EDITORIAL

The Current Role of Robotic-assisted Total Knee Arthroplasty

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Introduction

Lately, several interesting articles have been published on robotic-assisted total knee arthroplasty (RA-TKA).[1-9]

Level I evidence studies

In 2020, Kim et al compared RA-TKA with conventional total knee arthroplasty (C-TKA) at the long-run follow-up. The clinical and radiographic outcomes of 674 individuals (724 knees) in each group were evaluated. After a minimal follow-up of 10 years, no differences were found between RA-TKA and C-TKA regarding function, aseptic loosening, prosthetic survival, and adverse events. Taking into account the overtime and cost related to RA-TKA, Kim et al did not recommend its widespread use.[4]

In 2020, Vaidya et al postulated that mechanical alignment of the lower extremity axis, postoperative joint line reestablishment, and alignment of the prosthetic components (femoral and tibial) were more precise using RA-TKA than C-TKA.[5] The authors analyzed 60 patients. The authors performed preoperative and postoperative radiographic measurements and compared the two techniques. A significant difference was found between the two techniques regarding deviations of mechanical axis deviation and joint line, and coronal alignment of the prosthetic components (femoral and tibial). Compared with C-TKA, RA-TKA was highly accurate regarding coronal plane prosthetic component placement and mechanical alignment. In C-TKA, the joint line is elevated but can be accurately reestablished by RA-TKA, which might result in improved patellofemoral kinematics.[5]

In 2021, Lei et al published a network meta-analysis to compare C-TKA, computer navigation, patient-specific instruments (PSI), and RA-TKA. The conclusion was that navigation and RA-TKA ameliorated the alignment accuracy compared with PSI and C-TKA, although there was clinically no difference in the postoperative outcomes.[6]

Other studies with lower levels of evidence

In 2019, Kayani et al compared RA-TKA with C-TKA. RA-TKA was associated with reduced postoperative pain, better early functional rehabilitation, and shorter hospital discharge time than C-TKA. However, there was no difference in mid to long-run functional results between C-TKA and RA-TKA.[1]

Matassi et al evaluated whether an accelerometer-based navigation system could be useful for performing exact bone resections and restoring the neutral mechanical axis in patients with difficult TKA due to extraarticular deformity.[7] They analyzed 18 consecutive TKAs in 18 individuals with knee osteoarthritis (OA) and associated extraarticular deformity. No intraoperative or postoperative surgical adverse events were found. The accelerometer-based navigation accurately achieved neutral mechanical alignment and optimal implant position following TKA in individuals with extraarticular deformity.[7]

In 2021, Sires et al analyzed the precision of the Mako Total Knee system (Stryker, Kalamazoo, MI, USA) in accomplishing the preoperative strategy for osseous resection and final coronal lower extremity alignment.[8] The precision in accomplishing the preoperatively intended osseous resection and final coronal lower extremity alignment utilizing the Mako Total Knee system was excellent.[8]

In 2020, Batallier et al reported a systematic literature review (level IV evidence) to explore the clinical and radiological outcomes of the Mako RA-TKA. Compared with C-TKA, Mako diminished postoperative pain and ameliorated implant placement. One year after surgery, the functional outcomes were equal to or slightly superior to the Mako system.[9]

As recently published by St Mart and Goh, the main limitations of RA-TKA are its high initial expenditure, learning curves, and absence of long-run results. The short-run benefits and increased technical dependability of contemporary RA-TKA systems might give reasons for the funding of RA-TKA.[2] According to Siddiqi et al., RA-TKA systems have two major limitations: short-run follow-ups and big heterogeneity of the accesible systems.[3]

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Table 1. Main results of robotic-assisted total knee arthroplasty (RA-TKA) in the literature

Authors [Reference]	Year	Level of Evidence	Results
Matassi et al [7]	2019	NA	Accelerometer-based navigation accurately achieved neutral mechanical alignment and optimal implant position after TKA in patients with extraarticular deformity.
Kayani et al [1]	2019	NA	RA-TKA was associated with decreased postoperative pain, better early functional rehabilitation and shorter time to hospital discharge compared with C-TKA. However, there was no difference in medium to long-term functional outcomes between C-TKA and RA-TKA.
Kim et al [4]	2020	I	After a minimum follow-up of 10 years, no differences were found between RA-TKA and C-TKA in terms of functional outcome scores, aseptic loosening, overall survival and complications. Considering the additional time and expense associated with RA-TKA, the authors did not recommend its widespread use.
Vaidya et al [5]	2020	I	Compared with C-TKA, RA-TKA is highly accurate in terms of the placement of prosthetic components in the coronal plane and mechanical alignment. In C-TKA, the joint line is elevated but can be accurately reestablished by RA-TKA, which can result in better patellofemoral kinematics.
Batallier et al [9]	2020	IV	Compared with C-TKA, the Mako system reduced postoperative pain and improved implant placement. At 1 year after surgery, functional outcomes were equal or slightly superior with the Mako system.
Sires et al [8]	2021	NA	The Mako system showed high accuracy in achieving the preoperatively planned bone resection and final coronal alignment of the limb.
Lei et al [6]	2021	I	Navigation and the robot improved alignment accuracy compared to patient-specific instruments and C-TKA, although clinically there was no difference in postoperative outcomes.
St Mart and Goh [2]	2021	NA	RA-TKA improved component positioning and reduced alignment outliers compared with preoperative planning.
Siddiqi et al [3]	2021	NA	Compared with conventional C-TKA, RA-TKA has been shown in some studies to demonstrate greater reproducibility and accuracy in restoring mechanical alignment, with improved early functional outcomes and cost savings within 90 days of surgery.

