciate retaining or cruciate sacrificing technique and 3 degree slope for a posterior stabilized technique (Image 3).

I will always check my resection alignment with a tibial tray trial and handle with an alignment rod to ensure a 90 degree resection in the anteroposterior (A/P) plane, and the appropriate amount of posterior slope in the lateral plane.

The femoral preparation is modified dependent on deformity. An intra-condylar drill hole is created in the femur and an intramedullary rod with the Distal Resection Guide is introduced. The valgus resection angle will range from 3-6 degrees in the majority of cases with a 9 mm distal resection. I will increase it to 10 mm for a flexion contracture of 10-15 degrees, and to 11 mm for a flexion deformity of 20 degrees (Image 4). On the other hand, if there is hyperextension of the native knee, I may reduce the resection thickness to 7 or 8 mm.
After the distal femoral resection is made, a Spacer Block can be used to assess the extension space thickness and relative balance. Most of the time, there is no need for further soft tissue release in extension. If medial or lateral (in a valgus knee) tightness remains after removal of osteophytes, selective releases can be performed at this time if the surgeon chooses. My preference is to use piecrust technique with a number 11 blade to release tight fibers of the MCL for varus knees, and a posterolateral capsular release along the resected edge of the tibia in valgus knees.

Once the extension space has been defined and balanced, I proceed to femoral sizing and rotation. Lamina spreaders may be used with the knee flexed to 90 degrees to open the flexion space. Marks can be placed on the exposed distal femoral condyles a fixed distance from the resected tibial surface and then connected, creating a line to help orient femoral rotation perpendicular to the tibial axis. This line can be drawn with the width of an osteotome, a ruler or the tibial cutting guide extended to reach the resected femoral bone surface. In addition, bony landmarks such as the epicondylar axis and Whiteside's line may be drawn in for reference if desired. The Femoral Sizer is then placed on the distal femur. The measured resection guide allows placement in 0, 3, 5 or 7 degrees of external femoral rotation based on the posterior femoral condyles and can be adjusted on the back table, or in the incision (Image 5). This can be oriented perpendicular to Whiteside's line, parallel to the epicondylar axis or adjusted to a modified flexion space balancing technique.

I like to set the amount of external rotation to 3 degrees when I place the sizer, then adjust the rotation as needed within the joint space to place the pins parallel to the line drawn previously to correctly place the femoral rotation. The anterior stylus is brought into contact with the anterior femoral cortex and checked from medial to lateral to obtain the femoral implant size. Once the correct size and rotation are established, the femoral sizing guide then allows for pin placement using either an anterior-down technique which is referenced off of the anterior cortex of the femur (Image 6), or a posterior-up technique which is referenced off of the posterior femoral condyles. Drill Pins are then placed in either the posterior-up or anterior-down referencing holes (I prefer to use posterior-up referencing for my knees).
An alternative technique is to apply the sizer and place the pins for the cutting block in a preset position (3 or 5 degrees of external rotation). Once the pins are in, remove the sizer and check the flexion space with 2 lamina spreaders to assess the flexion space. If the pins are parallel to the resected tibial surface, proceed with femoral preparation. If there is asymmetry in the flexion space, a repositioning of the pins will be required. This can be done by placing the cutting block on the pins, pulling the lateral pin and rotating the cutting block into a position parallel with resected tibial surface, and reinserting a drill pin into the cutting block in a different hole position.

The pin holes in the cutting blocks are arranged in sets of 3, with the middle hole set in the neutral position relative to the sizing guide. The other 2 holes are either 1.5 mm anterior or posterior to the neutral hole. Changing the block position on the pins allows placement of the femoral component 1.5 mm more anterior or posterior if the surgeon desires to adjust the femoral position to improve the ligament balance of the knee. The flexion space can be assessed at this time with a Spacer Block inserted between the resected tibia and the posterior edge of the cutting block with the Modular Saw Capture removed. This will allow measurement of the flexion space thickness and stability with the proposed resection prior to making any femoral finishing cuts. With a CS technique, this may be a time where shifting of the femoral position 1.5 mm posteriorly may be desirable to match the flexion and extension space after resecting the PCL. If this is done, care should be taken to avoid notching the anterior femoral cortex.

