7-19-2022

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Arthroplasty Today 16 (2022) 219–223

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

Return to Work and Driving After Robotic Arm–Assisted Total Knee Arthroplasty

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ARTICLE INFO

Article history:
Received 9 March 2022
Received in revised form
4 May 2022
Accepted 1 June 2022
Available online xxx

Keywords:
Return to work
Return to driving
Robotic arm assisted
Total knee arthroplasty

ABSTRACT

Background: Robotic arm–assisted total knee arthroplasty (RATKA) has demonstrated improved patient-reported outcome measures. Less evidence has been reported on how frequently patients return to complex activities of daily living. Our purposes were to investigate (1) hospital lengths of stay (LOSs) (2) discharge dispositions and (3) the rates and postoperative time intervals at which patients returned to driving and working.
Methods: A total of 50 RATKA patients who were employed prior to surgery were included. Outcomes included hospital LOS, discharge dispositions, return to driving, and return to work.
Results: A total of 48 patients (96%) were discharged home with self-care or health aid discharge after a mean LOS of 1.2 ± 0.6 days. Twelve patients (24%) returned to driving within 3 weeks of surgery. In our study, 100% of patients who underwent RATKA returned to driving after a mean of 29 days (range, 4 to 62 days). Forty-five patients (90%) returned to their preoperative level of work after a mean of 46 days (range, 2 to 96 days). Nineteen patients (38%) returned to work within 3 weeks.
Conclusions: This study showed fast recovery after RATKA, with >90% returning to driving and working at full capacity within 2 months. Many (38%) returned to work within 3 weeks. Further studies to demonstrate the value of RATKA with respect to recovery of complex activities are needed. Compared to controls from previously published literature on manual total knee arthroplasties, it appears that patients who undergo RATKA have similar or better outcomes in reference to return to driving.

Introduction

Total knee arthroplasty (TKA) is an increasingly common surgery [1]. Current projections predict that the total number of primary TKAs will rise to 1.9 million by 2030 [2]. The excellent clinical results seen in older patients who have primary TKAs have translated to increased demand in the younger population (<65 years), which is expected to compose over 50% of all TKAs performed by 2030 [3–5]. With an increasing number of TKAs being performed in the younger population, the ability to return to driving and work is a substantial concern among patients.

Studies have reported that patients under the age of 65 years who underwent primary TKA were able to return to work after a mean postoperative time period of 7.7 to 13.5 weeks [6,7]. However, the time frame and proportion of patients who were able to return to work can vary based on the physical demand of their respective

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https://doi.org/10.1016/j.artd.2022.06.002
2352-3441/

occupations [6,8]. For driving, surgeons have recommended returning anywhere from 4 to 8 weeks after TKA, often using brake response time as a proxy for this recommendation [9–12].

Many of the current recommendations are based on studies reporting outcomes following manual TKA [6,7,11,13]. Since the rise of robotic arm–assisted TKA (RATKA), there are numerous studies that have demonstrated improved patient-reported outcome measures [14–16]. However, there is limited evidence on how RATKA patients have fared when returning to specific activities such as driving and work. Therefore, our purposes were to investigate the (1) hospital lengths of stay (LOS), (2) discharge dispositions, and (3) the rates and postoperative time intervals at which patients returned to driving and working.

Material and methods

A total of 143 patients underwent primary RATKA for symptomatic knee osteoarthritis at 4 different orthopaedic centers from July 1, 2016, to October 31, 2018. The inclusion criteria for this study encompassed the following: patients who had knee osteoarthritis undergoing primary RATKA and were employed prior to surgery. Patients were excluded if they underwent bilateral TKA, revision arthroplasty, and/or hardware removal; had retained hardware at the time of surgery; or were not employed prior to surgery. Of the 143 patients, 50 patients met the inclusion criteria. All of the patient records were fully deidentified; therefore, the study was exempt from our institutional review board and the need for consent was waived.

Prior to RATKA, patients received a computed tomography (CT) scan which was then uploaded to the robotic arm–assisted system. Utilizing the preoperative CT scan, a 3-dimensional (3D) model of the native knee was created. From this model, each surgeon was able to plan the tibial and femoral cuts, implant size, and alignment prior to the arthrotomy of the knee. Intraoperatively, a fixed array was placed above and below the arthrotomy, all extra-incisionally, on the femur and tibia, respectively. The bony landmarks of the femoral and tibial surfaces were registered with a sharp array probe to create a virtual map to augment the CT-based 3D model. Using this model, the surgeon was able to virtually adjust implant position and alignment prior to bony resection of the femoral and tibial condyles. The surgeon was then able to use the Mako System (Stryker, Mahwah, NJ) to perform the cuts within the virtual boundaries generated during the planning phase. These boundaries prevented the saw from resecting any bone outside of the virtual constraints.

