Original Article

Ann Med Res 2022;29(7):722–725

Ann Med Res

Current issue list available at AnnMedRes

Annals of Medical Research

journal page: www.annalsmedres.org

Evaluation of the learning curve in terms of operation time in robotic assisted unicondylar knee arthroplasty

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ARTICLE INFO

Keywords:
Robotic assisted
Osteoarthritis
Medial compartment
Arthroplasty
Unicondylar

Received: Jan 18, 2022
Accepted: Mar 16, 2022
Available Online: 25.07.2022

DOI:
10.5455/annalsmedres.2021.12.670

Abstract

Aim: There are few studies in the literature evaluating the robotic assisted unicondylar knee arthroplasty (rUKA) learning curve. This study aimed to evaluate the learning curve in robotic assisted unicondylar knee arthroplasty in terms of operation time.

Materials and Methods: The data of patients who underwent rUKA between October 2016 and December 2019 were retrospectively analyzed. Age, gender, side, and body mass index (BMI) values of the patients were obtained from the patient files. To compare the operation times, the patients were divided into two groups. The first group represented patients who had surgery in the first half of the follow-up period (n=27), while the last group represented patients who had surgery in the second half of the follow-up period (n=28).

Results: During the study period, rUKA was performed on 55 patients (42 females, 13 males) with a mean age of 64.1 years. The demographic data of the two groups were similar. The mean operative times of the first (n=27) and the last groups (n=28) were 101.816.1 minutes, and 84.89.9 minutes, respectively ($p < 0.001$).

Conclusion: The mean duration of operation was significantly shorter in the last group who underwent rUKA, compared to the first group. Our findings showed that there is a significant learning curve in rUKA surgery in terms of operation time.

Introduction

In knee arthroplasty, correct placement of prosthetic components, equalization of flexion and extension range, ensuring proper alignment, and good adjustment of ligament balance are the main objectives [1]. Although many different methods are used to achieve these goals, the desired results are still not observed in a significant number of patients and discussions are ongoing about how to achieve better outcomes [2]. Using advanced technology in orthopedic surgery was proposed at the beginning of the 21st century and navigation and robotic-assisted systems aimed at minimizing human-induced errors began to be introduced [3]. After 2010, the use of these systems increased. Various publications report that prosthetic components can be better placed with robotic- and navigation-assisted arthroplasty [4]. As with any surgical intervention, arthroplasty has a certain learning curve [5]. The learning curve may vary in procedures where complex systems such as robotics are used. A limited number of studies evaluated the robotic knee arthroplasty learning curve [6]. In addition to radiological and functional results, operation time is an important parameter in its evaluation. In this study, the learning curve of robotic unicondylar knee arthroplasty (rUKA) was evaluated in terms of surgical duration. We hypothesized that the duration of surgery could be significantly shortened after a certain number of cases were performed.

Materials and Methods

The patient files were retrospectively reviewed after the ethics committee (Istanbul Atlas University Non-Interventional Scientific Research Ethics Committee, 25.06.2021, E-22686390-050.01.04-4762) approved this retrospective case series study. Informed consent was obtained from the patients before all surgical procedures. Patients who underwent rUKA with the diagnosis of knee medial compartment osteoarthritis between October 2016 and February 2019 were included in the study. Seventeen patients who underwent bilateral rUKA in the same session were excluded. Age, gender, side, and body mass index (BMI) values of the patients were obtained from the patient files. All surgeries were performed in a single center

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by a single surgeon experienced in arthroplasty. Anesthesia records were analyzed for operative time, and the total duration of operation was calculated from the skin incision until its closure. The patients were divided into two groups chronologically as "first group" and "last group". The first group represented patients who had surgery in the first half of the follow-up period (n=27), while the last group represented patients who had surgery in the second half of the follow-up period (n=28). The primary outcome measurement was the total duration of the operation.

