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KNEE ARTHROPLASTY

COVID-19 disruptions to elective postoperative care did not adversely affect early complications or patient reported outcomes of primary TKA

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Abstract

Introduction Elective orthopedic care, including in-person office visits and physical therapy (PT), was halted on March 16, 2020, at a large, urban hospital at the onset of the local COVID-19 surge. Post-discharge care was provided predominantly through a virtual format. The purpose of this study was to assess the impact of postoperative care disruptions on early total knee arthroplasty (TKA) outcomes, specifically 90-day complications, 120-day rate of manipulation under anesthesia (MUA) and 1-year patient-reported outcome measures (PROMs).

Materials and methods Institutional records were queried to identify 624 patients who underwent primary, unilateral TKA for osteoarthritis and who were discharged home between 1/1/20 and 3/15/20. These patients were compared to 558 controls discharged between 1/1/19 and 3/15/2019. Cohort demographics and in-hospital characteristics were equivalent apart from inpatient morphine milligram equivalent (MME) consumption. Patient-reported access to PT ($p < 0.001$) and post-discharge care ($p < 0.001$) were worse among study patients. Study patients were prescribed fewer post-discharge PT sessions (19.8 vs. 23.5; $p < 0.001$) and utilized telehealth more frequently ($p < 0.001$). Mann–Whitney *U*, *T*, Fisher's Exact, and chi-squared tests were used to compare outcomes.

Results Ninety-day CMS complications were lower among study patients (3.5% vs. 5.9%; $p = 0.05$). Rates of MUA were similar between groups. Study patients reported similar PROMs and marginally inferior VR-12 mental and LEAS functional outcomes at 1 year.

Conclusion Disruptions to elective orthopedic care in March 2020 seemed to have had no major consequences on clinical outcomes for TKA patients. Our findings question the usefulness of pre-pandemic post-discharge protocols, which may over-emphasize in-person visits and PT.

Keywords Arthroplasty · Knee · Manipulation · COVID-19 · Complications · Outcomes

Introduction

The positive outcomes of total knee arthroplasty (TKA) are partially dependent on the availability of postoperative support services including nursing [1, 2], physical therapy (PT) [3, 4] and pain management [5, 6]. While historically these services were provided in the hospital, there has been a shift to "fast-track" or Enhanced Recovery After Surgery regimens [7–10]. These protocols emphasize a transition of postoperative care to outpatient and in-home settings in an effort to lower costs [10], reduce complications [7], expedite recovery [7, 10] and conserve hospital resources [9]. Over the years, our institution has heavily relied on post-discharge services to support the recovery of patients undergoing TKA, including visiting nurse services, visiting physical therapists, outpatient physical therapy and the availability of pain medication.

On March 16, 2020, all elective orthopedic services were halted in response to the rise of COVID-19 cases

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within our city [11]. Our hospital suspended all non-essential, in-person, post-discharge care including outpatient PT, visiting nurse services (VNS) and follow-up appointments [11]. Additionally, government "remain at home" recommendations largely confined patients to their homes [12], which further impacted postoperative ambulation and medical access. To overcome shortages in in-person care, telehealth and telerehabilitation services were expanded [13]. Despite these adaptations, there was a substantial disruption in post-discharge services provided to our patients immediately after March 15, 2020.

The purpose of this study was to determine if the aforementioned interruptions to standard post-discharge care negatively affected the early outcomes of TKA patients; specifically, 90-day unscheduled visits to outpatient clinics, emergency room (ER) and hospital readmissions, and postoperative CMS complications; rate of manipulation under anesthesia (MUA) during the first 120 days; and patient-reported outcomes measures (PROMs) 6 weeks, 3 months and 1 year postoperatively. We hypothesized that TKA patients who underwent surgery shortly prior to March 16, 2020, would experience inferior outcomes compared to a control group.

Materials and methods

This study was approved by our institutional review board. A query of institutional medical records was performed to identify all 624 patients above the age of 18 who had undergone elective unilateral TKA with a diagnosis of primary osteoarthritis, who were discharged from our hospital between January 1, 2020 and March 15, 2020 (study group). Exclusion criteria included removal of hardware and revision procedures, and a discharge disposition other than home. Study patients were compared to 558 consecutive patients with equivalent selection criteria, who underwent surgery between January 1, 2019 and March 15, 2019 (control group). All procedures were performed at a single specialty hospital (*** Blinded ***).

