A Deeper Dive in to Robotic Assisted TKA

Robots have been used in orthopaedic surgery for over 20 years. Over this time, they have evolved tremendously. The most common use for robots in the orthopaedic field is total joint arthroplasty (TJA), and in particular for the hip and knee.

There are three main components to robotic joint replacement

1. Navigation to allow the robot to "see"
2. The Robotic arm to which a cutting saw or burr can be attached
3. Software to allow the surgeon to plan the operation and make changes during the case

The current situation is most surgeons use rods placed either inside the canal of the main bones or on the outside to get a rough idea of the alignment. They then attached cutting jigs that guide the saw blade while cutting. This system allows for the possibility of sizable bone cut errors. The rods don't always show the true alignment, the saw can skive in the jigs, the pins holding the jigs can wobble. However, it is still the most common way of performing TKA and despite these issues, over 80% of the patients are very satisfied with their TKA.

The next generation of technology to help improve outcomes in TKA was navigation. How navigation works is, the surgeon places stiff steel pins into the femur and the tibia. Reflective balls or discs are then attached to the pins. A special camera in the operating room can "see" these reflective balls/discs and knows exactly where each of the bones are at any point in time. The surgeon then opens the knee in the routine manner. They take a stylus which also has reflective markers, and they mark out the joint surface and surrounding bone so the navigation system can see the joint. Once completed, the joint is taken through a range of motion and stressed. The computer displays the alignment of the knee and allows the surgeon to start planning the cuts more accurately. The jigs are also set up with reflective balls to allow more accurate placement and cuts. The issues that arise with this technology are the jigs can still be misplaced. The saw can still skive through the jigs and mistakes can be made marking out the joint line with the stylus.

Even if the surgeon knows how he or she wants to align and balance their patient's new TKA, the basic tools we currently use – using conventional jigs or basic navigation, still allow a sizable amount of user error and inaccuracies. Thereby meaning even if we know where we want to place something, it doesn't mean we will always get it right.

Robotics improves on these issues and brings accuracy and precision.

1. The patient undergoes a low dose CT scan of the affected limb several weeks before the operation
2. The images are uploaded onto the Robotic software allowing it to know the exact 3D structure of the joint and the alignment of the entire limb
3. The surgeon can now plan the operation, chose the size of the components needed, plan the initial positioning of the components

4. At the start of the operation pins are placed and reflective markers attached which allows the robot to “see” the limb
5. A stylus is used to mark out the bone surfaces and joint surfaces which allows the robot to now “see” the joint. The robot ensures the joint looks exactly the same as the 3D model, so there are no errors
6. The knee is taken through a range of motion and stressed
7. The surgeon then uses this information to personalise the exact balance and position of the prosthesis
8. The robotic arm and saw are brought in and the cuts are made exceptionally accurately – to within 0.3-0.5mm
9. Once the cuts have been completed, trial components are used and the knee is checked for alignment and balance.
10. Once the surgeon is happy with the alignment and balance, the definitive prostheses are installed and the knee is closed

There are several different robots currently being used for TKA. They are all very good at helping the surgeon perform TKA.

ADVANTAGES OF IMAGE-BASED ROBOTS OVER IMAGELESS ROBOTS:

1. CT based image guidance
    a. This allows a robot to be much more accurate than imageless robotic TKA
    b. It also removes any error that can come from inaccurate referencing of the joint surfaces with the stylus, as the imaged -based robot ensures it matches the 3D image from the CT scan.
    c. The surgeon can identify old metalwork in the bone from previous operations and determine if it will interfere with the joint replacement or not, prior to the operation starting.
2. Haptic Boundary
    a. The robot Mr. McLaren uses is the only robotic arm that has haptic feedback. It knows the exact location of the bone margins. It will not allow the surgeon to cut outside this boundary. This reduces trauma to surrounding soft tissues and reduces the risk of damage to nerves and vessels. This in turn reduces post operative pain and faster recovery.
3. The robot Mr. McLaren uses can also robotically assist with
    a. Total hip replacement and unicompartmental knee replacement which other robots currently cannot.