

## ROBOTIC APPROACH IN TOTAL KNEE REPLACEMENT SURGERY: A COMPREHENSIVE REVIEW

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### ABSTRACT:

Total knee arthroplasty is the answer if all conservative measures fail to decrease pain, stiffness, improve knee joint range of motion and restore the functional status of the patients with severe knee joint osteoarthritis. Most commonly Knee joint flexion-deformity, malalignment, abnormal gait patterns are the consequences following knee joint osteoarthritic-conditions. Thus, creating a optimal knee joint mechanical alignment is a primary requirement to get pain relief, decrease joint-stiffness, improvise limited knee joint range of motion, correct deformities and regain functions which become restricted on account of knee osteoarthritis. To get appropriate knee joint mechanical axis, robotic surgery has been found as first line of management in connection with total knee arthroplasty surgery. This robotic-assisted approach play significant role in getting most favorable and satisfactory outcomes in light of total knee arthroplasty. Extensive literature search made in this current review shows that this surgical technology is highly accurate and efficient compare to all others advanced surgical technologies such as computer navigation, sensor based, artificial intelligence based, imaging techniques and conventional techniques.

### Aim of the study

This review aims to find out most efficient surgical- techniques to restore the optimal mechanical axis of the knee joint while executing total knee replacement surgeries.

**KEY WORDS-** knee osteoarthritis, robotic surgery, total knee arthroplasty/replacement surgery and mechanical alignment

### INTRODUCTION:

The first use of a surgical robot in orthopaedic surgery was in 1986 and its main concerns were making an operated knee as similar as anatomical and functional knee to achieve good surgical outcomes in terms of patients' satisfaction. [1, 19] Conventional TKR have been suggested to have cutting errors up to 4° and 11° in coronal and sagittal planes successively. Conventional approach is depending upon surgeons' skills and experience for accurate bone cuts and implant positioning, Whereas, robotic-assisted approaches have been implemented to increase precision. Three types of robotic systems, namely, autonomous, hands-on, and passive robotic systems are different concerning surgeons control over procedure. Robotic-assisted total knee arthroplasty have been found to have good mechanical alignment, better functional status but 20% patients' dissatisfaction with respect to conventional strategy. [4, 34] Outliers related to implant position and alignment have been decreased with the robotics coming, with fewer shortcomings like more operating time, higher cost, short terms outcomes and learning curve. [3] Computer-assisted navigation systems have been invented to improve bone-cutting procedures leading to more precise alignment. [4]

Patient reported outcome measures (PROMS) get patient's information for their pain and physical performance; several standards such as questionnaires are followed. [5] Artificial intelligence (AI) can also

detect the issues even before clinical assessments and radiological approaches. [2] With the rapid development of 3D printing, patient-specific cutting guides has been manufactured based on preoperative imaging (CT scan, MRI) to improve the accuracy of implant positioning. One of the robotics technologies, interactive systems requires an interaction between the robot and the surgeon who constrains the robot. In semi-active systems, mechanical constraint can be a movement without feedback to the surgeon. Against this, for synergistic systems, the mechanical constraints are programmable (based on the principle of haptic models i.e. information feedback). Teleoperated systems are under surgeons' remote control. [19]

Robotics has been reported to be better for both unicompartmental as well as total knee replacement surgery as well in the light of alignment (knee joint) and implant positioning. [29, 30] Navigating systems have similar functional consequences to conventional, with extra 10 minute operative time. [31] Ligament balancing is the key factor corporate in robotic-assisted technologies and computer navigation systems to compare and check the pre-operative and intra-operative laxity. [6] TKA success highly depends upon better alignment, fixation, bony cuttings and optimal balancing of the soft tissues. Computer-navigated TKA design has its infra-red tracking modality along with display device, is the cause behind decreased complications during surgery. [7, 8] Various alignments in terms of biomechanical, soft-tissue, neutral, kinematic, anatomical and functional provides better surgical outcomes to get native plane and obliquity of the joint. [9] Latest highlights concerning TKR-technologies reveal AI, optimal implant array, 3D imaging and robotics. [10,11,12]. Video-based assessment is the measure to check the surgeons' technical skill, are now used to improve technical performance of orthopaedic surgeons. [13].