Postoperative care included inpatient physical therapy that began on the same day of surgery. Patients were discharged either to home with or without home health aide services or to a short-term hospital for inpatient care based on patient comorbidities and preferences. If discharged to home, patients were instructed to complete stretching and at-home rehabilitative exercises daily.

Hospital and patient metrics assessed included hospital LOS, discharge dispositions, return to driving, and return to working. Our return-to-driving results were compared to those of historical controls from previously published studies. A literature search was performed to identify studies that reported the rate of return to driving after manual TKA, as well as the postoperative time interval that elapsed before patients were able to resume driving. This search yielded 5 studies [9–11,17,18]. Among these, 2 studies reported brake response times as measured on automobile simulators [9,18], while the remaining 3 studies reported the rate of return to driving following TKA [10,11,17]. The return-to-driving data from these 3 studies were compared to our results of RATKA. A total of 37 patients specifically responded regarding the amount of time until they returned to work.

The physical activity of each patient's occupation was collected and categorized. Desk and sedentary jobs were classified as light physical demand. Jobs that required considerable amount of walking and/or stair climbing and/or required the patients to be on their feet for a substantial portion of the day were classified as moderate physical demand. Jobs with manual labor including kneeling, squatting, climbing and carrying were categorized as heavy physical demand. A total of 30 patients answered whether they returned to their preoperative activity level. Knee Society Scores (KSS) were collected preoperatively and 3 months and 1 year postoperatively.

Statistical analyses

Two-sided *t*-tests were used for comparison of continuous variables. Data were inputted and analyzed using Excel spreadsheets (Microsoft Corporation, Redmond, Washington, statistical significance levels [$P < .05$]).

Results

Demographic

Twenty-five of 50 patients received a left RATKA with no bilateral case. Twenty-three patients were female. The RATKA cohort had a mean age of 61 years (range, 45 to 78 years) and a mean body mass index of 30.8 (range, 20.4 to 39.9).

Discharge dispositions and in-hospital LOSs

Forty-eight patients (96%) were discharged home with self-care or home care after a mean hospital LOS of 1.2 days (range, 0.5 to 4 days) (Table 1). The remaining 2 patients were discharged to a short-term hospital. Nearly 85% of patients spent up to 1 day in the hospital, with 1 patient spending as much as 4 days in the hospital.

Return to driving

Among the 35 patients who reported the postoperative time interval at which they resumed driving, two-thirds (66%) reported doing so within 30 days after surgery and 94% returned to driving within 60 days postoperatively. The remaining 2 patients returned at postoperative day 62 (Fig. 1).

Table 2 depicts the time and rate at which patients in the current study returned to driving following RATKA compared to historical controls from previously published literature [10,11,17]. Among the 3 manual TKA studies, 676 of 683 patients returned to driving after a weighted mean of 33.5 days. In our study, 100% of patients who underwent RATKA returned to driving after a mean of 29.4 days (range, 4 to 62 days).

Table 1
Discharge disposition and in-hospital length of stay of RATKA patients.

Discharge status code	Discharge disposition description	Patients, n (%)	Average LOS (d)
01	Home or self-care (routine discharge)	29 (59%)	1.05
02	Short-term hospital for in-patient care	2 (4%)	3
06	Home under care of organized home health service organization	18 (37%)	1.12

RATKA, robotic arm–assisted total knee arthroplasty; LOS, length of stay.

