Patient Satisfaction Outcomes after Robotic Arm-Assisted Total Knee Arthroplasty: A Short-Term Evaluation

Robert C. Marchand, MD[1] Nipun Sodhi, BA[2] Anton Khlopas, MD[2] Assem A. Sultan, MD[2] Steven F. Harwin, MD[3] Arthur L. Malkani, MD[4] Michael A. Mont, MD[2]

[1] Ortho Rhode Island, Wakefield, Rhode Island
[2] Department of Orthopaedic Surgery, Cleveland Clinic, Cleveland, Ohio
[3] Arthroplasty Service, Mount Sinai West Hospital, New York
[4] Department of Orthopedic Surgery, KentuckyOne Health, Louisville, Kentucky

Address for correspondence Michael A. Mont, MD, Department of Orthopaedic Surgery, Cleveland Clinic, 9500 Euclid Avenue A40, Cleveland, OH 44115 (e-mail: montm@ccf.org; rhondamont@aol.com).

J Knee Surg

Abstract

Robotic arm-assisted total knee arthroplasty (RATKA) presents a potential, new added value for orthopedic surgeons. In today's health care system, a major determinant of value can be assessed by patient satisfaction scores. Therefore, the purpose of the study was to analyze patient satisfaction outcomes between RATKA and manual total knee arthroplasty (TKA). Specifically, we used the Western Ontario and McMaster Universities Arthritis Index (WOMAC) to compare (1) pain scores, (2) physical function scores, and (3) total patient satisfaction outcomes in manual and RATKA patients at 6 months postoperatively. In this study, 28 cemented RATKAs performed by a single orthopedic surgeon at a high-volume institution were analyzed. The first 7 days were considered as an adjustment period along the learning curve. Twenty consecutive cemented RATKAs were matched and compared with 20 consecutive cemented manual TKAs performed immediately. Patients were administered a WOMAC satisfaction survey at 6 months postoperatively. Satisfaction scores between the two cohorts were compared and the data were analyzed using Student's *t*-tests. A p-value < 0.05 was used to determine statistical significance. The mean pain score, standard deviation (SD), and range for the manual and robotic cohorts were 5 ± 3 (range: 0–10) and 3 ± 3 (range: 0–8, $p < 0.05$), respectively. The mean physical function score, SD, and range for the manual and robotic cohorts were 9 ± 5 (range: 0–17) and 4 ± 5 (range, 0–14, $p = 0.055$), respectively. The mean total patient satisfaction score, SD, and range for the manual and robotic cohorts were 14 points (range: 0–27 points, SD: $\pm$ 8) and 7 ± 8 points (range: 0–22 points, $p < 0.05$), respectively. The results from this study further highlight the potential of this new surgical tool to improve short-term pain, physical function, and total satisfaction scores. Therefore, it appears that patients who undergo RATKA can expect better short-term outcomes when compared with patients who undergo manual TKA.

Keywords
- orthopedic
- TKA
- RATKA
- score
- outcome

Advances in operative technology have led to the use of robotic-assisted devices in several medical fields.[1–3] Recently, robotics have been adopted in adult reconstructive surgery.[4–7] The development of robotic arm-assisted total knee arthroplasty (RATKA) potentially provides orthopedic surgeons an additional tool to achieve successful outcomes.

received
August 30, 2017
accepted
October 2, 2017

DOI https://doi.org/10.1055/s-0037-1607450.
ISSN 1538-8506.

Specifically, RATKA has been found to be able to accurately and consistently achieve implant placement along the hip–knee axis within the desired 3 degrees of alignment.[8–10]

Although mechanical axis alignment is important for long-term functionality and implant survivorship,[11–14] it is unknown whether the improved positioning achieved using robotic technology is superior to manual techniques in terms of patient outcomes. In fact, patient satisfaction is so important that surveys, such as the Press Ganey survey, can impact a hospital's reputation are shared with the public and can even affect surgeon reimbursement.[15–21]

As new technologies and surgical techniques such as the RATKA are introduced, it is essential to verify their positive impact on patients. Limited data are available assessing patient outcomes. Therefore, the purpose of this study was to assess short-term patient outcomes in TKA patients, by specifically, using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) to compare (1) pain scores, (2) physical function scores, and (3) total patient satisfaction outcomes at 6 months postoperatively.