Personalized TKR is performed to gain the native knee joint with more patients' satisfaction. [14] Procedural expertness of surgeons in future may be of no significance and others determinants like patients attributes, behaviors, preoperative recovery and social factors can be focus of attention, still no approach have been reported to take place surgeon intuition. [15]

Various Implant designs and surgeons preferences are the causative factors behind selecting the proper implant designs, for this Australian data-sets can be taken into consideration to find out which fixation, constraint, bearing mobility, patella and polyethylene provide minimum revision rate. [16] Despite faster recovery of pain after 1<sup>st</sup> year of surgery patient might be feel pain and limited functions, still at 10 years of surgery, patient feels pain but improved functionality. [17] Imperfect bone-cutting and technical issues have now been reduced in order that appearance of new technologies likes robots in the context of TKA surgeries. [18]

Robotic operations reduce the chances of instability (18.7%) and aseptic loosening (31.2%) substantially as compared to computer navigation systems, by managing the ligament balancing and mechanical alignment. however, traditional TKA techniques still looks better in the context of flexion range of motion. [20, 21] Additionally, patient specific instruments used for bony resections activities are costly with respect to conventional techniques. [22] Another advanced kinematic alignment technique creates native tibiofemoral joint line causing optimal balanced collaterals and posterior cruciate ligament while Robotics operations needs trained surgeons to refine the technique in terms of reducing learning curves (a rapid improvement through the first cases, steady improvement gained with enhanced experience, and ultimately, a flat phase where extra experience does not cause improvement). [23, 24, 25]

Limb length discrepancy after TKA is unavoidable since basic requirements of TKA surgery like proper flexion-extension gap, small bone cutting, and soft tissue balancing is the rule. [26]

Although custom-made implants based upon 3D imaging technology compare to standard implant designs have potential merit for unusual reconstructive needs, any potential advantages for routine TKA have not been proven. [35] A novel simplified navigation-based instrumentation system facilitates bone cutting by positioning the tracker on an existing cutting block without additional pin fixation, thus more accurate lower extremity mechanical alignment and tibial component alignment in the coronal plane could be achieved. [36] Functional alignment (FA) is a newer surgical technique that to position the prosthesis compared to each patients' specific bony anatomy whilst minimizing disruption to the soft tissue envelope. [37] Whether using gap balance (GB) or measured resection (MR) technique, the primary goal is to ensure the stability and good function of the knee prosthesis. For MR technique, the priority is bone resection, and for GB technique, the priority is the release of contracted ligaments. GB technique can provide better knee flexion in the early postoperative gait status compared with MR technique. [38] The universal use of the "safe zone" of  $\pm 3^\circ$  derived from the mechanical alignment strategy is hardly applicable to modern personalized alignment strategies in the light of current literature. [39]

Accelerometer-based navigation systems (with low cost, more time and higher portability) and computer-based navigation systems are considered to have more accuracy in alignment than conventional TKA. 3D CT Scans attached to robotics provide detailed information about pre-operative and intra-operative phases. [27, 28] Joint alignment is determined key factor for TKR however, greater than  $3^\circ$  of coronal mechanical alignment have been found with higher rate of failure. [32] Factors like better articular surface design, surgical implant positioning, alignment, soft tissue balancing and tension are the cause behind improved patients' clinical and functional outcomes. [33]

**This review aims to** highlight the importance of robotic-assisted technologies with reference to conventional TKR surgeries for precise joint alignment and component positioning.

#### **SEARCH STRAYEGY:**

Search with 1<sup>st</sup> concept: ( "Robotics/classification"[Mesh] OR "Robotics/history"[Mesh] OR "Robotics/instrumentation"[Mesh] OR "Robotics/methods"[Mesh] OR "Robotics/standards"[Mesh] OR "Robotics/trends"[Mesh] ) OR "Pattern Recognition, Automated"[Mesh] OR "Robotics"[Mesh] OR bionic person OR mechanical person OR machine OR automated OR cyborg Filters: Free full text, Clinical Trial, Meta-Analysis, Systematic Review, Humans, English

Search with 2<sup>nd</sup> concept: Knee arthroplasty OR Knee replacement surgery OR Artificial knee joint OR Total knee replacement (TKR) OR Total knee arthroplasty (TKA) ( "Arthroplasty, Replacement, Knee/classification"[Mesh] OR "Arthroplasty, Replacement, Knee/history"[Mesh] OR "Arthroplasty, Replacement, Knee/instrumentation"[Mesh] OR "Arthroplasty, Replacement, Knee/methods"[Mesh] OR "Arthroplasty, Replacement, Knee/rehabilitation"[Mesh] OR "Arthroplasty, Replacement, Knee/standards"[Mesh] ) Filters: Free full text, Clinical Trial, Meta-Analysis, Systematic Review, Humans, English

