Improved Clinical Outcomes of Outpatient Enhanced Recovery Hip and Knee Replacements in Comparison to Standard Inpatient Procedures: A Study of Patients Who Experienced Both

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Abstract

BACKGROUND: The benefits of combining enhanced recovery after surgery (ERAS) interventions with an outpatient program for total hip/knee arthroplasty (THA/TKA) are uncertain. The primary objective was to compare adverse event rate and secondly to compare pain management, functional recovery, PROMs and satisfaction in patients who experienced both an ERAS-outpatient protocol and standard-inpatient care.

METHODS: We conducted an ambidirectional single subject cohort study on 48 consecutive patients who experienced both a standard-inpatient and an ERAS-outpatient THA/TKA (contralaterally). We compared complications according to Clavien-Dindo scale and Comprehensive Complications Index (CCI), and unplanned episodes of care. Postoperative pain assessed with a numeric rating scale, opioid consumption in morphine milligram equivalents, functional recovery, patient-reported outcome measures (WOMAC, KOOS, HOOS, Forgotten Joint Score and Patient Joint Perception) and patients' satisfaction were also evaluated.

RESULTS: Following the ERAS-outpatient surgery, complication rates were reduced by more than 50% (2.1 vs 4.4, $p < 0.001$), CCI was significantly lower (12.3 vs 19.1, $p < 0.001$), and similar unplanned episodes of care were observed ($p > 0.999$). In the first 8 postoperative hours, perceived pain was similar ($p > 0.805$) while opioid consumption was significantly reduced (9.3 vs 26.5, $p < 0.001$). Patients walked, climbed stairs, showered, performed activities of daily living, practised sports, went back to work sooner ($p < 0.001$), but PROMs were similar between groups at the last follow-up ($p > 0.188$). Patients were more satisfied of the ERAS-outpatient pathway and recommended it significantly more ($p < 0.002$).

CONCLUSION: Compared to the conventional inpatient care, our ERAS-outpatient protocol proved to be safer, enable faster functional recovery, and improve patients' satisfaction which highlight the importance of following ERAS principles when implementing an outpatient THA/TKA program.

Introduction

In response to financial pressure and, more recently, to resume elective surgery in the pandemic period, there has been a shift toward using outpatient protocols for patients undergoing total hip arthroplasty (THA) or total knee arthroplasty (TKA).¹ Outpatient protocol success is often defined as returning home on the day of surgery while being noninferior to inpatient procedures regarding complications and readmission rates in selected^{2,3} and unselected⁴ cohorts. Rather than equalizing inpatient procedures, an alternative is to implement strategies that reduce postoperative complications, and improve patient wellbeing and function, to a level where they may safely return home sooner.⁵ As suggested by Vehmeijer et al.,⁶ reducing hospital LOS "should not be a goal in itself, but should rather be the result of a successful, already implemented fast-track program based on the concept first better—then faster." With the aim of optimizing all aspects of perioperative care, Drs. Husted and Kehlet developed the concept of Enhanced Recovery After Surgery (ERAS).⁵ In 2015, we developed a standardized ERAS-based outpatient THA and TKA protocol,² designed to reduce unwanted events (pain, opioid side effects, patient sedation,

anemia, wound complications, DVT, delayed function and mobilization, perioperative bowel malfunction). Compared to standard-inpatient care, our ERAS-outpatient program reduced direct health care costs and hospital LOS, improved patient care, significantly lowered the rate of complications, and was very efficient at reducing the frequency of adverse events including pain, nausea, vomiting, dizziness, headache, constipation, hypotension, anemia, edema, lameness, and urinary retention.² However, the benefits of combining ERAS interventions with an outpatient program are unclear. Some studies suggested that immediate postoperative pain was better controlled by ERAS interventions^{2,7} while others found no difference.³⁻⁸ Some studies showed faster recovery in the first few days⁷ and better functional outcomes 3-6-12 months after surgery^{9,10,11} while others found no difference at all.^{12,13} Improved patient satisfaction regarding the fast track pathway is also controversial.¹⁴ Thus, the primary study objective was to compare adverse event rate (complication and unplanned episode of care) and secondly to compare pain management, functional recovery, PROMS and satisfaction in patients who experienced both our ERAS-outpatient protocol and standard-inpatient care. We hypothesized that the ERAS-outpatient protocol would result in reduced adverse event rate, reduced pain and opioid consumption, faster functional recovery, improved PROMs and increased satisfaction when compared with standard care.