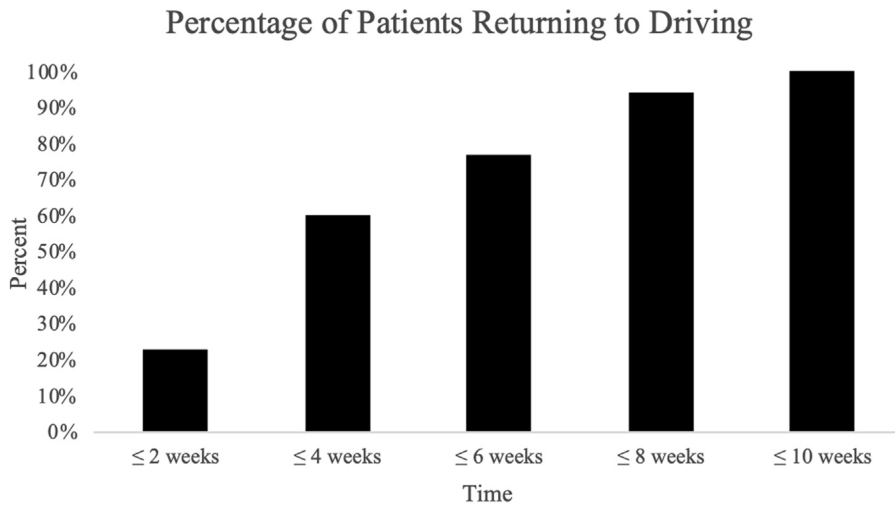

Figure 1. Cumulative bar graph of the percentage of patients returning to driving.

Return to work

A total of 45 patients (90%) returned to work. For the 37 patients for whom we had time until return-to-work data, 19 patients (51%) returned to work within 3 weeks of surgery. A total of 27 out of 30 patients (90%) returned at their preoperative physical activity level. For the 37 patients where we had time until return-to-work data, this occurred after a mean of 46 days (range, 1 to 96 days). Please note once again that these numbers may be skewed down because they do not include the 5 patients (10%), who did not return to work. The physical demands of the patients' occupations were described as light (41%), moderate (45%) and heavy (14%). Patients who only had light physical duties returned to work on average 44 days. Patients who had jobs with moderate physical requirements returned to work after an average of 64 days. Patients who had jobs that required heavy physical demand returned to work after a mean of 76 days (Table 3). Of patients who reported their disability benefit status, 12 patients (41%) received short-term disability and none were receiving workers compensation.

Mean KSSs of the RATKA cohort were 43 points (range, 16 to 84 points), 65 points (range, 18 to 98 points) and 80 points (range, 44 to 99 points) preoperatively and 3 months and 1 year postoperatively, respectively.

Discussion

With younger patients seeking surgical intervention and the mean age of retirement increasing, growing numbers of TKA patients are concerned about their ability to return to complex activities of daily life [19]. There are numerous studies that report on LOS, patient-reported outcome measures, and return to complex activities such as work and driving after manual TKA. The purpose of this study was to address the paucity of literature on these complex activities in patients who underwent RATKA. In our study, we found that 90 and 100% of employed RATKA patients in our study were able to return to work and driving, respectively. The mean time needed to return to work and driving for patients that reported these lengths was 46 and 29 days, respectively. Additionally, the hospital LOS was short, with an average of 1.2 days.

There were some limitations with this study. Despite a small sample size of 50 patients, our study did show that RATKA had successful postoperative results. However, due to the lack of a comparative group with manual TKAs, we were unable to compare return to work and driving outcomes with RATKAs within our study. This study cohort was compared to historical controls, which potentially may not isolate improvements attributable to robotic surgery from other improvements to TKA in general, such as rapid recovery protocols, multimodal pain control and intra-articular injections. The patients in the present study were allowed to return to driving when they felt fit. Therefore, the results may not be generalizable to populations where surgeons set strict time constraints regarding when patients can restart this activity of daily of living. In addition, our data did not report the transmission type of the vehicle that the patient drove. In an automatic transmission vehicle, only the right leg is required to manipulate the accelerator and brake pedals, whereas in a manual transmission vehicle, both the right and left leg are required to manipulate the accelerator, brake, and clutch pedals. Therefore, identifying the laterality of the arthroplasty and the physical requirements needed to operate each respective patient's car is important to determine if there are any confounding factors affecting return to driving time. Future studies on return to driving should analyze laterality and its association with automatic as well as clutch transmissions as the former

Table 2
Return-to-driving results compared to historical controls.

Study	# Of patients	Last follow-up	# Of patients who RTD	% RTD	Time to RTD, d[a]
Barker et al. [17]	31	1 y	30	97	58.3 ± 46.7 (14-244)
Ellanti et al. [10]	98	1 y	95	97	52.9 (14-98)
Rondon et al. [11]	554	12 wk	551	99.5	28.7
Current study	50	1 y	50	100	29.4

RTD, return to driving.
[a] Data reported as mean ± standard deviation (range).

Table 3
Mean time to return to work based on physical demand of occupation.

Physical demand level	n	Mean time, d
Light	9	44 ± 32 (range, 4 to 87)
Moderate	10	64 ± 24 (range, 29 to 96)
Heavy	3	76 ± 25 (range, 47 to 91)

stressed the right leg, while the latter stressed both. Furthermore, the present study did not test patients' capacity to drive, such as braking time. These limitations of patient flexibility to return to driving, laterality, and automobile operation ability should be examined in future studies, along with more investigation of the efficacy of RATKA. Many more studies on these issues need to be conducted.