**PubMed database search:** We made a general search on the PubMed database with concept 1<sup>st</sup>; we got 11,636 results without using any kind of search filter on 11<sup>th</sup> of December-2023 on Saturday. After that

while searched with concept 2<sup>nd</sup>, we found 519 results again without any shorts of timeline on Saturday, 11<sup>th</sup> of December-2023. Search: #1 AND #2 Filters: Free full text, Clinical Trial, Meta-Analysis, Systematic Review, Humans, and English. When we added both concepts with “AND” and applied filters, we found 45 articles. Search: #1 AND #2 Filters: Free full text, Clinical Trial, Meta-Analysis, Systematic Review, Humans, English, from 2021 – 2023. Finally we found 15 relevant articles on PubMed data base, with time frame 2021 to 2023.

**Google scholar database search:** We search with key word phrase “robotics and knee replacement surgery: systemic and Meta analysis” review articles and with filter time line 2021 to 2023, we got 4,890 articles. Then after screening 467 articles were selected. After that 80 results were found relevant to my current study.

The US National Library of Medicine (PubMed/Medline), Google scholar database of Systematic and meta-analysis reviews along with RCTs was systematically searched to identify publications from the past 3 years relevant to this review. Publications that compared the robotics assisted TKR surgery, computer navigated systems with conventional TKR surgeries, the clinical outcome measures, number of revisions and reoperations, and radiological assessment of implant alignment and position were eligible for inclusion. In the interest of capturing latest specific knowledge and potentially relevant information, we applied three years follow-up duration.

**Table.1: Summary of literature review associated with robotic technologies against TKR surgeries**

Author	Study-year	Topic	Methods	Main findings
Junren Zhang, Wofhatwa Solomon Ndou et al.	2021	Robotic-arm assisted total knee arthroplasty is associated with improved accuracy and patient reported outcomes:	a systematic review and meta-analysis	Robotic-arm assisted total knee arthroplasty (RATKA) is associated with improved accuracy and patient-reported outcomes compared to manual total knee arthroplasty (mTKA)
Liang Yuan, Bin Yang, Xiaohua Wang	2021	The Bony Resection Accuracy with Patient-Specific Instruments during Total Knee Arthroplasty	Case series	Patient-specific instruments (PSI) can accurately perform bone resection during total knee arthroplasty, with the distal femoral condyle showing the most accuracy and the tibial plateau second
Han-Jun Lee, K. Park, Yong-Beom Park	2022	Accuracy of Advanced Active Robot for Total Knee Arthroplasty	Cadaveric study	The advanced active robotic system for total knee arthroplasty demonstrates high accuracy in resection thickness and alignment, supporting its clinical application.
Vivek Singh, Greg M. Teo,	2021		Controlled	The novel image-free robotic-assisted system for total knee arthroplasty shows excellent benchtop accuracy and offers

William J. Long		Versatility and accuracy of a novel image-free robotic-assisted system for total knee arthroplasty	experimental study	notable improvement in bone resection accuracy compared to conventional instrumentation
Muzaffar Ali, Anthony O Kamson, Charlie Yoo	2022	Early Clinical and Radiographic Outcomes of Robot-Assisted Versus Conventional Manual Total Knee Arthroplasty	Retrospective review	Robotic-assisted total knee arthroplasty (RA-TKA) shows early improvement in pain, stiffness, and knee flexion compared to manual total knee arthroplasty (M-TKA) in the same patient
S. MacDessi, G. Wernecke, Durga Bastiras	2022	Robotic-assisted surgery and kinematic alignment in total knee arthroplasty (RASKAL study)	Multicentre, double-blinded, 2x2 factorial, randomized trial	Robotic-assisted surgery and kinematic alignment in total knee arthroplasty may improve clinical outcomes, functional measures, radiographic precision, and prosthetic survivorship compared to computer-assisted surgery and mechanical alignment.
Olga Adamska, Krzysztof Modzelewski, J. Szymczak	2023	Robotic-Assisted Total Knee Arthroplasty Utilizing NAVIO, CORI Imageless Systems and Manual TKA Accurately Restore Femoral Rotational Alignment and Yield Satisfactory Clinical Outcomes	Randomized Controlled Trial	Both robotic-assisted total knee arthroplasty (ra-TKA) and manual TKA achieve highly accurate femoral component rotational alignment and yield satisfactory clinical outcomes for primary knee osteoarthritis patients.
Jonathan H. Shaw, Kevin G. Lindsay-Rivera, P. J. Buckley	2021	Minimal Clinically Important Difference in Robotic-Assisted Total Knee Arthroplasty Versus Standard Manual Total Knee Arthroplasty	Prospective cohort study	Robotic total knee arthroplasty (R-TKA) demonstrated comparable minimal clinically important difference achievement to manual total knee arthroplasty (M-TKA) across the larger cohort, with single-surgeon comparison showing some early benefit.