Groups were similar in their distributions of age, sex, race, ethnicity, body mass index (BMI), Charlson comorbidity index (CCI), risk assessment and prediction tool (RAPT) score, laterality, anesthesia type, nerve block usage, number of in-hospital PT visits/visits to clear PT, in-hospital complications, transfusions received and length of stay (LOS). Study patients were prescribed significantly fewer in-hospital MMEs than controls (Table 1). This reduction in narcotic usage is a consequence of ongoing institutional efforts to reduce opioid consumption [14].

Assessing disruptions in post-discharge care

To objectively determine if study group patients experienced a substantial disruption in post-discharge care and therefore provide rationale for our study, we assessed post-discharge metrics during the first 90 postoperative days including: number of telehealth and in-person visits, outpatient and virtual PT visits prescribed, number of patients who received all post-discharge care virtually and narcotic consumption. Study patients had significantly fewer in-person visits and PT sessions prescribed per patient ($p < 0.001$); and had more telehealth visits per patient ($p < 0.001$). There were significantly more study patients who pursued post-discharge care entirely virtually ($p = 0.001$). Study patients were prescribed fewer MMEs ($p < 0.001$) and stopped requesting opioid refills earlier than controls ($p = 0.02$) (Table 2).

Additionally, before the initiation of this study, study and control patients completed a care-access satisfaction survey focusing on the first 90 postoperative days (Appendix Table 6). Study patients were more likely to not have received as much PT as desirable, were less likely to attend scheduled PT sessions and were less likely to be satisfied with their access to care ($p < 0.001$). Study patients received PT virtually ($p < 0.001$) or through self-guided exercises ($p = 0.001$) at significantly higher rates than controls (Table 3).

There were outcomes collected at 90 days, 120 days and 1 year postoperatively. Outcomes collected at 90 days included: (1) unscheduled outpatient visits, (2) ER visits, (3) hospital readmissions and (4) CMS complications. CMS-defined surgical complications include acute myocardial infarction, pneumonia, or sepsis/septicemia/shock during the index admission or within 7 days from the index admission; surgical site bleeding, pulmonary embolism, or death during the index admission or within 30 days from the index admission; or mechanical complications, or periprosthetic joint infection/wound infection during the index admission or within 90 days from the index admission [15, 16]. Each CMS complication and visit to a care facility (office, ER and readmission) was counted. Therefore, the number of complications or postoperative healthcare visits may have exceeded the number of patients with these events. This approach was taken to demonstrate the "worst-case scenario". MUA was considered an essential procedure during the COVID-19 surge and was recorded up to 120 days postoperatively. Finally, PROMs including KOOS JR, VR-12 physical/mental, lower extremity activity scale (LEAS) and visual analog scale (VAS) pain scores were collected preoperatively and 6 weeks, 3 months and 1 year postoperatively.

Study information was obtained by retrospective chart review and patient phone calls using a standardized phone

Table 1 Descriptive statistics of pre-surgical and in-hospital patient characteristics used for group comparison

Variable	Group								p
	Study				Control				
	N	Median	IQR		N	Median	IQR		
Age	624	66	60	72	558	66	61.3	72	0.637
Sex									
Female	368	–	–	–	325	–	–	–	0.799
Male	256	–	–	–	233	–	–	–	
Race									
White	509	–	–	–	466	–	–	–	0.394
Not white	115	–	–	–	92	–	–	–	
Ethnicity									0.288
Hispanic/Latino	40	–	–	–	28	–	–	–	
Not Hispanic/Latino	570	–	–	–	522	–	–	–	
BMI	624	30.9	27.2	35.1	558	30.5	26.7	35.5	0.381
CCI									
0	412	0	0	1	382	0	0	1	0.571
1	107				94				
≥ 2	105				82				
RAPT Score	440	10	9	11	410	10	9	11	0.177
Surgeon	–	–	–	–	–	–	–	–	< 0.001*
Laterality									
Left	297	–	–	–	278	–	–	–	0.445
Right	327	–	–	–	280	–	–	–	
Anesthesia									
Regional	607	–	–	–	545	–	–	–	0.658
Other	17	–	–	–	13	–	–	–	
Use of nerve block	12	–	–	–	19	–	–	–	0.202
IP PT visits	624	4	3	6	558	4	3	5	0.916
Visits to clear PT	624	4	3	5	558	4	3	5	0.987
In-hospital comps	4	–	–	–	7	–	–	–	0.366
Transfusions									
0	613	–	–	–	549	–	–	–	0.744
1	8				8				
≥ 2	3				1				
LOS	624	2	2	3	558	2	2	3	0.875
Discharge MME's	624	315	300	336	558	336	315	525	< 0.001*

Notes: *IP:* inpatient

*p < 0.05

script. All outcomes were reviewed by the junior and senior authors to obtain consensus regarding inclusion. No patient was lost to 90-day follow-up.

