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Editorial
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Robotics in Total knee Arthroplasty

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The recent introduction of new robotic systems for total knee arthroplasty (TKA) has created somewhat of a craze. Nevertheless, we can ask ourselves whether it is justified to use these new but very costly technologies. The results and limitations of these robotic tools must be analyzed systematically before confirming their benefits. Most of the newest robotic systems are interactive ones. The term "robotic surgery" refers to the use of programmable devices to perform a wide variety of surgical tasks. These are not intended to replace the surgeon but rather to provide assistance. This activity reviews the role of the interprofessional team in evaluation and treatment using robotic assistance to perform knee arthroplasty. (1)

Keywords: Robotic surgery, Total knee arthroplasty (TKA), Curexo Technology

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Robots present a tool in which surgeons can do surgical procedures while minimizing human error and maximizing operative accuracy. The term 'robot' begins from Czech word 'robota,' which means forced labor or activity. In 1920, Karel Capek, Czech play writer, wrote a science fiction play called " Rossum's Universal Robots," where Robots were a series of factory-manufactured artificial people that undertook ordinary tasks for their human masters. The play premiered on 25th of January 1921, and that is when word "robot" was introduced to English language and to science fiction as a whole. The first robot surgery ever was performed in 1988 to perform neurosurgical biopsies. Since then, applicability of robotics in surgery has progressed remarkably. Besides the rapidly increasing needs for TKA in past years, robotic total knee arthroplasty (TKA) has increased in number considerably. (1)

In orthopedics, a robotic TKR is designed to decrease mistakes associated with bone cuts and prosthesis position and alignment. Robotic TKR has better surgical and clinical patient outcomes than conventional TKR.[2] The first robotic-assisted TKA was performed in 1988 in United Kingdom.[3] Robotic TKR uses a preoperative CT scan to create a 3D reconstruction of original knee. This patient model is then used to calculate measurement of femoral and tibial bone resection and select exact size of implant.[4]

The aim of TKA is to restore the mechanical axis, restore the joint line, restore balance in flexion and extension gaps, and restore the Q angle for perfect patella tracking. To reach these goals, the preservation of the surrounding soft-tissue is crucial. Destruction of the collateral ligaments, PCL, or extensor mechanism may lead to delay in the recovery, decrease joint stability, and decrease prosthesis life. Robotic TKA limits saw action, which reduces iatrogenic bone and soft-tissue damage.[5][6]

Robotic total knee arthroplasty uses certain software to convert anatomical images into a virtual three-dimension reconstruction of joints. The anatomy is usually obtained by requesting pre-operative CT or intraoperative tibia and femur mapping. The surgeons use this model to plan the perfect bone cut, implant positioning, limb alignment, and bone coverage based on the patient's anatomy. The intraoperative robotic device helps to minimize iatrogenic soft-tissue and bony injury. [7][8]

Robotic TKR was developed to improve bone preparation accuracy and decrease the possibility of outliers to guarantee a longer prosthesis lifespan. Adequate restoration of the mechanical axis in TKA is associated with a decrease in polyethylene wear and a lower revision arthroplasty rate.[9][10][11]

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There are different types of robotic knee arthroplasty. Certain types actively do all steps of tibial and femoral bone resections, known as “fully active. Other types enable the surgeons to do the surgery while giving feedback intraoperatively to assist in control resection of the tibia and femur to the pre-operative surgical plan, and this group is known as “semi-active.” The surgeon makes the approach, puts the retractors to protect the soft tissues.

New robotic systems such as the Navio PFS (Blue Belt Technologies, Plymouth, MN, USA), Mako (Mako Stryker, Fort Lauderdale, FL, USA), Rosa (Zimmer-Biomet, Warsaw, Indiana, USA) and iBlock (OMNIlife Science, East Taunton, MA, USA) were developed that are being used more and more. (12) Various classification systems have been proposed to characterize the different designs of robotic technology used in medicine. The most well-known is the one proposed by Schneider and Troccaz in 2001 [13].