R. Tandoğan, N. Kort, E. Erçin	2021	Computer-assisted surgery and patient-specific instrumentation improve the accuracy of tibial baseplate rotation in total knee arthroplasty compared to conventional instrumentation	Systematic Review and Meta-analysis	Computer-assisted surgery and patient-specific instrumentation can improve the accuracy of tibial baseplate rotation in total knee arthroplasty compared to conventional instrumentation.
Y. Song, Shinichirou Nakamura, S. Kuriyama	2021	Biomechanical Comparison of Kinematic and Mechanical Knee Alignment Techniques in a Computer Simulation Medial Pivot Total Knee Arthroplasty Model	Computer simulation and finite element analysis	The kinematically aligned technique in medial pivot knee arthroplasty restores native joint line and limb alignment, but has higher peak contact stresses on the tibiofemoral joint at 90° and 120° of knee flexion.
Meredith P. Crizer, Amer Haffar, A. Battenberg	2021	Robotic Assistance in Unicompartmental Knee Arthroplasty Results in Superior Early Functional Recovery and Is More Likely to Meet Patient Expectations	Retrospective analysis	Robotic-assisted knee arthroplasty leads to faster recovery, less pain, and more patient satisfaction than conventional methods, but functional differences equilibrate by 1 year postoperatively.
Francesco Zambianchi, Gabriele Bazzan, Andrea Marcovigi	2021	Joint line is restored in robotic-arm-assisted total knee arthroplasty performed with a tibia-based functional alignment	Retrospective review	Robotic-arm-assisted total knee arthroplasty using functional alignment effectively restores the native joint line obliquity and minimizes soft tissue releases, with minimal implant revision needed.
Tejbir S Pannu, Justin Limtong, J. Villa	2021	Transitioning a Practice to Robotic Total Knee Arthroplasty Is Correlated with Favorable Short-Term Clinical Outcomes—A Single Surgeon Experience	Literature review	Robotic total knee arthroplasty (RA-TKA) is associated with favorable short-term clinical outcomes in a single surgeon's experience.

S. Masilamani, Praharsha Mulpur, Adarsh Annapareddy	2022	Enhanced Mid-Resection Workflow Technique for Severe Varus Deformity Correction Using Robotic-Arm Assisted Total Knee Arthroplasty	Review article	Robotic-arm assisted total knee arthroplasty (RA-TKA) can effectively balance severe varus deformities of the knee, improving surgical outcomes.
Zhongming Chen, P. Bonutti, W. Barsoum	2022	Technology Review: CT Scan-Guided, 3-Dimensional, Robotic-Arm Assisted Lower Extremity Arthroplasty	Systemic review	CT scan-based 3-dimensional robotic-arm assisted lower extremity arthroplasty offers multiple advantages, including decreased postoperative pain, reduced complications, and significant cost savings compared to traditional techniques.
Ming-cheng Yuan, Xiaojun Shi, Qiang Su	2021	A prospective randomized controlled trial on the short-term effectiveness of domestic robot-assisted total knee arthroplasty]	prospective randomized controlled trial	Domestic robot-assisted total knee arthroplasty (RATKA) is as effective as traditional total knee arthroplasty in improving knee joint function and pain relief in patients.
Satit Thiengwittayaporn, Pinyong Uthaitas, Chaipipathn Senwiruch		Imageless robotic-assisted total knee arthroplasty accurately restores the radiological alignment with a short learning curve	randomized controlled trial	The imageless robotic-assisted total knee arthroplasty (RATKA) provides better alignment accuracy and a shorter learning curve compared to conventional total knee arthroplasty, making it an attractive option for TKA.
S. Lustig, E. Sappey-Marinier, C. Fary	2021	Personalized alignment in total knee arthroplasty: current concepts	Literature review	Personalized alignment in total knee arthroplasty can restore native knee kinematics and improve functional outcomes, but long-term follow-up is crucial for assessing outcomes and implant survivorship.
Ye Zhang, Yu Zhang, Jian-Ning Sun	2021	Comparison of outcomes between gap balancing and measured resection techniques for total knee arthroplasty	Prospective RCT	Gap Balancing technique for total knee arthroplasty may lead to greater femoral component rotation angle, but measured resection technique for total knee arthroplasty may result in better joint line changes and shorter hospital stay.