Patient demographics, in-hospital characteristics and 90-day postoperative outcomes were reported using descriptive statistics. Continuous variables were reported as means and standard deviation (SD) or median and interquartile range (IQR). Differences between groups were investigated using independent samples t-tests or Mann–Whitney U tests. Categorical variables were presented as frequencies and percentages and compared using Pearson's chi-squared tests or Fisher's Exact tests. Statistical significance was predefined as $p < 0.05$. All analyses were performed using R: A Language and Environment for Statistical Computing (R Core Team 2021, Vienna Austria).

Results

Study and control patients experienced similar rates of unscheduled outpatient (in-person and telehealth combined) visits (12.8% vs. 10.2%; $p = 0.17$), ER visits (5.0% vs. 7.3%; $p = 0.11$) and hospital readmissions (5.8% vs. 7.2%; $p = 0.34$). A majority of unscheduled outpatient visits were

Table 2 Variables related to post-discharge medical and rehabilitation care, and pain management

Variable	Group		p
	Study (*N*/%) $n=624$	Control (*N*/%) $n=558$	
Days to first encounter	39.2	32.93	0.834
Telephone encounters	4.2	4.07	0.11
Telehealth encounters	1.4	0.06	<0.001*
Telehealth utilization (%)	36.4	0.9	<0.001*
Internal PT prescriptions	14.4	18.57	0.033*
External PT prescriptions	25.5	27.96	0.002*
Total prescribed PT sessions	19.8	23.56	<0.001*
Entirely virtual care (%)	43	9	<0.001*
MME total	814.2	965.32	<0.001*
MMEs refilled	829.3	871.19	0.151
MME refill events	1.6	1.79	0.104
Last refill day	17.1	20.27	0.022*

*$p < 0.05$

due to common postoperative complaints. Wound-related complications including drainage, erythema, bleeding and superficial infections accounted for 45% and 64.9% of visits among study and control cohorts, while severe postoperative pain motivated 25% and 14% of visits, respectively (Appendix Table 7). Twelve study patients experienced multiple unscheduled visits compared to 15 controls.

Reasons for ER admissions were diverse, however, urinary, mechanical, venous thromboembolism and neurologic concerns comprised 51.6% and 51.2% of visits among study patients and controls, respectively (Appendix Table 8). One study patient experienced multiple visits to the ER compared to four controls.

A majority of hospital readmissions were related to mechanical complications including stiffness requiring MUA and wound/prosthetic joint infections (72.2% and 87.5% in study and control patients, respectively) (Appendix Table 9). Two study patients experienced multiple readmissions to the hospital compared to two controls.

Additionally, study patients experienced fewer CMS complications per patient (0.04 vs. 0.07; $p=0.02$). Study patients also suffered at least one CMS complication at lower rates (3.5% vs. 5.9%; $p=0.05$) (Table 4). There were no study patients and four controls who experienced two CMS complications. There were fewer medical complications (myocardial infarction, sepsis, pneumonia, pulmonary embolism and death) than local complications in both groups (3 and 19 in study, 1 and 36 in control patients, respectively). A woman in the study cohort with a BMI of 30.4 and a CCI of 0 who was suffering from gastroesophageal reflux disease, hypercholesterolemia and depression passed away at age 72, 16 days postoperative from unknown causes. No autopsy was performed. Study patients experienced lower rates of superficial and deep infections compared to controls ($p=0.008$). Twelve of 624 study patients (1.9%) suffered superficial wound infections, whereas none developed deep infections. Twenty-six of 558 controls (4.7%) suffered local infections, including 19 superficial wound infections and seven deep joint infections. Despite this difference, both cohorts required outpatient antibiotic prescriptions for common skin flora at similar rates (3.4% vs. 4.5%; $p=0.4$). Only one of 22 CMS complications in study patients, and one of 37 among controls occurred prior to discharge (pulmonary embolism and periprosthetic tibial fracture, respectively). The remaining 57 of 59 CMS complications occurred following discharge (21 study and 36 control patients).

Study patients and controls experienced similar rates of MUA (2.2% vs. 2.3%; $p=0.99$). Eight study patients underwent MUA within 2, three within 3, and three within 4 months postoperatively. Six controls underwent MUA within 2, five within 3, and two within 4 months postoperatively.

