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Editorial

In My Experience...Navigation and Robotics in Total Joint Arthroplasty

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I present my experience with navigation and robotics in total hip arthroplasty.

In my extensive experience with navigation and robotics in hip and knee arthroplasty, I find it valuable to delineate between the two approaches and address the specific considerations for each joint.

Starting with hip replacement, my involvement in the development of the Mako robot provides me with a unique perspective. Having conducted robotic hip replacements with Mako and navigated hips with various systems like Stryker Mako, Brainlab, Intellijoint, and Naviswiss, I've concluded that robotics may not offer significant benefits in hip replacement. The simplicity of bony preparation on the socket side and the sphere-like nature of the implant placement make manual reaming and navigation more practical. The femur side, in particular, sees minimal impact from the robot, making navigation the preferred choice.

Conversely, knee replacement presents a distinct scenario where implant placement and bony preparation are critical due to the three degrees of freedom in the femoral component. In this context, robotics, with its focus on dimensional and positional accuracy, plays a crucial role. Dimensional accuracy becomes vital for press-fit implants, while positional accuracy significantly influences clinical outcomes, particularly in terms of flexion and extension gaps.

To delve into the rationale for using robotics in knee replacement, it's essential to understand the importance of two types of accuracy: dimensional and positional. Dimensional accuracy pertains to the precision of preparing specific dimensions, crucial when utilizing press-fit implants. On the other hand, positional accuracy is paramount for achieving accurate clinical outcomes, particularly concerning flexion and extension gaps. Robotics aids in achieving both types of accuracy.

However, there's an ongoing debate on the philosophy of knee replacement—whether it is primarily a bony or soft tissue operation. Many robotic surgeons lean towards considering it a bony operation, emphasizing gaps and varus/valgus alignment. Despite this trend, the assumption that equal gaps translate to equal soft tissue tension is not foolproof, as errors in robotic accuracy may compromise this correlation.

The soft tissue tensioning aspect becomes crucial in knee replacement, and currently, only a few technologies, such as eLIBRA (no longer available), OrthoSensor, and Bal-

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a As a board-certified and fellowship-trained joint replacement surgeon, Stefan Kreuzer, M.D., M.Sc., has pioneered the development of minimally invasive and computer-assisted hip and knee replacement surgery. He is actively involved in training and has been invited to lecture and demonstrate his surgical techniques for surgeons throughout the United States, Asia, Australia, and Europe. Dr. Kreuzer is currently on multiple design teams for the development of the next generation of knee and hip implants and acts as a consultant to many device companies to assist them with further advancing care for patients.

With many research and academic interests in addition to his clinical practice, he has devoted his career to improving the quality of life for patients in need of joint replacement surgery. A native of Switzerland, Dr. Kreuzer moved to the United States in 1983. He graduated from medical school at the University of Texas in San Antonio in 1995 and completed his orthopedic surgery residency at the University of Texas Medical Branch in Galveston, Texas. He then undertook a fellowship in Adult Joint Reconstruction at the Baylor College of Medicine in Houston, Texas in 2001.

As of October 2023, Dr. Kreuzer has performed over 6,500 anterior hip replacements and is one of the few experts in the world to perform revision total hip replacement through the anterior approach. Dr. Kreuzer is also a world expert on robotic joint replacement surgery; he was on the development team of the MAKO robotic system for anterior hip replacement and MAKO total knee replacement and was one of three surgeons to participate in the initial FDA approval study. He is currently working on the next generation of robotic surgery with THINK Surgical as a principal investigator in their FDA-approval clinical trial for total knee replacement, as well as working alongside Corin to develop kinematic alignment with the OMNIBotics system.

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anceBot, offer the capability to measure tension directly. Without these technologies, surgeons rely on manual assessment based on their tactile feel, which may not be as precise.

In the broader perspective, while robotics has brought positive advancements, there's a need for critical research on three main fronts:

1. **Correlation of Surgical Plan with Clinical Outcome:** Establishing a consensus on the ideal placement of the implant remains elusive, and research is needed to correlate various surgical plans (kinematic alignment, mechanical alignment, reverse kinematic alignment, gap balancing) with clinical outcomes.
2. **Measurement of Ligament Tension:** Defining the optimal ligament tension, especially focusing on the medial collateral ligament (MCL), and developing technology capable of measuring soft tissue tension directly, not just gaps, is essential.
3. **AI Algorithm and Machine Learning:** The development of artificial intelligence algorithms and machine learning models that can analyze surgical plans, ligament tension, and clinical outcomes to optimize future surgical plans, creating a feedback loop for continuous improvement.

While acknowledging the positive impact of robotics, these research areas are pivotal for refining and maximizing the benefits of knee replacement procedures. Ultimately, the goal is to enhance precision, improve patient outcomes, and bridge the gap between surgical planning and real-world results in knee arthroplasty, and I leave you with this final question: "Why to me hip replacements run marathons and my knee replacements don't?"

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