Methods

Study Design and Population

This ambidirectional single subject cohort study compared primary THA/TKA performed with standard (STD) inpatient care to the contralateral surgery using our ERAS-outpatient protocol published previously by Vendittoli et al.² STD-inpatient surgeries were performed first between 2000 and 2018, and interventions varied according to the medical team's preferences and the patient's characteristics. The contralateral ERAS-outpatient joint replacements were performed secondly, between January 2017 and June 2020, and team members followed a standardized protocol.² No changes in surgical technique or approach between interventions were made. For both programs, patients went straight home after discharge, followed the same rehabilitation program and received similar home care services. Patients in our ERAS-outpatient protocol were expected to be discharged the same day after a THA or in the first 24 hours after a TKA. A detailed description of both ERAS-outpatient and standard-inpatient interventions are available in Supplementary Material - Appendix A.

Patient Selection and Recruitment

Based on previous results,² 43 patients were needed to detect a 40% relative reduction in complications with a 95% confidence interval and 80% statistical power. We contacted all 50 patients who underwent an ERAS-outpatient THA/TKA and had the same intervention performed earlier on with the STD-inpatient care. Those who were > 18 years old, who were able to communicate in French or English, who were able to give an informed consent and who did not suffer from significant cognitive impairment were included. Two patients declined participating in the study, leaving 48 participants. The ethical approval for this

study was obtained from the *Comité d'éthique de la recherche du CIUSSS de l'Est-de-l'Île-de-Montréal* #2021–2420. The informed consent was obtained for all participants approved by *Comité d'éthique de la recherche du CIUSSS de l'Est-de-l'Île-de-Montréal*. The study was conducted in accordance with the Declaration of Helsinki.

Data Collection

Perioperative data was collected retrospectively from medical records. Complications were categorized according to the Clavien-Dindo classification and evaluated by the Comprehensive Complication Index (CCI). Patient files were reviewed for unexpected consultation, readmission, and reoperation until 3 months after surgery. Pain on postoperative day (POD) 0 was assessed using a numeric rating scale (NRS 0–10). Opioid consumption in the first 8 hours postoperatively was quantified in morphine milligram equivalents (MME). The number of days required to reach key functional recovery landmarks at the hospital (first rise/walk/stairs climb) was also evaluated. The following PROMs were gathered prospectively at the last follow-up (> 9 months after surgery) either by email or by mail: Forgotten Joint Score (FJS), Patient Joint Perception (PJP) question, WOMAC, HOOS, and KOOS. Additionally, patients completed the Patient's Experience survey (Supplementary Material - Appendix B) in which they recorded the number of days required to reach key functional recovery landmarks (activities of daily living, instrumental activities of daily living, return to sports/work, etc.), their satisfaction on a visual analog scale (0–100) regarding various components of care (hospital stay, pain management, recovery process, wound closure management, patient experience, etc.) and the program they would recommend ("ERAS-outpatient" or "STD-inpatient" or "No preference". All questions referred to "Right" and "Left" joint to avoid expectation bias. Answers were assigned to the corresponding protocol (ERAS-outpatient or STD-inpatient) post hoc. All the information gathered was codified and stored in our secured REDCap database (Research Electronic Data Capture, Vanderbilt University, TN, USA).

Statistical Analysis

All continuous data are presented with the mean (minimum-maximum, standard deviation) and categorical data with the number of observations (percentage). Descriptive analyses were conducted for all participants. The intrasubject comparison of continuous variables was done using paired Student T tests (parametric) or Wilcoxon signed-rank tests (nonparametric). McNemar tests and χ^2 were respectively conducted for paired and independent dichotomic nominal data. Marginal homogeneity tests were performed for paired variables with more than two categories or with zero values. Missing data were handled accordingly to the casewise deletion method. The statistical analyses were realized with the software *SPSS – 25* (IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY: IBM Corp.). A level of significance $\alpha = 0.05$ (two-sided) was used for all tests.

Results

Patient Characteristics

Patient characteristics at the time of the ERAS-outpatient and STD-inpatient surgeries are described in Table 1 and comorbidities can be found in Supplementary Material - Appendix C.

Table 1
Patients Characteristics

	ERAS-outpatient	STD-inpatient	P-value
Number of participants	48		
Gender			
(Men: Women)	27 (56.2%): 21 (43.8%)		
Average Age at Surgery	60.0 (45.0–76.0, 7.8)	52.9 (33.0–70.0, 8.3)	< 0.001 ^a
Average Body Mass Index	28.1 (20.7–37.6, 4.1)	28.3 (19.3–35.0, 4.0)	0.638 ^a
ASA Physical Status			0.007 ^b
1	17 (35.4%)	25 (52.1%)	
2	30 (62.5%)	23 (47.9%)	
3	1 (2.1%)	0	
Intervention			
THA	36 (75.0%)		
TKA	12 (25.0%)		
a: Paired T-test			
b: Marginal homogeneity test			

