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EDITORIAL

Robotic assistance in total knee arthroplasty surgery: necessity or trend?

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The word 'robot' was first used in 1921, when the Czech writer Karel Čapek (1890–1938) premiered his theater performance RUR (*'Rossumovi universality roboti'*) in Prague. A company built artificial humans to lighten people's workload. Although created to help humanity, these machines will conflict with society and start a revolution that will ultimately destroy humanity. 'Robota' means an enslaved person in the Slavic language.

Technology assistance for unicompartmental knee arthroplasty (UKA) and total knee arthroplasty (TKA) has significantly evolved since the 1990s. Saragaglia and Picard introduced computer-assisted surgery (CAS) for TKA surgery [1]. The first use of a surgical robot in orthopedics was in 1986 when the Robodoc (Curexo Technology, Fremont, CA, U.S.A.) was used to carry out knee and hip arthroplasty [2]. Subsequently, different robotic assistance systems have been developed: MAKO (Stryker Orthopedics), OMNIBotic® (Corin), Navio PFS and its update CORI (Blue Belt Technologies, Smith & Nephew), ROSA (Medtech SA, Zimmer-Biomet), VELYSTM (DePuy Synthes), HURWA (HURWA-ROBOT Technology Co. Ltd) and YUANHUA-TKA (YUANHUA). Like robotic technology, computer-guided TKA involves computer systems that provide on-screen information about the patient's anatomy and the kinematics of the knee during the procedure, with recommendations for bone resections and optimal implant placement. However, CAS systems neither actively control nor restrict the surgeon's surgical function and gestures [3]. Robotic-assisted TKA (R-TKA) was introduced to improve the geometric implantation of prosthetic components and alignment of the lower extremities, thereby improving patient functional outcomes and implant survivorship. However, has robotics demonstrated greater accuracy in prosthetic components' implantation, improving functional outcomes and increasing implant survival?

Additional advantages of robotic surgery have been published: the decrease of soft tissue damage and a reduction in postoperative pain and narcotic usage [4,5], the possibility of performing more complex and personalized surgeries than those that can be achieved with conventional techniques (uni- and bicompartmental replacements and precise personalized alignments), the surgeon's capacity and freedom to innovate, the fact that it is a remarkable educational tool and a valuable tool for research, due to the amount of data generated with its use. Do we all give enough importance to pain reduction and less iatrogenic effects on soft tissues to consider this technology essential today? Do these additional advantages justify considering robotics in knee replacement surgery as a necessity?

C. Batailler and S. Parratte have questioned in an interesting reflection whether or not assistive technologies in TKA surgery follow the parabola described by Scott in 2001 [6]. A British gynecologist, J.W. Scott, published a short article in the British Medical Journal entitled 'Scott's parabola: rise and fall of a surgical technique.' Scott's parabola describes the evolution of a new surgical technique, from being shown as a promising alternative at first to eventual standardization following reports of encouraging results to finally falling into disuse due to reports of adverse outcomes [7]. Batailler and Parratte conclude that technological innovations in TKA surgery do not follow 'Scott's parabola.' Is R-TKA following Scott's parabola?

Numerous peer-reviewed publications exist on R-TKA, and many show benefits in terms of safety, reduction in the postoperative inflammatory response, decreased analgesia requirements, reduced costs, and improved outcomes. The following editorial aims to address our primary concerns regarding the current state of R-TKA surgery and summarize enough data to answer the title's question: Is robotic assistance in TKA surgery a necessity or a trend?

Kort et al. published a systematic overview of meta-analyses to identify, synthesize, and critically appraise findings of meta-analyses published until November 2020 on robot-assisted versus conventional UKA and TKA [8]. The authors concluded that although robotics improved component positioning and placement within target zones, its clinical scores, patient satisfaction, and implant survivorship advantages have not yet been confirmed. Robotics considerably extended the operation time. Furthermore, Kort et al. underlined that of the ten meta-analyses evaluated, three were 'low quality,' and four were 'critically low quality,' which invites caution in interpreting the results [8]. Zhang et al. conducted a systematic review and meta-analysis (SR&MA) to compare the accuracy of component positioning, alignment and balancing techniques, patient-reported outcomes, and complications of R-TKA and C-TKA and the associated learning curve [9]. The