Methods

Patient Selection

RATKAs performed by a single orthopedic surgeon at a high-volume institution between July 1, 2016 and August 15, 2016 were included in this study. A total of 28 cemented RATKAs were performed. The first 7 days of robotic-assisted device use (eight cases) were considered as an adjustment period for both the surgeon and the operating room team. This assessment was based on several factors: (1) the surgical technique for using the robot, in terms of performance of bone cuts and soft tissue balancing, was modified until a uniform method was established, (2) the learning curve time for the surgeon performing the cases began normalizing closer to the mean operative time and mean in-room time after an initial increase. This left 20 consecutive cemented RATKAs that were analyzed in this study and matched to 20 consecutive manual TKAs performed directly prior to implementation of the robotic technology. The mean age and standard deviation (SD) for the RATKA cohort were 69 years (range: 50–88 years, SD: 10 years), while for the manual TKA cohort was 67 years (range: 54–83 years, SD: 8 years). The mean operative time and SD for the RATKA cohort was 79 minutes (range: 66–104 minutes, SD: 10 minutes), while for the manual TKA cohort was 74 minutes (range: 50–106 minutes, SD: 20 minutes). There were 14 (70%) women and 6 (30%) men in the RATKA cohort and 10 (50%) women and 10 (50%) men in the manual TKA cohort.

Robotic Total Knee Arthroplasty System Operative Details

A standard medial parapatellar approach with minimal medial release was performed. A preoperative plan was made from a computed tomography scan. The robot used in this study was Mako system (Stryker, Mahwah, NJ). A robotic-assisted checkpoint was placed in the tibia, followed by a checkpoint in the femur. Navigation data points were then collected from the tibia and femur. Using the robotic-assisted software, the prosthesis was then manipulated allowing for optimal balancing and realignment. The robotic arm was then brought to make sequential cuts first on the distal femur, the posterior chamfer, anterior condyle cuts, anterior chamfer, and finally the proximal tibia. Implant trials were then placed, the knee was brought into extension, and alignment was checked with the robotic-assisted device both in extension and at 90 degrees of flexion. Patellar tracking was also checked. After any soft tissue balancing was performed, the appropriate implants (Triathlon Cruciate Retaining System; Stryker) were cemented in place and alignment and tracking were once again checked before the knee closure.

Manual Total Knee Arthroplasty Operative Details

A standard medial parapatellar approach with minimal medial release was performed. Measured resection techniques were utilized with intramedullary alignment for femoral measurements and external alignment for tibial measurements. Sequential bone cuts were made on the distal femur, posterior chamfer, anterior condyle cuts, anterior chamfer, and finally the proximal tibia. Implant trials were then placed and trialed by bringing the knee into flexion and extension, confirming appropriate alignment. Patellar tracking was also checked. After any soft tissue balancing was performed, the case was performed with cemented implants (Triathlon Cruciate Retaining System; Stryker) similarly to how the robotic cases were done.

Postoperative Rehabilitation

Postoperatively, both the manual and RATKA patients followed the same rehabilitation protocols. While the exact protocol followed by an individual patient might have been unique to that patient, in general, patients started their rehabilitation within 1 day after their procedure. Initial stages of rehabilitation included weight bearing as tolerated, stretching exercises, and the full weight bearing as the patient was encouraged to walk on the implant. Once patients felt more comfortable, they were then encouraged to start a light strength training program to help build surrounding muscle tone. Almost all patients completed the above protocol at outpatient physical therapy facilities and supplemented those visits with self-driven in-home exercises.

Western Ontario and McMaster Universities Arthritis Index Survey

The WOMAC is a commonly used survey to assess hip and knee arthritis.[22–25] The self-administered survey consists of 24 questions in three subcategories: pain (5 questions), stiffness (2 questions), and physical function (17 questions). Higher WOMAC scores correlate to worse total mobility and function. Both the manual and robotic cohort patients completed these surveys during their 6 months postoperative visits.