Mean preoperative KOOS JR scores were lower among study patients compared to controls (47.5 vs. 49.2; $p=0.02$). The opposite was observed 6 weeks postoperatively (64 vs. 61.7; $p=0.03$). These differences fell below the KOOS JR minimum clinically important difference (MCID) of 6 [17]. VR-12 mental scores were equal between study and control cohorts for all collection intervals except at 1 year (54 vs. 56.4; $p=0.002$), but this disparity similarly fell below an MCID of 6.5 [18]. VR-12 physical scores were equal between cohorts for all intervals except at 6 weeks (35.4 vs. 33.3; $p=0.005$), with differences also falling below an MCID of 3 [19]. LEAS scores were inferior among study patients at the 3-month (8.9 vs. 9.7; $p<0.001$) and 1-year (10 vs. 10.9; $p<0.001$) periods. The MCID for the LEAS has yet to be defined. VAS pain ratings were greater among study patients during the preoperative period (63 vs. 57.8; $p=0.001$; MCID: 1.1 [20]) but were equivalent during all postoperative intervals. When computing the change (Δ) in PROMs between preoperative and postoperative ratings at 6 weeks and 1 year, study patients exhibited greater improvement of KOOS JR (15.3 vs. 11.3; $p=0.003$) and VR-12 physical (3.1 vs. 0.2; $p=0.009$) scores at 6 weeks compared to controls. Differences between KOOS JR scores again fell below an MCID of 6 [17]. An inverse effect was observed for ΔVR-12 mental (−2.4 vs. −0.1; $p=0.01$) and LEAS at 1 year (0.3 vs. 1.6; $p<0.001$) (Table 5), with VR-12 differences falling below MCID [18].

Discussion

The circumstances surrounding the COVID-19 pandemic severely limited available post-discharge services for TKA patients who had undergone surgery during the first quarter of 2020 and forced providers at our hospital to transition all non-emergent post-discharge care to a virtual or outpatient format. Transitions to telehealth may set lasting precedent

Table 3 A comparison of patient response frequencies to our care access satisfaction survey

Survey question:	Response	Study *N*/%	Control *N*/%	*p*
1. Patient could not get the number of PT sessions they desired				< 0.001*
	None of the time	61 (35.5)	116 (88.5)	
	A little of the time	26 (15.1)	5 (3.8)	
	Some of the time	34 (19.8)	6 (4.6)	
	Most of the time	25 (14.5)	1 (0.8)	
	All of the time	26 (15.1)	3 (2.3)	
2. Patients chose not to attend scheduled PT sessions				< 0.001*
	None of the time	129 (75.0)	124 (94.7)	
	A little of the time	11 (6.4)	3 (2.3)	
	Some of the time	13 (7.6)	2 (1.5)	
	Most of the time	9 (5.2)	1 (0.8)	
	All of the time	10 (5.8)	1 (0.8)	
3. Patient couldn't get enough pain killers from their pharmacy				0.291
	None of the time	160 (92.5)	125 (95.4)	
	A little of the time	3 (1.7)	3 (2.3)	
	Some of the time	4 (2.3)	1 (0.8)	
	Most of the time	0 (0.0)	1 (0.8)	
	All of the time	6 (3.5)	1 (0.8)	
4. Patient chose not to get their pain killer prescription filled				0.126
	None of the time	160 (92.5)	121 (92.4)	
	A little of the time	4 (2.3)	2 (1.5)	
	Some of the time	0 (0.0)	4 (3.1)	
	Most of the time	2 (1.2)	2 (1.5)	
	All of the time	7 (4.0)	2 (1.5)	
5. Patient satisfaction with the access to care they had				< 0.001*
	Not at all	8 (4.6)	1 (0.8)	
	A little bit	11 (6.4)	4 (3.1)	
	Moderately	27 (15.6)	5 (3.8)	
	Quite a bit	43 (24.9)	28 (21.4)	
	Extremely	84 (48.6)	93 (70.9)	
6. Type of PT most frequently used by patient				
	Visiting PT	112 (36.4)	92 (40.3)	0.313
	Telerehabilitation	26 (8.4)	4 (1.8)	0.001*
	Outpatient PT	107 (34.7)	108 (47.4)	< 0.001*
	Rehab Center	11 (3.6)	6 (2.6)	0.504
	Self-Exercise	52 (16.9)	18 (7.9)	0.001*