Surgical technique

Our indication for rUKA was isolated medial compartment knee osteoarthritis. We did not perform rUKA for bicompartmental or tricompartmental osteoarthritic patients. We also did not prefer rUKA for patients with inflammatory arthropathies such as romatoid arthritis. Varus deviation of mechanical axis more than 10 degrees was another relative contraindication for rUKA in our patient series. All the rUKA procedures was performed via using a specialized orthopedic arthroplasty robotic arm called MAKO™ (Stryker Mako Surgical Corporation, Fort Lauderdale, FL). Before all the surgical interventions, computed tomography slices were taken from the hip, knee, and ankle joint of the operative side for preoperative planning on the robotic arm's software. Femoral and tibial implant size and positioning, thickness of the insert also lower extremity alignment was planned on the virtual 3-dimensional bone models of the knee joint created by the MAKO™software. After preoperative planning, the patient was taken to the operating room. All the surgical procedures were performed in supine patient position. A high thigh tourniquet was used in all patients. The operative lower extremity was sterile prepared and draped. 10 cm medial parapatellar incision was performed and the medial compartment was visualized via medial parapatellar arthrotomy. Medial meniscus was resected, and the borders of medial femoral condyle and tibia plateau was visualized. Femoral array was introduced into the supracondylar femoral region via using two parallel Steinmann pins, also the tibial array was placed to the anteromedial tibial cortex 5cm under the tibial tubercule in the same manner. A check pin was inserted both medial supracondylar femoral and tibial proximal anteromedial cortex. Femoral and the tibial arrays, also the navigation probe was registered to the MAKO™. Joint surface was registered to the robotic arm via using the navigation probe. After registration of the joint, planned femoral, tibial components and the appropriate size insert was placed on the virtual 3-D images on the software of the robotic arm. Adjustments were done until we get the desired alignment and ligament balance. After virtual planning of the placement of the unicondylar components, femoral and the tibial bone cut were performed via using the robotic arm's high-speed burr. Trial implants were introduced to the femur, tibia and the polyethylene insert was placed. Knee range of motion, ligament balance and the alignment of the lower extremity was checked on the software virtually. After satisfactory prosthetic placement was achieved, the original components were placed with an antibiotic cement. The insert was placed. Alignment and knee balance was checked again virtually on the software. The joint was irrigated with sterile saline, a hemovac drain was placed and the layers were closed in standard fashion. The patients were mobilized the day after the surgery and the drain was removed. The stiches were removed after 15 days of the surgery.

Table 1. The comparison of the groups demographic characteristics.

	rUKA (n=55)		
	First group (n=27)	Last group (n=28)	P value
Age	62.9 ± 10.1	65.4 ± 8.4	0.331
Gender			0.290
Female	22 (81%)	20 (71%)	
Male	5 (19%)	8 (29%)	
BMI (kg/m^2)	33.8 ± 5.8	30.8 ± 5.9	0.087
Side (right/left)			0.790
Right	13 (48%)	14 (50%)	
Left	14 (52%)	14 (50%)	

* rUKA: Robotic assisted unicondylar knee arthroplasty.

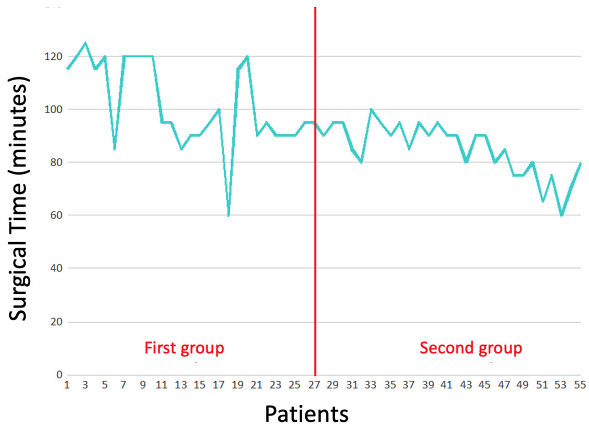

Figure 1. Graph showing the duration of surgery chronologically.

Statistical analysis

The data were analyzed with SPSS 26.0 (SPSS Inc., IBM, NY, USA). Numerical data were given as mean and standard deviation, and categorical data, as frequency and percentage. The normality of the continuous data was analysed by using Kolmogorov-Smirnov test. The t-test was used to compare the means of the two groups, while the Chi-Square test was used to compare frequencies. A p-value of less than 0.05 was considered significant.

Results

A total of 55 patients (42 females and 13 males) with a mean age of 64.1 years were included in the study. The demographic characteristics of the first group and the last group of patients are summarized in Table 1. No significant differences were found between the two groups in terms of age, gender, BMI, and side. The mean operative times in the first (n=27) and last (n=28) groups were

101.816.1 minutes, and 84.89.9 minutes, respectively (p = <0.001) (Figure 1).