Pain Scores

The pain score was assessed by having patients rank five items on level of difficulty. Specifically, the patients ranked their pain levels during: (1) walking, (2) using stairs, (3) in bed, (4) sitting or lying, and (5) standing upright. Higher pain scores correlate to worse total mobility and function. Both

the manual and robotic cohort patients completed the pain survey during their 6 months postoperative visits.

Physical Function Scores

The physical function score was calculated based on 17 patient-reported items. Specifically, patients were asked to assess their ability to: (1) descend stairs, (2) ascend stairs, (3) rise from sitting, (4) stand, (5) bend, (6) walk, (7) get in and out of a car, (8) shop, (9) put on and (10) take off socks, (11) rise from bed, (12) lie in bed, (13) get in and out of the bath, (14) sit, (15) get on and off of the toilet, (16) perform heavy domestic duties as well as perform, and (17) light domestic duties. Higher physical function scores correlate to worse total mobility and function. Both the manual and robotic cohort patients completed the physical function survey during their 6 months postoperative visits.

Total Patient Satisfaction Score

The total patient satisfaction score was calculated by taking the sum of the patient pain and patient physical function score.

Data Analysis

For each patient, the pain component, physical function component, and combined total WOMAC score were calculated. Analysis was performed comparing the means, ranges, and SDs of each component of each score, for both the manual and robotic TKA cohorts at their 6 months postoperative clinic visit. Scores were recorded in a Microsoft Excel Spreadsheet (2013 Microsoft Office Professional Plus; Redmond, WA). A cutoff p-value of < 0.05 was set to determine statistical significance of results. All statistical analyses were performed using SPSS version 24 (International Business Machine Corporation, Armonk, NY).

Results

Pain Scores

The mean postoperative pain scores for the manual cohort were found to be 5 ± 3 (range: 0–10, ►**Table 1**). The 6 months postoperative mean pain score for the robotic cohort was found to be 3 ± 3 (range: 0–8). The robotic-assisted cohort had a significantly lower mean pain score ($p < 0.05$).

Physical Function Scores

The mean physical function score for the manual cohort was found to be 9 ± 5 (range: 0–17, ►**Table 1**). The mean physical function score for the robotic cohort was 4 ± 5 (range: 0–14). Although the physical function score for the robotic-assisted cohort was nearly half of that for the manual cohort, no statistical significance was found between the two scores ($p = 0.055$).

Total Patient Satisfaction Score

The mean total patient satisfaction score for the manual cohort was 14 ± 8 (range: 0–27, ►**Table 1**). The mean total patient satisfaction score for the robotic cohort was 7 ± 8 (range: 0–22). The robotic-assisted cohort had a significantly lower mean total patient satisfaction score ($p < 0.05$), indicating greater patient satisfaction and clinical outcome for the robotic cohort.

Discussion

Robotic TKA is a new surgical technology that has shown potential in achieving mechanical axis alignment—a crucial factor for the success of any TKA.[11–14] However, along with these clinical outcomes, patient satisfaction contributes an equal amount to the overall patient and surgical outcome. In fact, patient satisfaction can play such an important role that it can markedly guide the direction of a clinical practice. For this reason, it is necessary to continuously evaluate satisfaction surveys, particularly for new technologies. Therefore, the purpose of this study was to assess short-term patient satisfaction outcomes in RATKA versus manual TKA patients. Specifically, we used the WOMAC patient satisfaction outcome survey to compare 6 months postoperative mean pain, physical function, and total patient satisfaction scores. Patients who underwent robotic-assisted surgery reported significantly better 6-month mean pain and overall satisfaction scores ($p < 0.05$).

There were several limitations to this study. This study was small and conducted at a single institution and each surgery was performed by a single orthopedic surgeon. However, to this point, this particular study design helped limit potential confounding factors, as both the manual and robotic-assisted cohorts were managed by the same or similar house staff, clinical, and surgical teams. Furthermore, this study only looked at short-term satisfaction (up to 6 months); therefore, future studies should evaluate RATKA at longer time points.