Complications

The rate of complications was significantly lower in the ERAS-outpatient surgery (2.1 versus 4.4, $p < 0.001$). Rates were significantly lower for the ERAS-outpatient side for Grade 1 complications: 2.0 (0.0–7.0, 1.6) vs. 4.2 (0.0–11.0, 2.3), $p < 0.001$, and Grade 2 complications: 0.1 (0.0–1.0, 0.2) vs. 0.2 (0.0–2.0, 0.5), $p = 0.033$. No difference was found for Grades 3 to 5. The CCI was significantly lower for the ERAS-outpatient side: 12.3 (0.0–34.8, 7.2) versus 19.1 (0.0–35.1, 7.2), $p < 0.001$ (Tables 2 and 3).

Table 2
Complications Rates According to the Clavien-Dindo Classification and Comprehensive
Complication Index (CCI)

Complications	ERAS-outpatient N = 48	STD-inpatient N = 48	P-Value
All Grades	2.1 (0–7.0, 1.6)	4.4 (0–11.0, 2.3)	< 0.001 ^a
Grade 1	2.0 (0–7.0, 1.6)	4.2 (0–11.0, 2.3)	< 0.001 ^a
Grade 2	0.1 (0–1.0, 0.2)	0.2 (0–2.0, 0.5)	0.033 ^a
Grade 3	0.02 (0–1.0, 0.2)	0	
Grade 4	0	0	
Grade 5	0	0	
Comprehensive Complication Index	12.3 (0-34.8, 7.2)	19.1 (0-35.1, 7.2)	< 0.001 ^a
a: Wilcoxon rank-signed test			

Table 3
Detailed Complications According to the Clavien-Dindo Classification

Complications	ERAS- outpatient N = 48	STD- inpatient N = 48	P- Value
Grade 1	96 (200.0%)	201 (418.8%)	< 0.001 ^b
Anemia without blood transfusion Hemoglobin women < 120, men < 130	17 (35.4)	37 (77.1%)	< 0.001 ^a
Nausea	8 (16.7%)	24 (50.0%)	0.001 ^a
Vomiting	3 (6.3%)	12 (25.0%)	0.012 ^a
Headache	0	6 (12.5%)	0.031 ^a
Pain	10 (20.8%)	17 (35.4%)	0.118 ^a
Fever	0	5 (10.4%)	0.063 ^a
Diaphoresis	1 (2.1%)	5 (10.4%)	0.219 ^a
Desaturation during hospital stay requiring supplementary O ₂	0	2 (4.2%)	
Dizziness	12 (25%)	17 (35.4%)	0.359 ^a
Hypotension	6 (12.5%)	10 (20.8%)	0.424 ^a
Edema	6 (12.5%)	10 (20.8%)	> 0.999 ^a
Urinary retention	1 (2.1%)	12 (25.0%)	0.003 ^a
Constipation	3 (6.3%)	5 (10.4%)	
Erythema	3 (6.3%)	4 (8.3%)	
Pruritus	3 (6.3%)	3 (6.3%)	
Visual disturbances	2 (4.2%)	0	

a: McNemar test

b: Wilcoxon signed-rank test

Complications	ERAS- outpatient N = 48	STD- inpatient N = 48	P- Value
Ecchymosis	6 (12.5%)	7 (14.6%)	> 0.999 ^a
Wound bleeding	2 (4.2%)	6 (12.5%)	0.289 ^a
Wound serous discharge	1 (2.1%)	4 (8.3%)	
Phlycten	1 (2.1%)	3 (6.3%)	
Stich abscess	1 (2.1%)	1 (2.1%)	
Hematoma	0	3 (6.3%)	
Symptomatic limb length inequality	1 (2.1%)	0	
Periprosthetic fracture treated with conservative treatment	1 (2.1%)	1 (2.1%)	
Thrombocytopenia	0	1 (2.1%)	
Temporary partial sciatic nerve block secondary to LIA (all resolved in < 12 hrs)	5 (10.4%)	0	0.063 ^a
Limping	3 (6.3%)	4 (8.3%)	
Grade 2	3 (6.2%)	11 (25.0%)	0.033 ^b
Anemia requiring blood transfusion	1 (2.1%)	5 (10.4%)	0.219 ^a
Superficial infection treated with oral antibiotics	1 (2.1%)	2 (4.2%)	
Deep venous thrombosis treated by anticoagulant	0	1 (2.1%)	
Gastritis	1 (2.1%)	2 (4.2%)	
Bradycardia treated medically	0	1 (2.1%)	
Grade 3	1 (2.1%)	0	
Deep infection requiring debridement surgery	1 (2.1%)	0	
Grade 4	0	0	
Grade 5	0	0	
a: McNemar test			
b: Wilcoxon signed-rank test			