Discussion

We hypothesized that surgical time in robotic assisted unicondylar knee arthroplasty may decrease with increasing surgical experience. In our study, there was a significant difference between the first and the last patient groups in terms of operation time. The mean operation time of the patients in the second half was shortened by 17 minutes compared to the first group. Our findings showed that there may be a certain learning curve in robotic unicondylar knee prosthesis and the operation time is shortened with increasing surgical experience. These results confirm our previously stated hypothesis. There is limited information in the literature concerning the learning curve of the robotic assisted unicondylar knee arthroplasty in the literature and our results should be confirmed with similar studies in the future. Robotic systems have become common in recent years, especially in unicondylar knee arthroplasty [7]. These systems offer the surgeon the opportunity to place the prosthetic components per the plan established preoperatively [8]. There are different types of robotic systems in the market. Robots mainly used in arthroplasty surgery can be divided into three: Passive, semi-active and active systems [9]. Passive systems are generally navigation-based and preoperative incisions are made by the surgeon with the help of navigation. In active systems, the planned incisions are made completely by the robot without any intervention of the surgeon [10]. In semi-active systems, bones are incised by the robot arm controlled by the surgeon. In these systems, even if the robotic arm is controlled by the surgeon, the robot does not allow incisions outside the pre-determined angles and limits [11]. The robot used in this current study (MAKO®Stryker–Portage, Michigan-USA) falls into the semi-active class. In this system, preoperative computerized tomography imaging is performed on the patient's hip, knee, and ankle. The images are arranged by the software specialists (MPS – MAKO product specialist) and transferred to the robot's system. Before the surgery, prosthesis placement and incisions are planned on 3D tomography images uploaded to the robot's system. During the surgery, optical markers are placed in the patient's femur and tibia. The robot's high-resolution camera detects these optical markers to determine the joint's spatial position. After the surgical approach is determined, the joint is introduced to the system and the simultaneous environment is matched with 3D tomography images. At this stage, the patient's ligament balance is evaluated simultaneously in the virtual environment. After the synchronization is complete, bone incisions are made using the robotic arm controlled by the surgeon. The robot arm does not allow the incision to be made outside the previously determined angle and incision limits. In the MAKO system, during unicondylar knee arthroplasty, the incisions are made with a high-speed shaver tip connected to the robotic arm. After the prosthetic trial components are placed, the connective tissue balance is rechecked in the virtual environment. If the result is satisfactory, permanent prostheses are placed. Unicondylar arthroplasty is a beneficial treatment option with favorable long-term outcomes, especially in patients with isolated medial compartment osteoarthritis [12,13]. However, under- or overcorrection of the alignment may lead to early revision, polyethylene abrasion, or lateral compartment osteoarthritis [14,15]. Implant placement and failure to obtain the desired degree of alignment led orthopedic surgeons to use high technology, hence the use of robotic surgery. Robotic surgery trials began in the nineties; however, due to the invasiveness of the robots used back then and the comparable results of robotic surgery to conventional surgery, it was avoided for a certain period [8]. After 2010, less invasive and easy-to-use robots were developed and made available to orthopedic surgeons. The MAKO robotic surgery system began to be used in these years. Different studies reported that better prosthetic component placement can be achieved with the MAKO robotic system and that the alignment can be brought to the desired level to a better extent [16,17]. Although this method does not have long-term results, Pearle et al. reported that the 2-year prosthesis survival rate was at least 96% and that 92% of the patients were satisfied or very satisfied with the surgery at the end of 2 years [18]. In a randomized controlled study published in 2017, Blyth et al. reported that in the unicondylar knee arthroplasty performed with robotic assistance compared to the conventional method, 54% less pain was experienced in the first 8-week follow-up of the patients and excellent clinical results were obtained in the robotic group at the end of the study [19]. However, the long-term results of robotic unicondylar knee arthroplasty. and its advantages or disadvantages compared to the conventional method have not been clarified [20]. As in any surgical technique, surgeons go through a learning stage in robotic unicondylar knee arthroplasty. In addition to radiological and functional results, the duration of the operation is an important parameter in evaluating the surgical learning curve. In our study, the duration of the operation was used to assess learning curve. There are only five studies in the literature evaluating the learning curve of robotic unicondylar knee prostheses. Four of these are abstracts [6]. In 2019, Batailler et al. compared the conventional method and the robotic system and reported that the prosthetic components were placed more accurately in patients who underwent robotic unicondylar knee prosthesis, and less revision was required in the robotic group. On the other hand, the mid-term functional results of robotic and conventional surgery were comparable. Researchers reported that there was no learning curve for robotic surgery in this study, but they did not provide information on how they reached this conclusion [21]. In this study, unlike ours, the NAVIO® (Smith & Nephew, Hertfordshire – United Kingdom) robotic system was used. Picard et al. reported that the surgical time was shortened by 15 minutes after the first 10 cases, while Wallace et al. reported that the duration of operation stabilized after 8 cases [22,23]. Simons and Riches reported that the mean surgical time was shortened by 37 minutes after the first 5 cases in their series [24]. Smith et al. reported that the learning curve affects the operative time and not the postoperative implant position accuracy. Despite advancements in knee preservation surgery, robotic assisted arthroplasty is taking more attention worldwide and future studies may reveal benefits of robotic assisted surgery over conventional techniques [26]. We noted several limitations for this study. The main limitation of this study was evaluating the learning curve according to the time of operation. Evaluating the learning curve in terms of prosthesis placement, alignment, and functional results, as well as the duration of the operation, may lead to healthier results. The low number of patient population is another limitation of this study. However, there are limited studies in the literature evaluating the learning curve for robotic unicondylar knee arthroplasty. The limited studies in the literature about the learning curve of robotic unicondylar knee arthroplasty reveal the strength of our study. Also, the demographic characteristics of our two groups were similar, which decreased bias.