RA-TKA, robotic-assisted TKA; C-TKA, conventional TKA; NA, not available

[Table 1] shows the main results of artificial intelligence (AI) systems (physical elements - robotics) in TKA. [Table 2] summarises the main limitations of RA-TKA.

RA-TKA improves the precision of component alignment compared with PSI and C-TKA, although clinically, there is no difference between them in terms of postoperative outcomes. RA-TKA still has significant limitations that advise against its widespread use, such as high establishment expenditure, a steep learning curve, the small number of implant designs compatible with robotic technology, the lack of long-term results, and the large heterogeneity of available systems.

Table 2. Main limitations of robotic-assisted total knee arthroplasty (RA-TKA)

Authors [Reference]	Year	Level of Evidence	Limitations
Kayani et al [1]	2019	NA	High installation costs, additional radiation exposure, learning curves to acquire surgical proficiency and compatibility of robotic technology with a limited number of implant designs.
St Mart and Goh [2]	2021	NA	High initial costs, learning curves and lack of long-term results.
Siddiqi et al [3]	2021	NA	Short-term follow-up and large heterogeneity of available systems.

NA, not available

References

1. Kayani B, Konan S, Ayuob A, Onochie E, Al-Jabri T, Haddad FS. Robotic technology in total knee arthroplasty: a systematic review. EFORT Open Rev 2019;4(10):611-7. doi: 10.1302/2058-5241.4.190022.
2. St Mart JP, Goh EL. The current state of robotics in total knee arthroplasty. EFORT Open Rev 2021;6(4):270-9. doi: 10.1302/2058-5241.6.200052.
3. Siddiqi A, Horan T, Molloy RM, Bloomfield MR, Patel PD, Piuzzi NS. A clinical review of robotic navigation in total knee arthroplasty: historical systems to modern design. EFORT Open Rev 2021;6(4):252-69. doi: 10.1302/2058-5241.6.200071.
4. Kim YH, Yoon SH, Park JW. Does robotic-assisted TKA result in better outcome scores or long-term survivorship than conventional TKA? A randomized, controlled trial. Clin Orthop Relat Res 2020; 478(2):266-75. doi: 10.1097/CORR.0000000000000916.
5. Vaidya NV, Deshpande AN, Panjwani T, Patil R, Jaysingani T, Patil P. Robotic-assisted TKA leads to a better prosthesis alignment and a better joint line restoration as compared to conventional TKA: a prospective randomized controlled trial. Knee Surg Sports Traumatol Arthrosc. 2022;30(2):621-6. doi: 10.1007/s00167-020-06353-2.
6. Lei K, Liu L, Chen X, Feng Q, Yang L, Guo L. Navigation and robotics improved alignment compared with PSI and conventional instrument, while clinical outcomes were similar in TKA: a network meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2022;30(2):721-33. doi: 10.1007/s00167-021-06436-8.
7. Matassi F, Cozzi Lepri A, Innocenti M, Zanna L, Civinini R, Innocenti M. Total knee arthroplasty in patients with extra-articular deformity: restoration of mechanical alignment using the accelerometer-based navigation system. J Arthroplasty 2019;34:676-81. doi: 10.1016/j.arth.2018.12.042.
8. Sires JD, Craik JD, Wilson CJ. Accuracy of bone resection in MAKO total knee robotic-assisted surgery. J Knee Surg 2021;34(7):745-8. doi: 10.1055/s-0039-1700570.
9. Batailler C, Fernandez A, Swan J, Servien E, Haddad FS, Catani F, et al. MAKO CT-based robotic arm-assisted system is a reliable procedure for total knee arthroplasty: a systematic review. Knee Surg Sports Traumatol Arthrosc 2021;29(11):3585-98. doi: 10.1007/s00167-020-06283-z.