Clinical Research Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2019, Vol. 47(4) 1667–1676
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DOI: 10.1177/0300060519832430
journals.sagepub.com/home/imr
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Clinical outcomes and patient satisfaction after total knee arthroplasty: a follow-up of the first 50 cases by a single surgeon

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Abstract

Objective: To examine the association between single-surgeon learning curve and clinical outcomes following total knee arthroplasty (TKA).

Methods: This prospective study included the first consecutive patients undergoing TKA conducted by the same surgeon using the JOURNEY II Bi-Cruciate Stabilized Knee System (Smith & Nephew, Andover, MA, USA). Patients were assessed preoperatively, and at three months and one year postoperatively using Oxford Knee Score (OKS), Knee Society Score (KSS) and Knee Function Score (KFS). Outcomes were statistically analysed using sequential patient cohorts.

Results: Fifty patients were grouped into five sequential cohorts of 10 patients each. All patients showed significant improvement in postoperative knee scores following TKA. There was a trend toward increased improvement in knee scores in the later patient cohorts, at the three-month and 1-year follow-up.

Conclusions: The single-surgeon learning curve for minimally invasive TKA had a small effect on knee satisfaction scores at 3 months and 1 year following surgery in the first 50 consecutive cases, and only minor complications were encountered. A larger trial is necessary to draw generalizable conclusions regarding patient outcomes during surgeon learning.

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Keywords
Total knee arthroplasty, arthroplasty, patient satisfaction, learning curve

Date received: 31 October 2018; accepted: 30 January 2019

Introduction

Total knee arthroplasty (TKA) is the mainstay of surgical treatment for osteoarthritis of the knee, with estimates from 2012 suggesting that more than 670 000 TKAs are performed each year in the United States alone.[1] TKA has been well documented to provide significant pain relief and functional improvement compared with nonsurgical treatment alone.[1] Despite objective improvement in range of motion and radiographic parameters following TKA, nearly one fifth (19–23%) of patients report being dissatisfied at 6 months of follow-up.[2,3] This is significantly higher than dissatisfaction rates for total hip arthroplasty (THA), which have been reported at 9%.[2] Additionally, patients undergoing TKA report more postoperative pain and reduced physical function compared with patients undergoing THA.[4,5] Because of this, recent literature has stressed the importance of patient-reported outcome measures in postoperative assessment of patients undergoing TKA.[6,7] Patient-related factors (such as age, sex, patient expectations, and medical comorbidities) as well as treatment-related factors (technical aspects of TKA, anesthetic management and postoperative rehabilitation) have been suggested as determinants of patient satisfaction following total joint replacement.[8] Although all of these variables likely play a role, no single factor clearly predicts postoperative pain or functional improvement.[9]

Recent research on THA has focused on the relationship between the experience level of the surgeon and patient satisfaction. Several studies have shown that there was no significant difference in postoperative complications, range of motion, and patient reported functional improvement during the learning curve of an experienced surgeon performing minimally invasive THA versus other procedures, suggesting that the surgeon's experience level in performing minimally invasive THA is not associated with patient outcomes.[10,11] There is little evidence however, on the effect of surgeon learning curve on patient-related outcome measures following TKA. One study examining a single surgeon's first 250 cases performing TKA using a second generation medial-pivot system showed that patient satisfaction was significantly improved following the first 50 cases.[12] This suggests that there may be a correlation between the experience of the surgeon and patient-reported satisfaction postoperatively. The purpose of the present study was to characterize the relationship between single-surgeon learning curve and clinical outcome following TKA using the JOURNEY II Bi-Cruciate Stabilized Knee System (Smith & Nephew, Andover, MA, USA).