<p>Kuo Hao, Maozheng Wei, G. Ji</p>	<p>2022</p>	<p>Comparison of the Imaging and Clinical Outcomes among the Measured Resection, Gap Balancing, and Hybrid Techniques in Primary Total Knee Arthroplasty</p>	<p>Review article</p>	<p>The hybrid technique in primary total knee arthroplasty shows promising imaging and clinical outcomes compared to the measured resection, gap balancing, and gap balancing techniques.</p>
<p>Abhinav K. Sharma, C. Plaskos, S. Shalhoub</p>	<p>2022</p>	<p>Ligament Tension and Balance before and after Robotic-Assisted Total Knee Arthroplasty – Dynamic Changes with Increasing Applied Force</p>	<p>Review article</p>	<p>Increasing distraction force during ligament balancing in total knee arthroplasty leads to non-linear and asymmetric gap changes, aiding in informed surgical decision-making and optimal soft tissue tensioning during TKA.</p>
<p>Qingfang Xiao, Bo Liu, Binghao Zhao</p>	<p>2021</p>	<p>Gap balancing improve squat function and knee function: a randomized controlled trial comparing gap balancing and measured resection</p>	<p>RCT</p>	<p>Gap balancing technique shortens operation time, relieves pain, improves knee range of motion, and enhances squat function and knee function in patients with knee osteoarthritis after primary total knee arthroplasty.</p>
<p>R. Steer, Beth Tippett, R. Khan</p>	<p>2021</p>	<p>A prospective randomised control trial comparing functional with mechanical axis alignment in total knee arthroplasty</p>	<p>prospective randomised control trial</p>	<p>Functional alignment (FA) in total knee arthroplasty (TKA) may provide better functional outcomes for patients compared to mechanically aligned (MA) knees.</p>
<p>M. Rousot, G. Vles, S. Oussedik</p>	<p>2020</p>	<p>Clinical outcomes of kinematic alignment versus mechanical alignment in total knee arthroplasty</p>	<p>Systemic review</p>	<p>Kinematic alignment in total knee arthroplasty shows excellent clinical outcomes and survivorship, but its effectiveness in restoring native knee motion needs further evaluation.</p>



Qiaojie Wang, Xianlong Zhang	2021	Optimal lower limb alignment and soft tissue balancing strategy for robot-assisted total knee arthroplasty	Review article	Robot-assisted total knee arthroplasty using kinematic and functional alignment principles can improve clinical results and patient satisfaction.
Houyi Sun, K. Zheng, Weicheng Zhang	2021	Early effectiveness of computer navigation-assisted total knee arthroplasty	Retrospective analysis of RCT	Computer navigation-assisted total knee arthroplasty (TKA) is an effective and safe procedure for treating osteoarthritis in knees, with no significant difference in outcomes compared to traditional TKA.
N. Jagadeesh, H. Kumar, Varma	2022	Comparative Analysis of Radiological Evaluation and Early Functional Outcomes of Total Knee Arthroplasty Using an Accelerometer-Based Handheld Navigation System and Conventional Instrumentation	Prospective Study	The handheld navigation system (HHNS) significantly increased accuracy in limb and implant alignment in total knee arthroplasty compared to conventional instrumentation, but no significant difference in two-year functional outcomes was found between the two groups.
Kai Lei, LiMing Liu, Xin Chen	2021	Navigation and robotics improved alignment compared with PSI and conventional instrument, while clinical outcomes were similar in TKA	Meta analysis	Navigation and robotics improve alignment accuracy in Total Knee Arthroplasty compared to patient-specific instruments and conventional instruments, but show no clinical significance in postoperative outcomes.
G. Rivkin, L. Kandel, I. Perets	2023	Total knee arthroplasty using a computerized assisted stereotaxic navigation system with bluetooth communication in obese patients	RCT	Computerized navigation in total knee arthroplasty does not significantly impact post-operative hip-knee-angle in obese patients compared to conventional techniques.

