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
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.

References
1. Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, Haddad
FS (2018) Robotic-arm assisted total knee arthroplasty
is associated with improved early functional recovery
and reduced time to hospital discharge compared with
conventional jig-based total knee arthroplasty: A prospective
2. Smith AF, Eccles CJ, Bhimani SJ, Denehy KM, Bhimani
RB, et al. (2021) Improved patient satisfaction following
robotic-assisted total knee arthroplasty. J Knee Surg 34:
730-738.
robotic-assisted total knee arthroplasty are the same. J Am
Concepts and techniques of a new robotically assisted
technique for total knee arthroplasty: The ROSA knee