Patients and methods

Study population

This prospective cohort trial included consecutive patients who underwent unilateral TKA at Loma Linda University Medical Center, Loma Linda, CA, USA, between February 2016 and November 2016. TKA was performed by a single surgeon (NHA) who was 2 years out of knee reconstruction fellowship, using the JOURNEY II Bi-Cruciate Stabilized Knee System (Smith & Nephew). Patients were recruited preoperatively and divided into sequential cohorts of equal size for analyses. Groups were based solely on the chronologic order in which the patients were preoperatively enrolled, and no randomization was performed. Inclusion criteria were the following: patients aged >18 years; primary TKA; unilateral surgery; and TKA was performed using the JOURNEY II Bi-Cruciate Stabilized Knee System (Smith & Nephew). Patients were excluded if they met the following criteria: body mass index (BMI) >50 kg/m^2; and/or decompensated cardiopulmonary pathology (e.g., chronic obstructive pulmonary disease or coronary artery disease) making them too high risk for elective general anesthesia. No other exclusion criteria were applied.

This study was reviewed and approved by the Loma Linda institutional review board (IRB No. 5170233). Verbal informed consent was obtained from all patients prior to study participation.

Surgical procedure and data collection

Patients were assessed preoperatively and at 3 months and 1 year postoperatively, using the Oxford Knee Score (OKS; https://innovation.ox.ac.uk/outcome-measures/oxford-knee-score-oks/), Knee Society Score (KSS)[13] and Knee Function Score (KFS).[13] Scoring was performed in a blinded fashion at each preoperative and follow-up appointment. Before the surgeon entered the room, patients were given a computerized questionnaire to be self-completed in private with no time limit, in order to calculate OKS, KSS, and KFS. Knee replacements were also assessed for range of motion through surgeon administered goniometry, and this part of the postoperative assessment was performed by the operating surgeon, so was not blinded.

All TKA's were completed under general anesthetic with a post-operative block and/or catheter for pain control. A cocktail of 20 ml Exparel® (bupivacaine liposome injectable suspension), 20 ml of either 0.25% or 0.5% bupivacaine, and 80 ml of physiological saline was administered intraoperatively, into the posterior capsular, the medial and lateral gutters, and the medial approach area. In addition, the patient was administered 1 g tranexamic acid prior to incision, and 1 g following closure of the arthrotomy. All the closures were performed in a layered manner, from the arthrotomy to the skin with a combination of vicryl (polyglactin 910) and monocryl (poliglecaprone 25) sutures.

Patients underwent standard rehabilitation and therapy regimens and were seen for follow-up at 6 weeks, 3 months and 1 year postoperatively.

Statistical analyses

Data are presented as mean ± SD or *n* (%) prevalence, and were analysed using a computer-generated calculator. Average improvement in knee score was calculated for each group by subtracting the mean preoperative knee score from the mean 3-month or 1-year knee score. Statistical significance was evaluated through one-way analysis of variance (ANOVA) and a P value < 0.05 was considered to be statistically significant.

Results

A total of 50 patients were enrolled into the study, divided into five sequential chronological cohorts of 10 patients each for analyses. Demographics for the overall study population showed a mean age of 66.9 years, 42% (21/50) male patients, 58% (29/50) female patients, average BMI of 35.4 kg/m^2 and 28% (14/50 patients) current smokers. Patients in all five cohorts

Table 1. Demographic characteristics of 50 patients who underwent primary unilateral total knee arthroplasty conducted by a single surgeon, grouped into sequential cohorts based on chronological order of surgery.

	Demographic			
Study group ($n = 10$ per group)	Age, years	Sex, male	BMI, Kg/m^2	Current smoker, yes
Group 1 (patient 1–10)	65.2 ± 3.1	3 (30)	33.4 ± 2.5	4 (40)
Group 2 (patient 11–20)	62.8 ± 4.4	4 (40)	35.2 ± 3.4	2 (20)
Group 3 (patient 21–30)	68.5 ± 7.1	5 (50)	37.8 ± 4.9	5 (50)
Group 4 (patient 31–40)	64.9 ± 5.4	4 (40)	36.7 ± 2.1	2 (20)
Group 5 (patient 41–50)	73.4 ± 8.4	5 (50)	34.1 ± 3.8	1 (10)
Statistical significance	NS	–	NS	–

Data presented as mean ± SD or *n* (%) prevalence.
NS, no statistically significant between-group differences ($P > 0.05$; one-way analysis of variance).