Many studies have reported on the LOS and postoperative KSS of manual TKA compared to RATKA. Kayani et al. [20] investigated RATKA and conventional TKA patients in a prospective cohort study of 40 patients each. Their study investigated the short-term functional outcomes and hospital discharge summaries for both cohorts. Kayani et al. [20] found that the total in-hospital LOS was shorter in the RATKA cohort (77 vs 105 hours, $P < .001$). Similar results were also found in a Medicare database study by Cool et al. [21] that compared over 500 and 2500 RATKAs and manual TKAs, respectively. In the study by Cool et al. [21], the in-hospital LOS was significantly shorter with the RATKA cohort, as well (1.84 vs 2.53 days, $P < .0001$). Although our study was limited to RATKA patients, our cohort had a shorter average in-hospital LOS with 1.2 days. Smith et al. [22] investigated patient satisfaction in both manual and RATKAs using the functional KSS at 6 weeks and 1 year postoperatively. When comparing patients who underwent RATKA and manual TKA, RATKA patients had a significantly higher knee function KSS at 6 weeks (63 vs 58 points, $P < .02$) and 1 year (80 vs 73 points, $P < .005$) after surgery. In our study, the mean functional KSSs for the RATKA patients were similar at postoperative year 1 with a mean score of 80.2.

Although there are studies that investigate in-hospital LOS and KSSs after manual TKA and RATKA, reports on return to work and driving are currently limited to manual TKAs. The results from these reports have been comparable to our RATKA results. One common and quantifiable method to assess driving readiness is brake response time. This records the total amount of time that is required for patients to fully depress the brake pedal when exposed to a stimulus. In a meta-analysis of break response time after lower extremity total joint arthroplasty, there were 9 reports that investigated TKA [13]. Their findings showed that brake response time returned to preoperative speeds approximately 4 weeks after TKA. A study published after the aforementioned meta-analysis by Davis et al. [18] reported that brake response time returned to preoperative levels 2 weeks after TKA and indicated that there was no significant difference in relation to laterality of the arthroplasty performed. Although brake response time is an important component of driving, the exact correlation between brake response time and safe driving is not clear and is not the definitive measure of readiness to drive. This is supported by reports that indicate that over 90% of patients who underwent manual TKA return to driving 4 to 8 weeks after surgery, which is later than when patients return to baseline with their brake response times [10,11]. Similar success has also been seen when returning to work. Studies have shown that of patients who were employed prior to TKA, many are able to return to work within 3 months despite the different levels of physical demand, which is similar to the findings in our study [7,8].

Conclusions

This study has shown that there was fast patient recovery after RATKA, with >90% of patients returning to driving and working at full capacity within 60 days after surgery. Further studies to demonstrate the value of RATKA with respect to recovery of complex activities are needed. Nevertheless, compared to historical controls from previously published literature on manual TKA, it appears that patients who undergo RATKA have similar or better outcomes in reference to return to driving.

Conflicts of interest

Manoshi Bhowmik-Stoker is a paid employee for and receives financial material/support from Stryker; Antonia F. Chen is a consultant for 3M, Adaptive Phage Therapeutics, Avanos, BICMD, bOne, Convatec, Ethicon, GLG, Guidepoint, Heraeus, Irrimax, Pfizer, and Stryker; William J. Hozack receives royalties from, holds stock options at, and receives research support from Stryker, is a consultant for Stryker and ValueHealth, and is a member of the editorial board of the JOA; Ormonde Mahoney receives royalties from, is a consultant for, and receives research support from Stryker and is an unpaid consultant for Surgical Devices, Inc.; Fabio R. Orozco is a consultant for Stryker; Michael A. Mont is a consultant for Sage Products, Inc., Stryker, TissueGene, 3M, Centrexion, Ceras Health, Flexion Therapeutics, Johnson & Johnson, Mirror-AR, NXSCI, Pacira, PeerWell, Pfizer-Lily, Skye Biologics, SOLVD Health, Smith & Nephew, and US Medical Innovations, is the Editor-in Chief of the Journal of Arthroplasty and is a member of the Journal of Knee Surgery, Surgical Technology International, and Orthopaedics, and is a member of the Knee Society and the Hip Society; all other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2019.12.004.

Informed patient consent

The author(s) confirm that informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this article.