Matthias Meyer, T. Renkawitz, F. Völlner	2021	Pros and cons of navigated versus conventional total knee arthroplasty—a retrospective analysis of over 2400 patients	Observational study	Navigated and conventional total knee arthroplasty both provide accurate postoperative leg alignment with low complication rates and equally successful patient-reported outcomes and responder rates one year postoperatively.
Eran Beit Ner, Saad Dosani, L. Biant	2021	Custom Implants in TKA Provide No Substantial Benefit in Terms of Outcome Scores, Reoperation Risk, or Mean Alignment	Systemic review	Custom TKA implants show no significant improvement in outcomes, revision risk, or implant alignment compared to off-the-shelf implants for anatomically uncomplicated primary TKA.
Brandon Passano, Ji Won Lee, Brian P. Gallagher	2022	Two-year outcome comparison of custom versus conventional total knee (TKA) implants	retrospective cohort study	Custom total knee arthroplasty (TKA) and conventional TKA show no significant differences in patient-reported outcomes or complication or revision rates after a 2-year follow-up.
J. Müller, M. Liebensteiner, N. Kort	2021	No significant difference in early clinical outcomes of custom versus off-the-shelf total knee arthroplasty	systematic review and meta-analysis	Custom total knee arthroplasty showed no significant difference in early clinical outcomes compared to off-the-shelf total knee arthroplasty.
E. Sappey-Marinier, J. Shatrov, C. Batailler	2021	Restricted kinematic alignment may be associated with increased risk of aseptic loosening for posterior-stabilized TKA	case-control study	Restricted kinematic alignment (rKA) in posterior-stabilized total knee arthroplasty with a post-cam system may increase the risk of tibial implant loosening.

on Tran, P. McEwen, Yi Peng	2022	Kinematic alignment in total knee arthroplasty	five-year prospective, multicentre, survivorship study	KA TKA using image derived instrumentation (IDI) shows no significant differences in patient outcomes, ligamentous stability, and revisions over five years, with no significant differences in alignment categories.
Andrew P. Kurmis	2023	A role for artificial intelligence applications inside and outside of the operating theatre: a review of contemporary use associated with total knee arthroplasty	Systemic review	scientific evidence base supporting the use of AI in knee arthroplasty
Jean-Pierre St Mart1 En Lin Goh2	2021	The current state of robotics in total knee arthroplasty	review	newer robotic systems have demonstrated promise by minimizing soft tissue damage, reducing hospital stay and improving short-term functional outcomes.
Ahmed Siddiqi1 Timothy Horan2	2021	A clinical review of robotic navigation in total knee arthroplasty: historical systems to modern design	clinical review	Robotic TKA has shown improved reproducibility and precision in mechanical alignment restoration with improvement in early functional outcomes and 90-day episode-of-care cost savings compared to conventional TKA
Natalia Czerwonka1* , Puneet Gupta1,2	2023	Patient-reported outcomes measurement information system instruments in knee arthroplasty patients: a systematic review of the literature	Review	Patient-reported outcomes measurement information system ( PROMIS) global physical health, physical function, and pain interference were found to be significantly responsive, with PROMIS pain interference most effectively capturing clinical improvement
Akash Ghosh, Rajendra Kumar Kanojia	2021	Total Knee Arthroplasty-A Review of Emerging Trends in Patient Management and Surgical Practices	review	Favorable outcomes have been observed with various blood preservation and pain management techniques. TKA remains the forefront of evolution of scientific innovation that have a great potential for refining the TKA alignment and biomechanical outcome to subsequently reduce the incidence of TKA revision and improve patient's satisfaction