Notes: *Rehab:* rehabilitation

*$p < 0.05$

within the arthroplasty community, as various studies have demonstrated the effectiveness of virtual care in performing preoperative consultations, education, postoperative follow-up, and telerehabilitation while promoting patient satisfaction, care access, cost savings and treatment efficiency [21–23]. Two recent systematic reviews by Petersen and Windsor et al. found that virtual visits did not produce lower patient satisfaction, inferior PROMs or functional outcomes compared to in-person visits among orthopedic patients [21, 22]. Additionally, an analysis by Kolin et al. found that nearly 60% of orthopedic surgeons would be willing to continue using telemedicine as a supplement to in-person care after the conclusion of the COVID-19 pandemic [24]. To the authors' knowledge, this is the first study which investigates the impacts of limiting care access on TKA outcomes.

Despite study patients having lower self-reported ratings of care access compared to controls, they experienced similar rates of unscheduled post-discharge visits, ER visits, hospital readmissions and MUA. Study patients experienced fewer CMS complications than controls. One-year PROMs were equivalent between cohorts for KOOS JR, VR-12 physical

Table 4 A comparison of CMS complications between cohorts

CMS complication	Group				p
	Study (n=624)		Control (n=558)		
	N	%	N	%	
Acute myocardial infarction	0	0	0	0	–
Pneumonia	0	0	0	0	–
Sepsis	0	0	0	0	–
Pulmonary embolism	2	0.3	1	0.2	0.999
Death	1	0.2	0	0	0.999
Surgical site bleeding	5	0.8	5	0.9	0.999
Mechanical complications	2	0.3	5	0.9	0.265
Surgical site infection	12	1.9	26	4.7	0.008*
Total complications:	22	–	37	–	0.016*
Total patients:	22	3.5	33	5.9	0.05*

*$p < 0.05$

and VAS pain scales. One-year differences in VR-12 mental scores were below MCID. Our findings question the assumption that in-person post-discharge care is necessary for successful outcomes.

Our study has limitations. First, its retrospective nature introduces recollection and documentation biases. All patients with missing outcomes were contacted to achieve complete 90-day follow-up. Second, this was an unmatched investigation. However, study and control patients were comparable based on a variety of preoperative and in-hospital metrics (Tables 1 and 2). Third, this study was conducted at an orthopedic specialty hospital, and therefore our findings may not be generalizable to other institutions. Fourth, we were unable to capture progressions in patient range of motion (ROM). This was due to numerous factors including the large proportion of postoperative visits that were carried out virtually and the different techniques our surgeons used to measure ROM. We believe that if a reduction in ROM was clinically significant, it would be reflected in KOOS JR, LEAS and VR-12 physical scores. Fifth, it is possible that patients and physicians were more reluctant to justify a visit to the ER in view of local COVID-19 surges. However, as patients continued to have access to remote care, it is unlikely that this affected our ability to capture clinically relevant post-discharge complications.

Study and control patients experienced equivalent rates of unscheduled post-discharge visits (in-person and telehealth combined) (12.8% vs. 10.2%; p = 0.17). As all elective in-person post-discharge care was halted on March 16, 2020, our results reflect the consequences of a rapid expansion of telehealth services in our hospital [13]. Study patients reported higher utilization of telehealth visits compared to controls, with nearly five times as many patients pursuing care entirely virtually (43% vs. 9%; p < 0.001). Although telehealth services have been acknowledged as a method for increasing care access throughout the pandemic and promoting arthroplasty patient/provider safety [21, 25], patients in our study group reported lower care access satisfaction. We suspect that this was attributable to expectations for in-person care, an underdeveloped virtual care network during the early pandemic and a lack of familiarity with telemedicine among providers and patients [21, 25, 26]. As was suggested by findings from Edwards et al., as telemedicine in orthopedics continues to develop and be used worldwide, intentional preoperative education is needed for arthroplasty patients to more effectively understand, and benefit from remote care regimens [23].

Study and control patients experienced equivalent rates of ER visits (5% vs. 7.4%; p = 0.11). No ER visits were associated with a diagnosis of COVID-19. Interestingly, there were more patients who required unscheduled post-discharge office/telehealth visits in the study (80 of 624) than in the control group (57 of 558); but the opposite was observed for ER visits, which were required in 31 of 624 study and in 41 of 558 control patients. Although these differences were insignificant (p = 0.17 and 0.11, respectively), it is possible that study patients were more reluctant to go to the ER amidst ongoing COVID-19 surges [27, 28]. A recent investigation by Frink et al. which compared the frequency of ER admissions for orthopedic trauma patients during the early phases of the COVID-19 pandemic (March 16, 2020–May 10, 2020) to that of a control period exactly one year prior (2019) found a 33% reduction in the quantity of patients presenting to the ER during the COVID period, with a greater proportion of patients requiring surgical intervention due to the severity of their conditions [28].

