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LITERATURE REVIEW

Robotically Assisted Total Knee Arthroplasty - Literature Review

*Marcus Vinicius Danieli, MD, PhD** and *João Paulo Fernandes Guerreiro, MD, PhD*

Unort.E Hospital de Ortopedia, Londrina/PR, Brazil

***Corresponding author:** *Marcus Vinicius Danieli, MD, PhD, Unort.E Hospital de Ortopedia, Av. Higienópolis n° 2600, Londrina/PR, CEP 86050-000, Brazil, Tel: +55(43)99146-4799*

Abstract

Despite the evolution in implant design, surgical technique, rehabilitation and better medical training, a great number of patients are not satisfied with the final result of Total Knee Arthroplasty (TKA). The conventional TKA technique could result in a high number of outliers in limb alignment and are related to a high rate of residual symptoms. Robotically assisted (RA) surgery was introduced to improve these results. Recent studies showed this technique is associated to lower costs, better accuracy in implant placement and limb alignment, improvement in function and patient satisfaction. RA technique is also related to less blood loss, less bone resection and smaller aggression to soft tissues. Besides that, this brings better ergonomics to the surgeon with less caloric waste. In this way, by the benefits showed, the adhesion to the robotic surgery must be encouraged.

Keywords

Robotically assisted system, Total knee arthroplasty, Knee osteoarthritis, Robotic surgery

Review

The number of surgical total knee arthroplasties (TKA) are exponentially growing all over the world. In the United Kingdom 90.000 TKA were performed in 2018 [1]. In the United States of America (USA) the incidence were 700,000 in 2012 and are expected 3.5 million of TKA to be performed in 2030 [2].

Despite the evolution in implant design, surgical technique, rehabilitation and better medical training, literature shows that 20% of patients are not satisfied with the final result of the surgery [2,3]. This unsatisfaction could be related to expected complications like infection. However there is still a high incidence of surgical technical problems like implant malposition, error in final limb alignment, ligament imbalance, soft tissues aggression and excessive bone cuts, that could lead to poor results [2].

The conventional TKA technique could result in up to 32% of alignment error greater than 3º [2,4,5]. A big related problem is the objective in achieve mechanical alignment in all patients, without emphasizing the anatomical individuality of each person. This kind of alignment, called kinematic, could theoretically lead to better patient satisfaction and member function and increase the implant survival [6]. Residual symptoms of pain, instability and stiffness are observed in up to 50% of TKA were the mechanical alignment are the goal, what could be avoided by using the kinematic alignment [7].

With the objective of achieve better results, new technologies has been adopted in the TKA surgery. The navigation showed promising results, with better alignment and ligament balance, mainly for low volume surgeons, but without better function or patient satisfaction, and the same level of bone and soft tissue aggression [8-10]. Evolving, there was the introduction of the custom-made guides, manufactured for each patient based on x-ray or computed tomography images of the knee that will be operated on. Nonetheless, this technology did not show improvements regarding to pain and limb function, but a higher risk of revision surgery were related, without better alignment than the conventional technique [11-13].

In recent years we are seen the introduction of robotics. The robotic systems are classified into 2

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categories: Haptic and active. The haptic are totally guided by the surgeon, depending entirely on physical manipulation by the user. The active (or autonomous) follow a prior planning without the surgeon intervention [14].

The Robodoc® (Curexo Technology, Fremont, CA, USA) was one of the first to be used in orthopedics, for hip replacement primarily. It was an autonomous system, but the adoption was limited because of the technical complexity, great increase in surgical time and insufficient versatility [6,14].

The most used systems today are a mixture of haptic and active, called collaboratives or semi-autonomous. As examples we can cite the MAKO® (Stryker Corp, Mahwah, NJ USA), Navio PFS® (Smith & Nephew, Memphis, TN, USA) and ROSA® Knee (Zimmer Biomet, Warsaw, IN, USA). In this kind of control the surgeon is able to actively correct, during surgery, problems that could appear, by using detailed information provided by optical readers and sensors in real time, making the surgeon more active and at the center of the procedure, with the robot being a precision guide [5].

However some disadvantages are cited related to the use of robot like longer surgical time; learning curve, costs; dubious results regarding to function and patient satisfaction; and surgery durability [15].

In medicine, a new technology should only be deployed once there is a problem that need a solution. This solution (technology, implant, technique, therapy) must be sustained by a solid research base and gradually adopted with scrutiny of clinical outcomes [16].

Cost studies including from surgery until 90 days after procedure showed the robotically assisted (RA) surgery could lead to savings of between US$ 587 to as much as US$ 4049, this being related to shorter hospital stay, lower complications rate, lower use of health assistance after hospital discharge and lower rate of readmissions [17-19].

The learning curve for RA TKA is cited to be around 7 to 15 cases, being this curve mainly to shorten the surgical time, because the results regarding alignment and implant position are observed since the first case [4,20].

Smith, et al. [2] showed mean surgical time of RA TKA of 1 h 36 min versus 1 h 26 min by the conventional technique, in other words, only 10 minutes difference. The average increase in surgical time with the use of this technology is cited to be around 10 to 20 minutes [6].

Studies show the RA TKA can achieve better implant placement accuracy, positioning and choice of implant and polyethylene size [21,22]. It also results in better precision in post-surgical limb alignment [14,20,23]. The RA surgery is related to less pain in the immediate post-surgical period, better initial recovery and reduction of hospitalization time [1,2,14]. This technology leads to better functional scores when compared to the conventional technique [2,23]. Furthermore, the RA TKA is related to lower complications rate like stiffness, infection and wound problems [20]. All this leading to a better overall patient satisfaction [2,14].

The RA TKA showed a 23.7% decrease in blood loss compared to the conventional technique with a decrease of 83% in the relative risk of blood transfusion in the post-surgical period [24]. It is suggested that this is due to the lack of bone marrow milling, less bone resection and less soft tissue aggression [4,24,25]. A study of Kayani, et al. [26] also showed less inflammatory response of the patient after surgery. Another studies have shown surgeon advantages with better ergonomics during the procedure and lower caloric waste [4,27].

Other advantage could be the lesser amount of trays and instruments to perform the surgery, reducing logistics and sterilization costs [4,6,15].

The rate of problems related specifically to the use of robotic systems are cited about 0.4 to 4.6%. Among these occurrences are described: unexpected robotic arm movement; software delay to start procedure; specifically for the knee, the occurrence of femoral notching; and the conversion to conventional surgery [28]. It is therefore recommended always keep the conventional guides available.

However, these disadvantages, in addition to their low occurrence rate, do not cause enough harm to the patient to the point of compromising the final results.

In this way, by the benefits showed, the adhesion to the robotic surgery must be encouraged. The results must be analyzed always with attention for an increasingly wide adoption or even for a evolution to a new technology that presents itself more advantageous.

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