Table 2. Comparison of preoperative knee scores, measured by Oxford Knee Score (OKS), Knee Society Score (KSS), and Knee Function Score (KFS), between chronological cohorts of patients who underwent primary unilateral total knee arthroplasty conducted by a single surgeon.

	Study cohort					
Score instrument	Group 1 (patients 1–10)	Group 2 (patients 11–20)	Group 3 (patients 21–30)	Group 4 (patients 31–40)	Group 5 (patients 41–50)	Statistical significance
OKS	16.2 ± 2.1	17.2 ± 4.7	13.1 ± 3.4	14.2 ± 5.2	16.1 ± 1.2	NS
KSS	46.2 ± 5.4	51.0 ± 6.9	53.2 ± 4.7	48.1 ± 8.9	50.2 ± 4.3	NS
KFS	43.4 ± 10.2	52.9 ± 13.4	50.8 ± 5.3	48.3 ± 8.7	40.1 ± 11.5	$P = 0.0434$

Data presented as mean ± SD.
NS, so statistically significant between-group differences ($P > 0.05$; one-way analysis of variance).

were similar in terms of age, sex, and BMI (Table 1).

All TKAs were implanted using a modified medial parapatellar approach. In all cases, the posterior cruciate ligament was resected and tibial, femoral, and patellar components were implanted using cemented fixation. The patella was resurfaced in all patients. No lateral releases were completed in the patient pool being assessed.

Preoperative knee scores for all five cohorts are shown in Table 2. There were no statistically significant between-cohort differences in terms of preoperative OKS and KSS scores ($P > 0.05$; one-way ANOVA), however, differences in preoperative KFS values between the chronological cohorts were statistically significant ($P < 0.05$). Preoperative, and 3-month and 1-year postoperative follow-up knee scores (OKS, KSS and KFS) for the overall study population are shown in Table 3. All five cohorts showed significant improvement in knee scores following arthroplasty, at both 3 months and 1 year versus preoperative scores ($P < 0.001$; Table 3). There were no statistically significant differences between the 3-month and 1-year follow-up for any of the knee scores (OKS, KSS or KFS).

Table 3. Comparison of overall preoperative and postoperative (3-month and 1-year) knee scores in 50 patients who underwent primary unilateral total knee arthroplasty conducted by a single surgeon.

	Time-point		
Score instrument	Preoperative	3-month follow-up	1-year follow-up
Oxford Knee Score	15.4 ± 3.32***	40.2 ± 4.38	40.9 ± 5.72
Knee Society Score	49.7 ± 6.04***	79.5 ± 8.56	80.8 ± 6.48
Knee Function Score	47.1 ± 9.82***	86.2 ± 7.96	87.2 ± 5.18

Data presented as mean ± SD.
***$P < 0.001$, preoperative scores versus 3-month scores and 1-year scores.