Study and control patients experienced equivalent rates of hospital readmissions (5.8% vs. 7.2%; p = 0.34). Interestingly, no readmissions were associated with COVID-19 infections, likely reflecting adherence to local social distancing recommendations.

Fifty-five of 1,182 patients developed CMS complications (4.7%). The likelihood of patients developing at least one CMS complication (p = 0.05) and the rate of CMS complications per patient (p = 0.02) were lower among study patients. In a recent study reporting on 10,621 selected primary THA patients from the American College of Surgeons National Surgical Quality Improvement Project database, the 30-day rate of any CMS complication was 4.5% [29]. Again, it can be argued that study patients were more reluctant to seek medical care during the COVID-19 surge [27, 28]. However, rates of CMS complications were very low among both cohorts. The reason for a lower infection rate among study patients remains to be elucidated.

Cohorts experienced similar rates of MUA (2.2% and 2.3%). These rates are comparable to those of other investigators reporting rates of 3.6% [30] and 5.8% [20]. This observation calls into question the necessity of in-person post-discharge PT and consistent pain medication use, as

Table 5 A comparison of PROMs between cohorts

Questionnaire	Group								p
	Study ($n=624$)				Control ($n=558$)				
	Mean	Median	IQR		Mean	Median	IQR		
KOOS JR (Pre)	47.51	47.5	39.6	54.8	49.15	50.01	42.3	59.38	0.021*
KOOS JR (6 wk)	63.97	63.8	57.1	70.7	61.65	61.58	54.8	68.28	0.029*
KOOS JR (3 mon)	67.84	68.3	59.4	76.3	68.12	68.28	59.4	76.33	–
KOOS JR (1 yr)	77.65	76.3	68.3	92	78.96	79.91	68.3	91.97	–
VR-12 Men. (Pre)	56.03	59.6	49.5	64.1	55.91	58.61	48.9	63.72	–
VR-12 Men. (6 wk)	53.67	56.3	46.6	62.4	52.88	54.74	45.8	61.25	–
VR-12 Men. (3 mon)	54.97	58.7	49.3	62.1	56.43	58.47	51.2	63.28	–
VR-12 Men. (1 yr)	53.95	56.4	47.5	61.1	56.38	59.07	52.3	62.2	0.002*
VR-12 Phys. (Pre)	32.27	31.2	26.3	38	32.46	31.55	25.7	38.13	–
VR-12 Phys. (6 wk)	35.38	35.3	29.4	41.5	33.27	33.15	26.5	39.55	0.005*
VR-12 Phys. (3 mon)	40.65	40.4	35.1	47.5	39.32	39.83	33	45.14	–
VR-12 Phys. (1 yr)	44.36	45.3	37.8	52.3	45.01	47.19	39.2	53.24	–
LEAS (Pre)	9.64	9	7	12	9.37	9	7	11	–
LEAS (6 wk)	7.74	7	6	8	7.93	7	6	9	–
LEAS (3 mon)	8.85	8	7	10	9.67	9	8	11	< 0.001*
LEAS (1 yr)	10	9	8	13	10.86	10	9	14	< 0.001*
VAS Pain (Pre)	63.03	70	50	80	57.83	60	40	76	0.001*
VAS Pain (6 wk)	34.37	30	20	50	32.71	30	20	47.25	–
VAS Pain (3 mon)	20.26	11	5	30.5	23.03	20	5	34.5	–
VAS Pain (1 yr)	14.93	5	0	20	12.85	8	0	20	–
Δ KOOS JR (6 wk)	15.3	15.2	5.2	24.2	11.25	11.31	2.2	20.2	0.003*
Δ KOOS JR (1 yr)	28.36	28.4	17.7	40.5	27.51	26.37	15.5	39.69	–
Δ VR-12 Men. (6 wk)	− 2.05	− 2	− 7.7	3.7	− 2.58	− 2.85	− 8.3	3.39	–
Δ VR− 12 Men. (1 yr)	− 2.35	− 3.5	− 9.1	3.9	− 0.10	− 1.04	− 5.5	5.37	0.013*
Δ VR− 12 Phys. (6 wk)	3.06	2.9	− 4.2	9.2	0.17	− 0.33	− 5.8	6.11	0.009*
Δ VR− 12 Phys. (1 yr)	11.75	11.3	4.7	18.2	11.87	12.63	4.1	18.86	–
Δ LEAS (6 wk)	− 2.03	− 1	− 5	0	− 1.52	− 1	− 3	0	–
Δ LEAS (1 yr)	0.26	0	− 1	2	1.62	1	0	3	< 0.001*
Δ VAS Pain (6 wk)	− 28.39	− 29	− 50	− 10	− 22.75	− 20	− 40	− 0.75	–
Δ VAS Pain (1 yr)	− 44.03	− 50	− 60	− 25	− 42.59	− 40	− 61	− 25	–