Once the femoral size and rotation have been established, the cutting block is secured with 2 Threaded Headed Pins (care should be taken to stop drilling the headed pin once it has made contact with the block). This will lock the cutting block to the distal femur and allow for precise bone preparation. I prefer to leave the 4 pins in place while I make the first 3 bone cuts (anterior, posterior, and anterior chamfer). The posterior chamfer cuts are made last after the 2 anterior or posterior referencing pins are pulled. If the 2 referencing pins are pulled early, care should be taken to avoid levering the saw blade through the cutting slots and adversely affecting the cut accuracy.

The Femoral Finishing Guide allows for checking the posterior condylar resection and for any bone or cartilage that might be prominent beyond the implant. Bone in this area can block flexion as the tibia rotates around the femoral condyle. For this reason, the posterior condyles should be checked for any overhanging bone or cartilage. The other function of the finishing block is to allow preparation of the sulcus cut in the trochlear groove for the CR femoral implant (Image 7). A small amount of bone needs to be removed from the anterior chamfer region prior to trialing the femoral implant. This can be accomplished with a rasp or saw and the guide will show you where this occurs. The Femoral Finishing Guide has the same outer profile of the implant to aid with positioning on the distal femur. This bone removal is over-prepared slightly medial/laterally to allow for fine tuning of the final implant position.

Image 7: The Femoral Finishing Guide completes the sulcus cut and has the same posterior condyle shape as the PS femur to aid in osteophyte removal.
PS FINISHING BLOCK

The Notch Guide allows for cutting the notch in the intercondylar region for the PS femoral implant. Since the Notch Guide is size specific with the intercondylar box varying in width per size, different blocks are needed for each femoral implant size. The notch is oriented 18 degrees posterior and proximal to allow a deepened trochlear groove on the PS femoral implant (Image 8). The block is the same width as the femoral implant to allow accurate medial – lateral placement of the block and ultimately the femoral implant.

TIBIAL PREPARATION

When using a fixed bearing implant, I like to “float” the Tibial Base Plate with the Trial Insert and the Evaluation Bullet. The Evaluation Bullet fits into the trial base plate and allows it to slide freely on the resected tibial surface. I then take the knee through the range of motion with the Femoral Trial and Patellar Trial reduced. This allows the tray to find a stable position rotationally and in the A/P direction relative to the femoral implant. This is a kinematically driven position and I mark it on the tibia next to the hash marks on the tibial base plate.

Once the final tibial position is determined, femoral lug holes are drilled through the Femoral Trial and trial implants removed. The Tibial Base Plate is repositioned relative to the hash marks on the tibia. Short fixation pins can be used if desired. The Drill Tower can be inserted by hand or connected to a Universal Handle and impacted onto the tibia with the spikes entering the base plate holes in the designated positions. If the Universal Handle is used to insert the tower, the red button needs to be pressed to release the tower when removing the Universal Handle. Reaming to the designated depth is then performed, followed by impaction of the appropriate size Keel Punch. The Keel Punch is attached to the Universal Handle and impacted until the Keel Punch seats fully with in the base plate. The handle can then be pulled out with the Drill Tower attached, allowing an easy way to remove both (Image 9). A final trial reduction may be performed at this time if desired.

When doing a rotating platform knee, a best fit of the Tibial Base Plate to the patient’s resected tibia is chosen and final preparation can be made prior to trialing of the tibial articulating trials.
Modular Trials were designed to reduce the number of parts needed and to simplify the work flow in the operating room. The trials are made of a very durable polymer (Image 10). They create an accurate assessment of the bearing insert and allow assessment of the knee kinematics and ligament balancing. The Modular Tibial Trials have two mobile and fixed Articulating Surfaces each so that two thicknesses of trial can be assembled on the back table prior to trialing. The Articular Surfaces are size specific and should be mated to the same size femoral implant. They attach to shims that represent the combined thickness of the shim and the Articulating Surface, or the resultant polyethylene bearing that will be chosen.

The shims can attach to either the fixed or mobile Articulating Surface and fit onto the Evaluation Bullets or Keel Punches (Image 11). The shims have a key slot on one side and an open slot on the opposite side of the central hole and can attach to the Articular Surface in only one way. The keyed slot for the fixed bearing application locks the bearing to the base plate and prevents rotation, while the rotating platform slot allows the articulating trial to rotate. The ATTUNE Knee inserts come in 1 mm increments from 5-8mm, followed by 2mm increments from 10-20mm.