Cécile Batailler <sup>1</sup> Sébastien Parratte <sup>2,3</sup>	2021	Assistive technologies in knee arthroplasty: fashion or evolution? Rate of publications and national registries prove the Scott Parabola wrong	review	Most of the innovations in modern knee arthroplasty are not following the Scott Parabola. After a fast rise, these techniques do not disappear but continue to evolve.
Michael S. Woods, MD, MMM	2022	Association between Surgical Technical Skills and Clinical Outcomes	Systematic Literature Review and Meta-Analysis	surgeon technical skill appears to predict clinical outcomes. However, there are surprisingly few articles that evaluate this association
Mina Wahba Morcos <sup>1</sup> , David Uhuebor	2023	Overview of the different personalized total knee arthroplasty with robotic assistance, how choosing?	review	Whether one personalized robotic assisted TKA technique is superior to the other or provides better patient outcomes is yet unclear
Cécile Batailler, MD a, b, *, Timothy Lording, FRACS	2021	Predictive Models for Clinical Outcomes in Total Knee Arthroplasty	Systemic analysis	preoperative pain and PROM scores were highly predictive for clinical outcomes after TKA.
Régis Pailhé	2021	Total knee arthroplasty: Latest robotics implantation techniques	Review article	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
Kaif Qayum, Irfan Kar	2022	WE7.11 Robotic-assisted versus conventional total knee arthroplasty	Systematic Review and Meta-analysis	Robotic-assisted TKA had better outcomes than conventional TKA regarding mechanical alignment and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). However, the conventional approach showed a better range of motion-flexion in the long term.
Isobel M Dorling, Lars Geenen	2023	Cost-effectiveness of patient specific vs conventional instrumentation for total knee arthroplasty	systematic review and meta-analysis	Cost for PSI and CI TKA can differ when considering distinct aspects of their implementation. Total costs per patient case are increased for PSI TKA when compared to CI TKA.

Giorgio Cacciola <sup>1</sup> , Francesco Bosco <sup>1</sup>	2022	Learning Curve in Robotic-Assisted Total Knee Arthroplasty	Systematic Review of the Literature	No learning curve was observed for implant placement and lower limb alignment because the implants were correctly placed from the first raTKAs. No significant complication rates were reported during the raTKA learning curve
Yichao Luan <sup>1</sup> , Huizhi Wang	2023	Comparison of navigation systems for total knee arthroplasty:	systematic review and meta-analysis	no significant difference in the accuracy of component alignment between the ABN and CN systems, but the ABN approach had a shorter surgical duration and at lower cost. The ABN system also significantly improved the accuracy of component alignment when compared to the CONI approach, although the surgery was longer
Kyle N. Kunze <sup>a,*</sup> , Daniel Farivar	2021	Comparing clinical and radiographic outcomes of robotic-assisted, computer-navigated and conventional unicompartmental knee arthroplasty	meta-analysis of randomized controlled trials	(robotassisted)RA(unicompartmentalknearthroplasty) UKA results in fewer complications than conventional UKA with a clinically significant increase in operative time.
Juntan Li <sup>1†</sup> , Yuqi Zhang <sup>2</sup>	2022	Accelerometer-based navigation vs. conventional techniques for total knee arthroplasty (TKA):	systematic review and meta-analysis of randomized controlled trials	The present meta-analysis demonstrated that ABN was superior to (conventional) CONV in restoring (mechanical alignment) MA of the lower limb. In addition, ABN reduced the loss of blood and the duration of surgery was not prolonged. However, patient reported outcome measurements (PROMs) were not improved
Cécile Batailler <sup>1,2</sup> · Andrea Fernandez <sup>1</sup>	2021	MAKO CT-based robotic arm-assisted system is a reliable procedure for total knee arthroplasty	Systemic review	The CT-based robotic-assisted system for TKA reduced postoperative pain and improved implant positioning with equal or slightly superior improvement of the functional outcomes at one year, compared to conventional TKA.
Zien Alabdin Foza <sup>1</sup> , Ahmed Hussein Ghazal	2023	A Systematic Review and Meta-Analysis of Conventional Versus Robotic-Assisted Total Knee Arthroplasty	Systematic Review and Meta-Analysis	Study-findings support the superiority of the conventional TKA over the robotic-assisted TKA, as conventional TKA had lower operative time and tourniquet time. Additionally, the HKA angle

			change was superior in the conventional TKA. The superiority of the robotic-assisted TKA was in the pain outcome taking into consideration that the result was not significant.
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**DISCUSSION:**

Total knee replacement surgeries have found excessive values since increasing population of patients with osteoarthritis demanded it at a larger extent. So both shorts of techniques (conventional and advanced) are performed to manage the osteoarthritis population. Patients’ satisfaction rates are appropriate enough with these replacement operations; however increased expectations and challenges from patients’ side cannot be neglected.[40] Proper placement of implants and better soft tissue adjustment in terms of balancing are the excellent criteria followed during these surgeries. Robotic assisted TKR caused a meticulous alterations in mechanical alignment of the knee joint surgeries in connection with restoring it efficiently way. Thus accuracy of replacement surgeries has been increased because of better knee balancing. Also, robotic surgeries have improved reduction in radiology related outliers, with its exclusive surgical execution. [41]