References

[1] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89:780–5.
[2] Singh JA, Yu S, Chen L, Cleveland JD. Rates of total joint replacement in the United States: future projections to 2020-2040 using the national inpatient sample. J Rheumatol 2019;46:1134–40.
[3] Mont MA, Sayeed SA, Osuji O, Johnson AJ, Naziri Q, Delanois RE, et al. Total knee arthroplasty in patients 40 years and younger. J Knee Surg 2012;25:65–9.
[4] Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: national projections from 2010 to 2030. Clin Orthop Relat Res 2009;467:2606–12.
[5] Losina E, Katz JN. Total knee arthroplasty on the rise in younger patients: are we sure that past performance will guarantee future success? Arthritis Rheum 2012;64:339–41.
[6] Scott CEH, Turnbull GS, MacDonald D, Breusch SJ. Activity levels and return to work following total knee arthroplasty in patients under 65 years of age. Bone Joint J 2017;99B:1037–46.
[7] McGonagle L, Convery-Chan L, DeCruz P, Haebich S, Fick DP, Khan RJK. Factors influencing return to work after hip and knee arthroplasty. J Orthop Traumatol 2019;20:9.
[8] Lombardi AV, Nunley RM, Berend KR, Ruh EL, Clohisy JC, Hamilton WG, et al. Do patients return to work after total knee arthroplasty? Knee. Clin Orthop Relat Res 2014;472:138–9.

[9] Dalury DF, Tucker KK, Kelley TC. When can I drive?: brake response times after contemporary total knee arthroplasty. Clin Orthop Relat Res 2011;469:82–6.
[10] Ellanti P, Raval P, Harrington P. Return to driving after total knee arthroplasty. Acta Orthop Traumatol Turc 2015;49:593–6.
[11] Rondon AJ, Tan TL, Goswami K, Shohat N, Foltz C, Courtney PM, et al. When can I drive? Predictors of returning to driving after total joint arthroplasty. J Am Acad Orthop Surg 2019;28:427–33.
[12] Hernandez VH, Ong A, Orozco F, Madden AM, Post Z. When is it safe for patients to drive after right total knee arthroplasty? J Arthroplasty 2016;31:2495–8.
[13] Van Der Velden CA, Tolk JJ, Janssen RPA, Reijman M. When is it safe to resume driving after total hip and total knee arthroplasty? Bone Joint J 2017;99B:566–76.
[14] Liow MHL, Goh GSH, Wong MK, Chin PL, Tay DKJ, Yeo SJ. Robotic-assisted total knee arthroplasty may lead to improvement in quality-of-life measures: a 2-year follow-up of a prospective randomized trial. Knee Surgery. Knee Surg Sports Traumatol Arthrosc 2017;25:2942–51.
[15] Ren Y, Cao S, Wu J, Weng X, Feng B. Efficacy and reliability of active robotic-assisted total knee arthroplasty compared with conventional total knee arthroplasty: a systematic review and meta-analysis. Postgrad Med J 2019;95:125–33.
[16] Marchand RC, Sodhi N, Khlopas A, Sultan AA, Harwin SF, Malkani AL, et al. Patient satisfaction outcomes after robotic arm-assisted total knee arthroplasty: a short-term evaluation. J Knee Surg 2017;30:849–53.
[17] Barker KL, Hannink E, Pemberton S, Jenkins C. Knee arthroplasty patients predicted versus actual recovery: what are their expectations about time of recovery after surgery and how long before they can do the tasks they want to do? Arch Phys Med Rehabil 2018;99:2230–7.
[18] Davis JA, Bohl DD, Gerlinger TL. Brake response time after modern total knee arthroplasty: how soon can patients drive? Knee 2018;25:939–45.
[19] Munnell AH. What is the average retirement age? Center for Retirement Research. 2011. p. 1–8. https://crr.bc.edu/wp-content/uploads/2011/08/IB_11-11-508.pdf. [accessed 30.7.20].
[20] Kayani B, Konan S, Pietrzak JRT, Tahmassebi J, Haddad FS. Robotic-arm assisted total knee arthroplasty is associated with improved early functional recovery and reduced time to hospital discharge compared with conventional jig-based total knee arthroplasty. Bone Joint J 2018;100-B:930–7.
[21] Cool CL, Jacofsky DJ, Seeger KA, Sodhi N, Mont MA. A 90-day episode-of-care cost analysis of robotic-arm assisted total knee arthroplasty. J Comp Eff Res 2019;8:327–36.
[22] Smith AF, Eccles CJ, Bhimani SJ, Denehy KM, Bhimani RB, Smith LS, et al. Improved patient satisfaction following robotic-assisted total knee arthroplasty. J Knee Surg 2021;34:730–8.