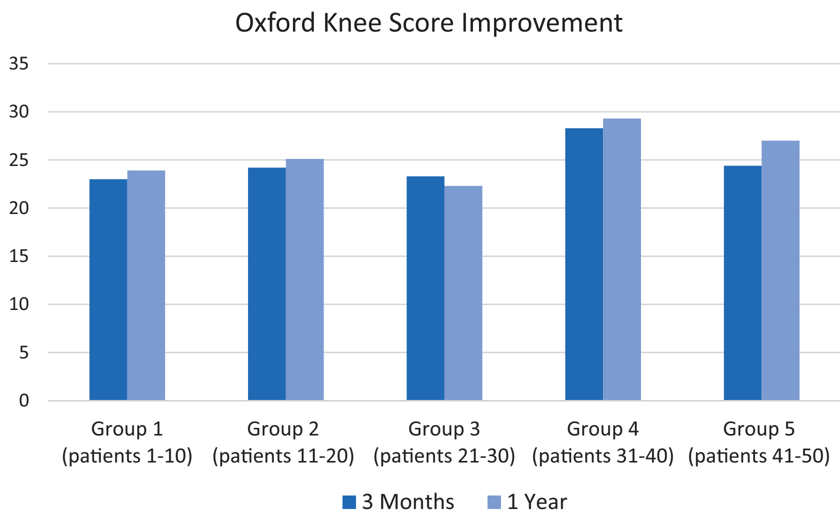

Figure 1. Mean improvement in Oxford Knee Score (OKS) at 3 months and 1 year following primary unilateral total knee arthroplasty conducted by a single surgeon, in patients grouped into sequential cohorts; there were no statistically significant differences in score change between the sequential cohorts.

Mean improvement in knee scores for each group at 3 months and 1 year are shown in Figures 1–3. There was no statistically significant trend toward increasing mean improvement in OKS scores between the five sequential groups (Figure 1). There was a statistically significant increased improvement in KSS score in group 4 compared with group 3 at the 3-month follow-up ($P < 0.05$; Figure 2). There were no other statistically significant differences in KSS score improvement between the sequential cohorts. Finally, there was a statistically significant increased improvement in KFS score in group 5 versus group 2 and group 5 versus group 3 at both the 3-month and 1-year follow-up ($P < 0.05$; Figure 3). No other statistically significant differences in KSS score improvement were observed between the sequential cohorts.

Postoperative mean range of motion values for the five cohorts were as follows: Cohort 1, 1.2–115.6°; Cohort 2, 0.4–118.5°;

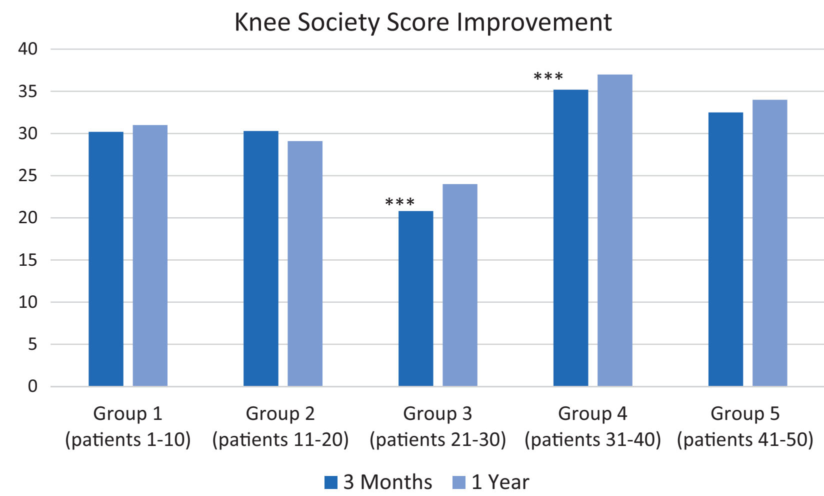

Figure 2. Mean improvement in Knee Society Score (KSS) at 3 months and 1 year following primary unilateral total knee arthroplasty conducted by a single surgeon, in patients grouped into sequential cohorts; ***$P < 0.05$, group 3 versus group 4 at the 3-month follow-up.