These alterations in replacement surgeries have attracted the surgeons towards its efficacious results with reference to excellent performance. Positive influence can be seen in surgeon’s community considering the demands of robotic assisted systems in this era of replacement surgeries.[42] Although kinematic alignment showed its preciseness still its superiority cannot be declared over others soft tissues balancing techniques. RTKA assured its theoretical concerns, increased operating time and significant learning curves will have to consider along with this. As radiological interference also needs substantial time, cost and arrangement, definitely surgical complexity gets increased while performing TKR surgeries. [43]

My study, in contrast, provides the evidence on this topic, as it includes many review articles, RCTs found in the literature that compare both techniques. Statistical reports found in these researches supports the robotic knee arthroplasty compared with conventional techniques. However, the evidences of heterogeneity in the outcomes after TKR for proper interpretation regarding various surgical execution causes uncertainty in patients satisfaction and clinical applications.

Conventional manual techniques have low precision compared to Robotic-assisted primary knee arthroplasty if we consider bone cuts and component position. [44] Robotic-assisted knee arthroplasty had been found as an increased accuracy of alignment with reference to creating a mechanical axis and reducing the number of outliers. Robotic technology produce better component placement in terms of precision during revision TKR surgeries. [45] Anatomical pillars are not found in revision surgeries that are the reason abnormal joint line is the result after operation. Keeping native joint line optimal is the crucial factor for primary and revision knee replacement operations. If knee joint line not in its native states creates huge functional problems. So during surgery flexion and extension gaps are of prime importance to focus these consequences. [46]

Imaging-based robotic system can determine the joint line as a preoperative planning maneuver thus minimizes the tissue destruction during replacement surgeries. [47] Shorter length of hospital stay is the outcome after robotic-assisted operations since intra-operative feedback is provided during this procedure to help the surgeons and protect the soft tissues injuries with those who received computer-navigated knee arthroplasty. With the help of the robotic system can achieve a balanced knee with lesser joint pain following operations. Through proper time bound information with the help of sensors during procedure, objectivity of the procedure in terms of measurement can be increased up to the mark and knee gaps are planned preoperatively via this system with the result that well quantitative knee alignment. [48]

The important results of this narrative review was that robotic TKA is associated with longer operative time, unavoidable soft injuries after the replacement procedures.[49] Determine beneficiary impacts of robotic surgeries, accurate prosthesis placement with lesser outliers regarding its positions, alignment, better bone cuttings, and better soft tissue balancing with lesser injuries cause the good functional recovery with better patients satisfaction rate. Active, semi-active and passive robotic systems are three categories used in the TKR surgeries now a day. [50] In this system surgeon control the procedure and robots perform the surgeries independently. Active system has been found with unavoidable injuries during the procedures. So to overcome these problems semi-active system has been configured which provide touch feel to the surgeons to detect the specific limitations. After all management in terms of several improvements in these systems, few complications and errors cannot be avoided. Complications like patellar tendon injury, dislocation and fracture of the patella, nerve injuries, excessive blood loss are found after procedure. Along with that other downsides of robotic surgeries are prolonged -operating time however robotics are advantageous to reduce post-surgery stiffness. [51]

Learning curve is another challenge with these technologies. It creates anxiety during initial phases of robotic learning to the surgeons. Stress and mental fatigues may lead to poor decision making by surgeons. However after being trained in these techniques surgical procedure becomes easy and comfortable to the surgeons. [52]

Some important limitations have been noted in literature after going through these studies. Various approaches of evaluation for assessing the complications and downside of the robotic system are first limitation. Selection criteria for finalizing the population with TKR surgeries are another limitation. Also there is lack of sufficient studies in the literature in this regards.

## **Conclusion**

Robot-assisted TKR surgeries are promising technologies to improve surgical results by increasing the accuracy of implant placement, soft tissue protection and achieving a better-balanced knee. Robotic total knee replacements offer superior post-operative anatomical and mechanical alignment compared to conventional total knee replacements. More studies needed to confirm the superiority of robotic assisted systems over conventional and others techniques.

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