Conclusion

The mean duration of operation was significantly shorter in the last group who underwent rUKA, compared to the first group. Our findings showed that there is a significant learning curve in rUKA surgery in terms of operation time.

Conflicts of interest statement

The authors of this study declare no conflicts of interest.

Ethics approval

Istanbul Atlas University Non-Interventional Scientific Research Ethics Committee, 25.06.2021, E-22686390-050.01.04-4762.

References

1. Cherian JJ, Kapadia BH, Banerjee S, et al. Mechanical, Anatomical, and Kinematic Axis in TKA: Concepts and Practical Applications. Curr Rev Musculoskelet Med. 2014;7(2):89-95. doi:10.1007/s12178-014-9218-y.
2. Jaffe WL, Dundon JM, Camus T. Alignment and Balance Methods in Total Knee Arthroplasty. J Am Acad Orthop Surg. 2018;26(20):709-716. doi:10.5435/JAAOS-D-16-00428.
3. Jacofsky DJ, Allen M. Robotics in Arthroplasty: A Comprehensive Review. J Arthroplasty. 2016;31(10):2353-2363. doi:10.1016/j.arth.2016.05.026.
4. Sousa PL, Sculco PK, Mayman DJ, et al. Robots in the Operating Room During Hip and Knee Arthroplasty. Curr Rev Musculoskelet Med. 2020;13(3):309-317. doi:10.1007/s12178-020-09625-z.
5. Nzeako O, Back D. Learning Curves in Arthroplasty in Orthopedic Trainees. J Surg Educ. 2016;73(4):689-693. doi:10.1016/j.jsurg.2016.02.006.
6. Clement ND, Al-Zibari M, Afzal I, et al. A systematic review of imageless hand-held robotic-assisted knee arthroplasty: learning curve, accuracy, functional outcome, and survivorship. EFORT Open Rev. 2020;5(5):319-326. doi:10.1302/2058-5241.5.190065.
7. Crawford DA, Berend KR, Thienpont E. Unicompartmental Knee Arthroplasty. Orthop Clin North Am. 2020;51(2):147-159. doi:10.1016/j.ocl.2019.11.010.
8. Pearle AD, O'Loughlin PF, Kendoff DO. Robotic-assisted Unicompartmental Knee Arthroplasty. J Arthroplasty. 2010;25(2):230-237. doi:10.1016/j.arth.2008.09.024.
9. Kızılay YO. Bilgisayar destekli ve robot yardımlı total kalça artroplastisi. In: Özmanevra R, Işın Y, Kara YS, Yaman F, Demirkıran ND, eds. Erişkinlerde Kalça Hastalıkları ve Tedavisinde Güncel Yaklaşımlar. 1st ed. Ankara: Akademisyen Kitabevi; 2020:333-345. ISBN:978-605-258-943-4.
10. Liow M, Chin P, Tay K, et al. Early experiences with robotic-assisted total knee arthroplasty using the DigiMatchTM ROBODOC® surgical system. Singapore Med J. 2014;55(10):529-534. doi:10.11622/smedj.2014136.
11. Kızılay YO, Kezer M. Comparison of component positioning in robotic-assisted and conventional total hip arthroplasty. J Surg Med. 2020;4(4):276-280. doi:10.28982/josam.656702.
12. Berger RA, Meneghini RM, Jacobs JJ, et al. Results of Unicompartmental Knee Arthroplasty at a Minimum of Ten Years of Follow-up. J Bone Jt Surg. 2005;87(5):999-1006. doi:10.2106/JBJS.C.00568.