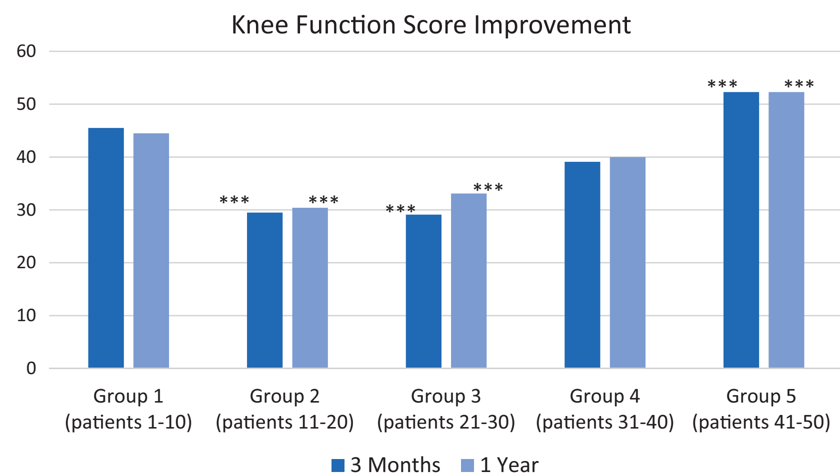

Figure 3. Mean improvement in Knee Function Scores at 3 months and 1 year following primary unilateral total knee arthroplasty conducted by a single surgeon, in patients grouped into sequential cohorts; ***$P < 0.05$, group 2 versus group 5, and group 3 versus group 5 at both the 3-month and 1-year follow-up.

Cohort 3, 0.1–129.9°; Cohort 4, 0.6–121.5°; and Cohort 5, 0.1–127.4°.

A total of three patients were noted to experience complications: one superficial wound infection and dehiscence, one manipulation under anesthesia (patient No. 24), and one non-displaced femoral fracture managed non-operatively (patient No. 19). Four patients were lost to follow-up after 3 months (patient Nos. 8, 11, 32 and 48).

Discussion

The present study investigated the relationship between single-surgeon learning curve and clinical outcome following TKA using the JOURNEY II Bi-Cruciate Stabilized Knee System (Smith & Nephew). Despite various study limitations, discussed later, some interesting trends in the data were noted. Although there was no trend toward increased improvement in OKS scores, there was a trend toward increased improvement in KSS and KFS scores in the later patient cohorts, suggesting a possible correlation between surgeon experience and patient outcome. The trend toward increased improvement in KSS and KFS was not statistically significant in all groups, however, but statistical significance alone can be misleading when comparing small cohorts where statistical outliers may have a significant effect on the population mean and standard deviation. Additionally, statistical significance is not a surrogate marker for clinical significance. The trends noted in the study may have clinical significance even if the cohorts were not large enough to reach statistical significance.

Interestingly, the lowest improvement in KSS and KFS was noted in Group 2 and Group 3. If the results followed the distribution of a true learning curve, one might expect improvement in knee scores to be lowest in group 1 and gradually increase in the rest of the groups. Instead, the present data seem to show a nadir in chronological groups 2 and 3. One possible explanation for this is that the learning curve may exert a nonlinear effect on patient outcomes. It is possible that significant fluctuation in patient outcome may exist in the initial stages of physician learning and perhaps this accounts for the numerically greater (but not statistically significant) increase in knee scores in group 1 compared with groups 2 and 3. Additionally, it is possible that the increased complication rate in earlier patient cases may have contributed to the suggested trend toward increased score improvement in the later cohorts. The complications noted among the 50 cases in the present study were one intra-operative femoral fracture, one superficial wound dehiscence, and one manipulation under anesthesia. The nondisplaced femoral fracture in patient No. 19, and the manipulation under anesthesia on patient No. 24 may have significantly affected the knee scores for group 2 and 3, respectively. Thus, the apparent difference in knee score improvement in different groups was possibly due primarily to the occurrence of complications.

It is difficult to determine whether the timing of complications in the present study are directly related to surgeon learning curve. A review of the California Patient Discharge Database from 2005–2013 found that the cumulative incidence of manipulation under anesthesia for primary unilateral TKA was 2.14% (4 398 events per 205 744 patients) during a 90-day follow-up period.[14] In the present study therefore, one incidence of manipulation under anesthesia out of 50 cases (incidence of 2%) seems to be in accordance with the literature. Additionally, four patients were lost to follow-up at 1 year in the present study. This loss to follow-up did not seem to significantly affect the data as knee scores at the 3-month and 1-year follow-up followed the same trend with only mild variation. These data also suggest that long term clinical outcomes following TKA may be largely determined by perioperative and intraoperative factors before three months postsurgery.