It places robotic systems in four categories: passive, active, interactive, and tele-operated passive systems consist of an articulated arm that holds an instrument moved manually by the surgeon, with the instrument's position being recognized by the navigation system. They do not directly participate in carrying out the procedure, which remains completely under the surgeon's control. The OMNI® robot fits in this group. Conventional navigation systems used for TKA are often integrated into this type of system.

Active systems are robots that use preoperative and intraoperative planning data to perform multiplanar surgical manipulations autonomously (without the surgeon's participation). The Robodoc® fits into this group. interactive systems are robots that require an interaction between the robot and the surgeon who constrains the robot. There are two types of strategies in this group: semi-active and synergistic systems.

In semi-active systems, this mechanical constraint can be summarized as a movement without feedback to the surgeon. Conversely, for synergistic systems, the mechanical constraints are programmable: these newer systems are based on the principle of haptic models (i.e. information feedback) with the robot generating forces where the amplitude and frequency reproduce true sensations (touch, vision). Lastly, teleoperated systems correspond to robots that are controlled remotely by a surgeon. The most well-known example is the DaVINCI® robot.

Developed in 1986, Robodoc (Curexo Technology, Sacramento, CA, USA) was the first system with ORTHODOC (robotic arm and software) to be used for joint replacement surgery [15], [16] (Fig. 2). It is currently sold under the name TSolution-One (Think Surgical Inc, Fremont, CA, USA; previously Curexo Technology). This is an autonomous active system (without surgeon interaction) based on preoperative CT scan images with an open platform (i.e. suitable for all implants) [14], [17]. The iBlock robotic cutting guide (OMNIlife Science, Raynham, MA, USA), which was previously called Praxiteles, was approved by the Food and Drug Administration (FDA) in 2010 to assist with TKA implantation [14].

This is a motorized cutting guide that only helps the surgeon make the femoral bone cuts based on a preoperative plan and avoids errors associated with using a standard oscillating saw blade. The main advantage of this system is that no CT scan is needed. Conversely, it operates as a closed platform, thus can only be used with one specific type of knee implant and does not provide gap balancing. [14]

The Navio PFS, developed by Blue Belt Technologies and currently distributed by Smith & Nephew (Watford, UK), is a robotic reamer controlled manually by the surgeon [14]. First approved in 2012 by the FDA for partial knee replacement, it is now available for total joint replacement. To our knowledge, no studies on this system have been published. This is another semi-active system that follows the reamer's trajectory in the navigation field. It controls the reamer's rotation speed and its extension (or retraction) from its sleeve which allow the resections to be done as planned. (18,19)

The Mako Robotic Arm Interactive System was initially developed by Mako Surgical Corporation and is now sold by Stryker Orthopaedics (Mahwah, NJ, USA) (Fig. 5). It was approved by the FDA in 2016. This system consists of a robotic arm that helps with TKA implantation using a haptic interface. This semi-active robot stops the saw when it goes beyond the cut defined in the preoperative plan; thus, it improves a surgeon's ability to restore the knee's alignment and to protect the soft tissues [20], [21], [22].

The Rosa Knee robot was developed by Zimmer-Biomet (Warsaw, IN, USA) in collaboration with MedTech (Montpellier, France) and was approved by the FDA in January 2019. This system is an interactive robotic platform where the robotic arm allows the cutting guides to be positioned based on intraoperative plan obtained using navigation data. This is an imageless system, like the Navio robot, that can be supplemented with preoperative radiographs to create a 3D model of the patient's knee using an atlas (X-Atlas™). This step can be used to deform the 3D knee model using certain prominent points determined on the patient's radiographs. The pitfall of this technology is the modelling precision in patients whose anatomy is outside the norms (post-traumatic malunion, fracture fixation devices in place, major dysplasia, etc.). Since this system is very new, no published studies exist on it. (22) In summary, given their cost, diffusion of these new technologies will be limited to high-volume surgical facilities, use of these new technologies requires that we define patient-specific surgical strategies based on big data analysis.

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