13. Berger RA, Nedeff DD, Barden RM, et al. Unicompartmental Knee Arthroplasty. Clin Orthop Relat Res. 1999;367:50-60. doi:10.1097/00003086-199910000-00007.
14. Hernigou P, Deschamps G. Alignment Influences Wear in the Knee after Medial Unicompartmental Arthroplasty. Clin Orthop Relat Res. 2004;423:161-165. doi:10.1097/01.blo.0000128285.90459.12.
15. Collier MB, Engh CA, McAuley JP, et al. Factors Associated with the Loss of Thickness of Polyethylene Tibial Bearings After Knee Arthroplasty. J Bone Jt Surg. 2007;89(6):1306-1314. doi:10.2106/JBJS.F.00667.
16. Bell SW, Anthony I, Jones B, et al. Improved Accuracy of Component Positioning with Robotic-Assisted Unicompartmental Knee Arthroplasty. J Bone Jt Surg. 2016;98(8):627-635. doi:10.2106/JBJS.15.00664.
17. Lonner JH, John TK, Conditt MA. Robotic Arm-assisted UKA Improves Tibial Component Alignment: A Pilot Study. Clin Orthop Relat Res. 2010;468(1):141-146. doi:10.1007/s11999-009-0977-5.
18. Pearle AD, van der List JP, Lee L, et al. Survivorship and patient satisfaction of robotic-assisted medial unicompartmental knee arthroplasty at a minimum two-year follow-up. Knee. 2017;24(2):419-428. doi:10.1016/j.knee.2016.12.001.
19. Blyth MJG, Anthony I, Rowe P, et al. Robotic arm-assisted versus conventional unicompartmental knee arthroplasty. Bone Joint Res. 2017;6(11):631-639. doi:10.1302/2046-3758.611.BJR-2017-0060.R1.
20. Lonner JH, Klement MR. Robotic-assisted Medial Unicompartmental Knee Arthroplasty. J Am Acad Orthop Surg. 2019;27(5):207-214. doi:10.5435/JAAOS-D-17-00710.
21. Batailler C, White N, Ranaldi FM, et al. Improved implant position and lower revision rate with robotic-assisted unicompartmental knee arthroplasty. Knee Surgery, Sport Traumatol Arthrosc. 2019;27(4):1232-1240. doi:10.1007/s00167-018-5081-5.
22. Wallace D, Gregori A, Picard F, et al. The learning curve of a novel handheld robotic system for unicondylar arthroplasty. Orthop Proc. 2014;96(b). doi:10.1302/1358-992X.96BSUPP_16.CAOS2014-013.
23. Picard F, Gregori A, Bellemans J, et al. Handheld Robotic-assisted Unicondylar Knee Arthroplasty: A Clinical Review. Orthop Proc. 2014;96-B(16).
24. Simons M, Riches P. The learning curve of robotically-assisted unicondular knee arthroplasty. Orthop Proc. 2014;96(b). doi:10.1302/1358-992X.96BSUPP_11.CORS2013-152.
25. Smith J, Gregori A, Picard F, et al. Does image free robotic assisted unicondylar knee arthroplasty achieve surgeons' specific plan? In: 15th Annual Meeting of CAOS. ; 2015.
26. Arslan A, Sevimli R. Open wedge high tibial osteotomy with sliding cancellous bone in distal fragment into the osteotomy gap; 2-year follow up results. Medicine Science, 2020;9(3), :683-687. doi: 10.5455/medscience.2020.05.089.