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authors concluded that R-TKA demonstrated improved accuracy of component positioning and early patient-reported outcomes, though it may not be clinically significant. The learning curve of R-TKA for operating time was between 7 and 11 cases [9]. Alrajeb et al. published an SR&MA of seven randomized controlled trials (RCTs) comparing the outcomes of robotic and conventional TKA (C-TKA) [10]. The authors found a markedly improved and significant restoration of mechanical alignment in robotic-assisted knee arthroplasty compared to jig-based methods. Despite this, clinical and functional outcomes and complication rates were similar between R-TKA and C-TKA. Alshahrani published a methodologically impeccable SR&MA comparing the outcomes relative to efficacy and safety (functional scores and postoperative complications) of R-TKA to traditional procedures [11]. The pooled functional scores of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Knee Society Score (KSS), Hospital for Special Surgery (HSS) score, and pain visual analogue scale (VAS) showed no significant differences between R-TKA and conventional procedures. The safety profile was similar, except for a higher readmission rate following R-TKA, despite no statistically significant difference in blood loss. Bensa et al. published an SR&MA of RCTs, written in the English language, published in the last 15 years, focusing on the comparison of C-TKA and R-TKA in terms of clinical outcomes, radiological results, perioperative parameters, and complications [12]. This SR&MA showed that R-TKA did not provide superior results to C-TKA regarding clinical and radiological outcomes in mechanically aligned implants. R-TKA showed longer operative time and similar complication rates compared to C-TKA. Fozo et al. have also found no advantages that justify using robotics in TKA surgery [13]. Hoveidaei et al. published an SR&MA evaluating patient satisfaction and found no statistically significant difference between R-TKA and C-TKA. Additionally, various patient-reported outcome measures were examined, showing mixed results across different studies and follow-up periods, so this study does not assert superiority for R-TKA [14]. Hoeffel et al. published an SR&MA of economic and healthcare resource utilization outcomes for robotic versus manual TKA [15]. The authors state that R-TKA was associated with longer mean operating times, a 14% reduction in hospital length of stay, similar outcomes for R-TKA and C-TKA regarding pain and opioid use, and no differences for total procedure cost and 90-day emergency room visits. Furthermore, they claim that no significant difference in cost between R-TKA and C-TKA procedures was observed, though numerically, there was a 4% reduction in cost for R-TKA. Some of these conclusions are the opposite of those of other studies. Three of the authors of this work are employees of a company that manufactures one of the robotic systems marketed, and three others belong to a consultancy firm that this first company paid to carry out the study [15]. In 2020, DeFrance et al. published an interesting RS&MA entitled 'The Impact of Author Financial Conflicts on Robotic-Assisted Joint Arthroplasty Research.' The authors stated that compared to studies favoring conventional techniques, those demonstrating favorable robotics outcomes had more conflicted authors and higher mean industry payment per author [16]. Oppositely, Via et al. stated that funding does not affect clinical outcomes of total joint arthroplasty emerging technologies in a systematic review of bibliometrics and conflicts of interest (in this case, the authors did not limit their analysis to robotics but also evaluated CAS and patient-specific implants or instrumentation) [17]. Recently, Rinehart et al. examined the marketing on surgeon websites regarding R-TKA benefits and sought to determine if the claims were supported by existing literature [18]. They concluded that claims are variable and not definitively supported by existing literature. We cannot and do not want to forget the statement of William Sherman and Victor Wu, 'Surgeons in competitive markets may be inclined to adopt R-TKA in their practice for a variety of reasons including industry advertising money, the appearance of surgeon expertise and authority, and a competitive edge over other surgeons not using R-TKA' [19].

We should point out that one significant bias is generalization. Not all robotic surgery systems are identical, function in the same way, or are based on the same technology. Some differ little from navigation systems, and others have haptic limits and preoperative planning based on three-dimensional virtual models. We may also need more time, data, and unbiased prospective studies to obtain irrefutable evidence of all the theoretical advantages claimed for robotic technology in knee replacement surgery.

However, today, based on the literature reviewed and not hiding the subjectivity of our opinion, we dare to affirm that there does not seem to be evidence that R-TKA is superior to C-TKA in terms of function, complications, costs, satisfaction, and survival in surgery based on principles of mechanical alignment, which is the most studied. Although there are discrepancies in the published literature regarding costs, it seems reasonable to think that R-TKA increases the cost per procedure, and it will have to be assessed to what extent the alleged advantages justify the extra cost (even more so in Public Health Systems). Initiatives like 'The Robotic Arthroplasty Clinical and Cost Effectiveness Randomised Controlled Trials (RACER)' may provide valuable information to objectify the usefulness of robotics in knee joint replacement surgery [20]. Undoubtedly, technology alone does not explain a better outcome. The result is dependent on multiple factors, including static and dynamic alignment of the limb, physiological laxity, stability, respect for the asymmetric and anisometric behavior of the medial and lateral ligament complexes of the knee, accuracy, implant constraint, insert conformity and kinematics, and others. The decision to use robotics in TKA surgery is multifactorial, influenced by different non-clinical aspects (advertising, economic, marketing-related, and dependent on the surgeon's characteristics and aspirations). Nowadays, R-TKA is more of a trend than a necessity.

Perhaps time and further high-quality, unbiased research will prove us wrong, and R-TKA will not be doomed to follow 'Scott's parabola.' Perhaps.

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