The Femoral Trials (either CR or PS) can be easily removed by inserting a blunt Hohmann retractor in the intercondylar drill hole and prying the femoral implant forward. It will pop forward with little effort.

**Image 10:** Polymer Femoral Trials allow for clear markings, reduced weight, and cut outs for narrow sizes

**Image 11:** Modular Tibial Trials reduce the SKUs needed for FB and RP trialing

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**FINAL BALANCING OF THE KNEE**

There is a certain “feel” surgeons like to have when checking range of motion and stability. For me, I like to ensure the knee has full extension and demonstrates stability in extension by having 0.5-1 mm of separation of the femoral and tibial trials with a moderate varus and valgus moment applied to the fully extended knee. This separation should be equal on the medial and lateral sides. This stability should be maintained through midflexion. At 90 degrees of flexion, I test the flexion space with a blunt Hohmann retractor. This device is 1 mm thick at the end of the retractor. I like to be able to slide the curved end of the retractor between the articulating surfaces (medial and lateral) and feel the tension in the ligaments. If I am unable to insert the retractor, then the flexion space is too tight and adjustments need to be made, usually adding slope to the tibial resection. If it is too loose and more than 2 mm of separation occurs, then adjustments should be made to tighten the flexion space, usually adding bearing thickness.

As the knee goes into deep flexion, the contact area on the medial tibial trial should remain near the center of the bearing. Slight rollback can be allowed, but excessive rollback on the medial side indicates a tight posterior cruciate ligament (in CR knees). This can be remedied by a PCL recession (off of the femur or tibia) or by adding additional posterior slope to the tibial resection. This is where knee arthroplasty becomes an art and the tools at hand can be used to fine tune the end result. Once I am happy with the ligament balancing achieved, I double check the posterior condylar region behind the femoral trial to ensure that no bone or cartilage overhangs the femoral implant. Range of motion could be limited if anything impinges in this area.
FINAL FINE TUNE OF UNBALANCED GAPS

In most cases, the result is a well balanced knee. A final fine tuning might be necessary in a small amount of cases despite efforts to balance the knee during the procedure.

VARUS KNEES

A common occurrence in a varus knee is residual medial tightness in extension, demonstrated by a tight medial space in extension with lateral liftoff or laxity. In this instance, I recheck the bone cuts first, make sure the knee comes to full extension, and then consider an MCL release. I prefer to palpate (with finger or small periosteal elevator) the tight fibers of the MCL and release them with the tip of a knife (number 11 blade or 18 gauge needle). By gradually releasing tight fibers in different locations of the MCL (pie-crusting technique), a gradual lengthening of the MCL can be achieved. I do this until there is 0.5-1 mm of separation on the medial side under a valgus load. This will often allow the lateral side to close and create equal balancing on the medial and lateral sides (It is important to keep in mind that any extension releases may affect balance in flexion). If the lateral side remains “loose”, then I consider using a thicker bearing and do further medial releases as needed to create the balance in extension. Flexion imbalance can be treated in a similar way but is less common when a modified balanced resection technique is used.

VALGUS KNEES

For valgus knees, the lateral joint structures may be contracted and lead to difficulties with extension balancing. For this, I make the bone resections first and remove any osteophytes that might affect the balancing of the ligaments. Two lamina spreaders are then used with the knee in extension. If there is a rectangular extension space, no further work needs to be done. If the lateral side remains tight relative to the medial side, then I palpate the tight posterolateral structures and do a posterior capsular release along the resected border of the tibia, preserving the popliteus tendon. I will continue the releases if needed anterolaterally along the tibia up to the iliotibial (IT) band. If the knee remains tight laterally, the IT band can be lengthened in a pie-crusting technique similar to the MCL.

A note of caution: In severe valgus deformities, the MCL can be attenuated and lengthening the lateral side to equal the loose medial side would be ill advised due to risk of stretching the peroneal nerve. In these cases, consideration should be given to an MCL advancement procedure. This can be accomplished with either a femoral advancement through the condyle, or a tibial advancement with a staple.
REFERENCES

1. As compared to predicate instruments (Data on File)