Notes: Men: mental; Phys: physical

*$p < 0.05$

study patients consumed fewer MMEs both in-hospital and post-discharge. We believe that the diminished use of opioids does not reflect a lack of access associated with the pandemic but evolving institutional practices and social awareness surrounding the opioid epidemic. We recently reported that an institutional effort to reduce the use of post-discharge opioids over the course of 4 years in 8,799 primary TKA patients did not result in increased rates of MUA [31].

Lastly, we found equivalent 1-year outcomes between cohorts aside from VR-12 mental and LEAS scores. A recent matched analysis by Ulivi et al. involving 200 TJA patients compared PROMs between patients who underwent TJA shortly prior to COVID-19 suspensions of in-person care (2/21/20–3/16/20) to those of a control cohort 1 year prior (2/1/19–3/31/19) [32]. Among TKA patients, no significant differences in 3-month VAS pain, KOOS and SF-12 mental/physical scores were observed. However, study patients experienced superior KOOS activity, but inferior KOOS functional scores. This is in partial agreement with our 90-day LEAS findings, which were higher among controls. Unfortunately, no long-term data were reported for comparison. Similarly, the systematic reviews by Petersen and Windsor et al. indicated that patients who underwent telerehabilitation compared to in-person PT following TJA had similar or superior functional outcomes as evaluated by the Western Ontario and McMaster Universities osteoarthritis index (WOMAC) and progressions in ROM [21, 22]. Among our study patients, we suspect that inferior VR-12 mental scores were created by the circumstances surrounding the COVID-19 pandemic, which affected the emotional and mental well-being of citizens nationwide [33]. However, decreased care access could have also contributed to these findings [34]. Differences in VR-12 mental scores did not exceed the previously defined MCID [17]. Furthermore, decreased lower extremity functionality relative to controls was likely created by reduced care access [30], and fewer opportunities to ambulate outdoors [12].

Our findings suggest that reduced post-discharge care access and an increased reliance on telehealth did not result in significantly inferior outcomes among TKA patients. The importance of in-person follow-up may be overstated, and further externalizing postoperative care may be desirable for TKA patients. Further research among a larger cohort involving longitudinal outcomes is needed to confirm our findings.

Appendix

See below Tables 6, 7, 8, 9.

Table 6 Standardized care access satisfaction survey administered to all study participants

Confidential

CS:Gonzalez D5: The Effect Of COVID-19 On The Rate Of Manipulation Under Anesthesia After Total Knee Replacement
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MUA

Record ID ______________________

This survey will ask you about your recovery during the first 90 days after your total knee replacement. Answer every question by selecting the appropriate box. If you are unsure about how to answer a question, please give the best answer you can.

	None of the time	A little of the time	Some of the time	Most of the time	All of the time
I was limited in the number of scheduled physical therapy visits I could attend due to circumstances that were out of my control.	○	○	○	○	○
I was limited in the number of scheduled physical therapy visits I attended due to circumstances that were in my control (i.e. actively chose not to attend).	○	○	○	○	○
I was unable to pick up pain medications that my physician prescribed to me in a timely fashion due to circumstances that were out of my control.	○	○	○	○	○
I did not pick up pain medications that my physician prescribed to me in a timely fashion due to circumstances that were in my control (i.e. actively chose not to fill my prescriptions).	○	○	○	○	○

Overall, I am satisfied with the access to care I had during my recovery process after my total knee replacement.

- ○ Not at all
- ○ A little bit
- ○ Moderately
- ○ Quite a bit
- ○ Extremely

Which were the two most frequently used forms of physical therapy you used during the first 90 days after your knee replacement?