Similar to this study, other studies have also found RATKA to be associated with better patient satisfaction outcomes as compared with manual techniques. Although these are older studies that used a different robotic-assisted device, their

Table 1 Six-month manual versus robotic TKA WOMAC scores

Surgical technique	Manual TKA	Robotic arm-assisted TKA	p-Value
Mean 6-mo postoperative WOMAC—pain	5 ± 3 (range: 0–10)	3 ± 3 (range, 0–8)	<0.05
Mean 6-mo postoperative WOMAC—physical function	9 ± 5 (range: 0–17)	4 ± 5 (range, 0–14)	0.055
Mean 6-mo postoperative WOMAC—total score	14 (range: 0–27, SD: ± 8)	7 (0–22; SD: ± 8)	<0.05

Abbreviations: SD, standard deviation; TKA, total knee arthroplasty; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

results are still potentially relevant. Liow et al[26] performed a randomized controlled trial of 60 knees (31 robotic assisted and 29 manual), and found the robotic-assisted cohort to have higher Short Form (SF)-36 quality of life measures. Specifically, the group noted a significant difference in SF-36 vitality ($p = 0.03$), emotional role ($p = 0.02$), and a larger number of patients reaching SF-36 vitality minimum clinically important difference (48 vs. 14%, $p = 0.009$), all in favor of the robotic group. In addition, Kim et al[27] performed a study on 32 patients who underwent RATKA and found Knee Society scores significantly improved postoperatively (27–82.8, $p < 0.001$).

In contrast, other studies have not found significantly greater patient satisfaction after RATKA. Song et al[28] performed a prospective randomized controlled trial of 100 patients (50 robotic assisted and 50 manual) who underwent unilateral TKA and found no statistical differences between the cohorts with respect to postoperative Hospital of Special Surgery (HSS) scores (robotic: 96, manual: 95) and WOMAC scores (robotic: 29, manual: 30). Song et al[29] also performed another study with 30 patients who underwent bilateral sequential total knee replacement with one knee operated on using the robotic device and the other using the manual technique. The group found the robotic cohort to have nonsignificantly better last follow-up HSS scores (95.2 vs. 94.7) and WOMAC scores (11 vs. 13) than the manual cohort. Although these studies report nonsignificant differences in patient satisfaction, both studies still report greater overall clinical satisfaction in patients who underwent RATKA.

Although a paucity of literature exists comparing RATKA and patient outcomes, there have been some studies performed on unicompartmental knee arthroplasty (UKA). Pearle et al[30] performed a multicenter prospective study on 797 patients (909 knees) who underwent robotic-assisted UKA utilizing Mako system (Stryker). They had a mean 30-month (range, 22–52 months) follow-up period and found excellent results both with the survivorship of the implant and with patient satisfaction. At the 2.5-year follow-up point, only 11 knees required revision, resulting in a 99% survivorship. Also, the group found that for the 898 knees (99%) that were not revised, 92% of patients were very satisfied or satisfied with their surgery. Cobb et al[31] conducted a prospective, randomized controlled trial using the Acrobot Surgical System (The Acrobot Co. Ltd., London, United Kingdom) to perform UKA on 27 patients (28 knees) and found that patients who underwent robotic-assisted UKA had significantly better American Knee scores at 6 and 18 weeks postoperatively ($p = 0.004$). In addition, Conditt et al[32] performed a multicenter study with six surgeons who performed robotic-assisted UKA on 788 patients (890 knees) using Mako system (Stryker). The group found a 2-year revision rate of 1.1%, and at a mean of 2-year follow-up, 93% of patients reported very satisfied or satisfied outcomes.

Conclusion

As new technology continues to be introduced in the operative room, continued evaluation of this technology is essential to ensure physicians are providing the best care possible to their patients. To the best of our knowledge, this is the first study evaluating short-term patient satisfaction outcomes in this new RATKA. This technology has been shown to significantly improve mechanical axis alignment and reduce alignment outliers—factors which can influence the survivorship and functionality of an implant.[11–14] However, since this technology is relatively new, additional studies correlating clinical outcomes and patient satisfaction are necessary. The results from this study show a distinct advantage in the patients who underwent RATKA with better overall patient satisfaction scores.

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