Several different studies in the literature have suggested a time frame of 20–30 cases for surgeon learning curve in TKA, although these studies did not focus on patient centered outcome measures. In a study examining 86 consecutive TKAs by a single surgeon, mean operative time was found to be significantly longer in the first 30 cases, however, the authors found no statistically significant difference in postoperative TKA alignment between the first 30 and latter 56 cases.[15] In another study, there was a statistically significant correlation between surgeon inexperience and tourniquet time, but outcomes such as patient satisfaction and improvement in quality of life were not investigated.[16] Lubowitz et al.[17] found that operative duration decreased significantly in minimally invasive TKA after a surgeon's first 10 cases, and in a prospective study of 50 consecutive TKAs performed by a single surgeon, mean incision length was found to decrease in the second 25 patients versus the first 25 patients, and knee failure rate diminished significantly after 16 cases.[18]

A study investigating the learning curve in computer navigated TKA found no significant difference in mean oxford score, mechanical axis and range of motion between the first 50 cases performed by a novice surgeon and 50 cases performed by an experienced surgeon.[19] The only significant difference was in operative time between the novice surgeon's first 20 cases and the experienced surgeon's cases.[19] Analysis of operative time was not included in the present paper, as the analysis was focused primarily on patient centered outcomes.

Taken in the context of previously published literature, the present paper helps describe the impact of learning curve on clinical outcome in knee replacement surgery. Although there are several studies in the literature examining physician learning curve with TKA, there has been very little research on patient centered outcomes. Further research expanding the present study beyond one surgeon would be helpful in further distinguishing how patient satisfaction can be maximized during the learning period of TKA. Additional surgeons would add valuable information about the variation in surgeon learning curve between different physicians. A larger study would also provide the possibility for randomizing patients, which may help limit baseline differences in patient cohorts that may be confounding the results. Additionally, the present study only provides information about short-term follow-up after TKA. It would be interesting to extend the follow up period to 5 or 10 years to determine if the effect of surgeon learning curve on patient satisfaction persists over the long term. Perhaps there is a certain length of time at which other factors, such as patient activity level, medical compliance, and other medical comorbidities, begin to eclipse the effect generated by surgeon learning curve.

This study has several important limitations that are inherent to the study design. First, the study is relatively small with only one surgeon, which limits the generalizability of the results. Caution should be used when trying to extrapolate the results of a single cohort study to generalized practice. Additionally, due to the need to enrol patients into groups chronologically to assess surgeon learning curve, the cohorts in the present study were not randomized, which may result in significant baseline variation between groups that might confound the study results. Despite this chronological recruitment however, the groups were relatively similar with respect to the demographics of age, sex, smoking status and BMI. Preoperative OKS and KSS were similar, but preoperative KFS showed variation that was not attributable to random chance alone (based on ANOVA testing with a P value < 0.05). In order to minimize the effect of baseline differences between the groups, the mean change in knee scores from preoperative assessment to postoperative assessment was calculated instead of using the raw knee scores themselves.

Conclusion

In the present cohort of 50 patients who underwent primary unilateral TKA performed by a single surgeon, the learning curve for minimally invasive TKA appeared to have a small effect on knee scores at the 3-month and 1-year follow-up. Only minor complications (one superficial wound infection, one manipulation under anesthesia, and one non-displaced femoral fracture) were encountered, but a larger trial is necessary to draw generalizable conclusion about patient outcomes during the physician learning curve for TKA.

Declaration of conflicting interest

Consulting fees received from Smith and Nephew, Trice, Flexion, Depuy, Zimmer, and Pacira.

Funding

The publication charges for this research were funded by Smith & Nephew.

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