Novel Surgical Technique for Total Knee Arthroplasty Integrating Kinematic Alignment and real time elongation of the ligaments

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In this video, we present a surgical technique for total knee arthroplasty (TKA) that blends the principles of kinematic alignment (KA) and the use of an augemented reality (AR) device that provides the real-time elongation of the collateral lateral ligaments of the knee. While resurfacing the femur during knee replacement surgery typically allows for a predictable restoration of the femoral joint line due to the predictable nature of femoral wear, this is not always straightforward for the tibia . The tibial joint line can be more challenging to assess and restore accurately because tibial wear patterns are less consistent and more variable. NextAR is CT-based AR navigation system, that consists of a pair of smart glasses, two small single-use infrared sensors, and a control unit. The use of the head-mounted display allows the superimposition on the surgical field of relevant surgical information. One of the main advantages of this system is the possibility to evaluate intraoperatively the elongation of the medial (MCL) and lateral collateral ligament (LCL). The MCL is a primary stabilizer of the knee, responsible for resisting valgus stress. Many kinematic studies, made with different technique in both cadaver specimen or in vivo, demonstrate that during knee flexion the MCL fibers undergo mininal length changes. On the other hand the LCL that is thigthen in full extension, resisting varus stress, became a bit more lax in deep flexion (corresponding to a shortening of the ligament). This technique was proposed as a computer-assisted surgical procedure to the unrestricted KA proposed by Howell. The concept of soft-tissue elongation tibial cut aim to restore the preoperative distal and femoral joint line and to restore the native MCL and LCL elongation of during the whole range of motion.

Surgical Approach and Device Registration (Step 1): After adequately exposing the joint, position the femoral and tibial pins. The femoral pins should be placed approximately 5-6 cm from the joint plane, oriented at about 45° to the ground, while the tibial pins should be positioned outside the surgical field, oriented perpendicularly and approximately 8 cm from the tibial plateau. The system employs a single-point acquisition method, wherein a pointer is held on the relevant anatomical structure to activate automatic point acquisition. To establish the reference length (L0) of the collateral ligaments, the knee should be held between 0° and 10° of flexion. Once L0 is determined, ligament length variation can be evaluated throughout the range of motion.

Femoral Resurfacing (Step 2): This procedure involves performing femoral resurfacing as described in Howell's KA unrestricted technique. Using the AR system, we will navigate the position of the cutting guide, first matching the sagittal plane by adjusting the flexion/extension of the component, and then the varus/valgus alignment. Next, the posterior cut will be performed at 0° relative to the posterior condylar axis and 2 mm less than the thickness of the prosthesis to close the flexion gap for the reasons previously explained. This cut can be made manually using the MIKA instrument sizer or it can be navigated like the previous cut.

Definition of the tibial cut by having real time soft tissue elongation (Step 3): With the trial component in place, we will evaluate the knee's stability in extension and flex-ion, as well as the elongation of the medial and lateral collateral ligaments. Based on the intraoperative information acquired after femoral resurfacing, we will modify the planning of the tibial cut to achieve isometry of the MCL throughout the entire range of motion, and an LCL that matches the L0 length in extension and tends to shorten with increased flexion.

Evaluation of Soft Tissue Balance with Spacer Blocks and Trial Components (Step 4): As in the standard calibrated technique, we will place spacer blocks in flexion and extension to confirm the accuracy of the cuts. First, we will evaluate the flexion space with a 10 mm spacer, expecting to achieve a "medial pivot" where the spacer block pivots medially and moves more freely laterally. Next, we will place the 12 mm spacer block in extension and verify that there is less than 1 mm of laxity under varus and valgus stress. We use the 12 mm spacer in extension instead of the 10 mm spacer because, at this stage, the posterior condyles are absent, reducing their tension on the posterior capsule.

Components implantation and final evaluation (Step 5): Firstly, the tibial component (will be implanted using a double cementation technique, where both the tibial plate and the lower portion of the tibial component are cemented with low-viscosity cement. Next, the liner will be positioned. Lastly, the femoral component will be cemented. A final assessment of the soft tissue elongation will be performed. At the end of the procedure, the system will generate a detailed report of the planned and executed cuts and the elongation of the ligaments during the various phases of the surgery.

By combining KA and AR, this technique strives to achieve a balance between soft tissue tension and bone alignment, aiming to restore the knee's natural function and stability. This approach is particularly beneficial in addressing the complexities of tibial alignment, offering a more accurate and individualized method for TKA. To es-tablish the true efficacy and long-term benefits of integrating KA and AR technologies like the NextAR, further studies involving larger patient populations and comprehen-sive clinical data need to be performed.