- ☐ Home program with a visiting physical therapist.
- ☐ Home program with computer based physical therapy (HSS@Home program, telehealth).
- ☐ Outpatient physical therapy.
- ☐ In-patient physical therapy in a rehabilitation center.
- ☐ My own repetition of exercises I learned during my hospital stay.

Table 7 Full list of adverse medical events requiring an unscheduled visit to an outpatient care facility

Reason	Group		p
	Study $n = 624$	Control $n = 558$	
Wound/prosthetic joint infection			
Wound check – Drainage, erythema, bleeding, blister, dehiscence	26	17	
Prosthetic joint infection	0	1	
Superficial infection	10	19	
Bleeding			
Hemarthrosis	0	1	
Lower extremity hematoma	2	0	
Venous thromboembolism			
Lower extremity swelling with negative ultrasound	7	6	
Deep vein thrombosis	1	1	
Pulmonary			
Pulmonary embolism	1	0	
Spastic diaphragm	1	0	
Urinary			
Urinary tract infection	3	3	
Hematuria	1	0	
Gastrointestinal			
Gastrointestinal discomfort	1	0	
Other			
Vertigo	1	0	
Vasovagal syncope	1	0	
Pain	20	8	
Fall	2	0	
Insomnia	1	0	
Safety check/post-emergency room follow-up	2	1	
Total	80	57	0.713

Table 8 Full list of adverse medical events requiring a visit to an emergency room

Reason	Group		p
	Study $n=624$	Control $n=558$	
Wound			
Cellulitis or wound infection	2	1	
Dehiscence	0	1	
Urinary			
Urinary tract infection	1	2	
Other urinary symptoms	2	0	
Hematuria	0	1	
Mechanical			
Fall	1	5	
Knee dislocation	0	1	
Venous thromboembolism			
Deep vein thrombosis	0	3	
Ultrasound for leg swelling	8	3	
Cardiovascular			
Palpitations	0	1	
Tachycardia	0	1	
Hypertensive episode	1	0	
Neurologic			
Transient ischemic attack	0	1	
Weakness, vertigo and dizziness	0	3	
Altered mental status	1	0	
Syncope and loss of consciousness	3	1	
Unresponsive	0	1	
Pulmonary:			
Pulmonary embolism	1	0	
Pneumonia	1	0	
Respiratory distress	2	1	
Gastrointestinal			
Nausea and vomiting	0	2	
Constipation	1	1	
Other gastrointestinal symptoms	2	0	
Other			
Sepsis	1	0	
Other infection	1	0	
Allergic reaction	0	1	
Uterine bleeding	0	1	
Pain	3	4	
Malaise	0	1	
Hematoma	0	1	
Burn	0	1	
Laceration	0	2	
Low white blood cell count	0	1	
Total	31	41	0.113

Table 9 Full list of adverse medical events requiring readmission to a hospital

Reason	Group		*p*
	Studyn = 624	Control n = 558	
Urinary			
Urinary tract infection	1	0	
Gastrointestinal			
Gastrointestinal bleeding	1	0	
Epigastric abdominal pain	1	0	
Perforated appendicitis	0	1	
Pulmonary			
Pneumonia/pulmonary embolism	1	1	
Cardiovascular			
Myocardial infarction	0	1	
Neurological			
Cerebrovascular accident	1	0	
Wound/Prosthetic joint infection			
Dehiscence	0	1	
Knee pseudoaneurysm drainage	1	0	
Cellulitis	0	1	
Irrigation and debridement (pain/crepitus)	0	3	
Prosthetic joint infection	0	8	
Mechanical			
Revision total knee arthroplasty	3	5	
Manipulation under anesthesia	14	13	
Scar tissue excision/arthroscopy	8	3	
Fall	0	1	
Other			
Severe pain	1	2	
Prostate surgery	2	0	
Hyponatremia	1	0	
Pelvic bloating	1	0	
Total	36	40	0.334

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Non-financial interests Steven Haas is on publications editorial/governing boards for Healthgrades-Medical Advisory Board. Steven Haas is on board member/committee appointments for the Knee Society. Geoffrey Westrich is on board member/committee appointments for the Eastern Orthopedic Association.

Declarations

Conflict of interest Myself and/or my co-authors have no relevant conflicts of interest to disclose.

Ethics approval The questionnaires and methodology for this study were approved by the Human Research Ethics Committee/Institutional Review Board of our institution (Approval Date: 10/26/2021; ID: 2020-0746).

Consent to participate Informed consent was obtained from all individual participants included in this study.

Consent to publish The authors affirm that human research participants provided informed consent for publication of their deidentified medical data.

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