Unplanned Episodes of Care

After ERAS-outpatient surgery, bleeding from the surgical wound (2), dizziness (2), urinary retention (1), and logistic problems preventing the functional evaluation at POD 0 (1) resulted in five (10.4%) failures to discharge in the expected time (4 [11.1%] THAs and 1 [8.3%] TKA). The average length of stay (hours) was significantly lower for ERAS-outpatient side for both THA (8.2 [4.0–32.0, 6.2] vs. 66.8 [14.0-141.0, 32.4], $p < 0.001$) and TKA (24.0 [5.0–47.0, 9.1] vs. 119.8 [67.0-211.0, 50.0], $p < 0.001$). In the 3 months following ERAS-outpatient and STD-inpatient surgeries, 9 (18.8%) patients required unplanned care. (Table 4).

Table 4
90-days Unplanned Episode of Care

	ERAS-outpatient N = 48	STD-inpatient N = 48
Emergency Care Unit visits without intervention	3 (6.3%)	1 (2.1%)
Vasovagal episode	1 (2.1%)	0
Gastritis secondary to NSAIDS	1 (2.1%)	0
Mild pain	1 (2.1%)	1 (2.1%)
Clinic consultations without intervention	3 (6.3%)	6 (12.5%)
Suspicion of stich abscess	1 (2.1%)	2 (4.2%)
Leg oedema	1 (2.1%)	1 (2.1%)
Joint pain	0	2 (4.2%)
Serous wound discharge	1 (2.1%)	0
Headache	0	1 (2.1%)
Emergency Care Unit visits requiring interventions	3 (6.3%)	1 (2.1%)
Moderate joint pain	1 (2.1%)	0
Deep prosthetic infection	1 (2.1%)	0
Cellulitis	1 (2.1%)	0
Suspicion of deep venous thrombosis	0	1 (2.1%)
Clinic consultations requiring interventions	0	1 (2.1%)
Stitch abscess requiring oral antibiotics and superficial debridement.	0	1 (2.1%)

Postoperative Pain and Opioid Consumption

No significant difference between ERAS-outpatient and STD-inpatient was observed regarding postoperative pain on NRS (0–10) in the recovery room (1.8 [0.0–10.0, 2.3] vs. 1.3 [0.0–8.0, 1.4], $p = 0.903$) and on the ward at POD 0 (1.7 [0.0–8.0, 2.1] vs. 1.7 [0.0–8.0, 2.0], $p = 0.805$). However, the average opioid consumption in morphine milligram equivalents in the first 8 hours after surgery was significantly lower following ERAS-outpatient surgeries (9.3 [0.0–49.0, 11.8] vs. 26.5 [0.0–179.0, 32.4], $p < 0.001$).

Functional Recovery and PROMs

Patients following the ERAS-outpatient interventions walked, climbed stairs, took a shower, achieved activities of daily living, returned to sports, and returned to work significantly faster (Table 5). At last follow-up, no significant difference was found between protocols for the PJP question, FJS, HOOS, KOOS, and WOMAC (Table 6).

Table 5
Functional Recovery

	ERAS- outpatient N = 48	STD- inpatient N = 48	P- Value
Average delay between the end of surgery and:			
- first physiotherapy evaluation (in hours)	5.8 (2.0–19.0, 4.4)	20.1 (7.0–59.0, 15.2)	< 0.001 ^a
- first rise/standing (in days)	0.1 (0–1.0, 0.3)	1.1 (0–3.0, 0.5)	< 0.001
- walking (in days)	0.1 (0–1.0, 0.3)	1.4 (1.0–4.0, 0.9)	< 0.001 ^a
- going up and down the stairs (in days)	0.4 (0–1.0, 0.5)	2.9 (1.0–7.0, 1.4)	< 0.001 ^a
Lying to sitting at the first physiotherapy evaluation			< 0.002 ^b
Alone	42 (87.5%)	29 (63.0%)	
With help	6 (12.5%)	17 (37.0%)	
Sitting to standing at the first physiotherapy evaluation			0.109 ^b
Alone	44 (91.7%)	36 (81.8%)	
With help	4 (8.3%)	8 (18.2%)	
First shower (in days)	5.3 (0–21.0, 4.5)	8.3 (1.0–30.0, 5.2)	< 0.001 ^a
a: Wilcoxon rank-signed test, b: McNemar test			
*Four (8.3%) participants of the ERAS-outpatient group and 3 (6.3%) of the STD group reported not performing mild physical activity in their lifestyle.			
**Twenty-two (45.8%) participants of the ERAS-outpatient group and 20 (41.7%) of the STD group reported not performing intense physical activity in their lifestyle.			
***Seventeen (34.6%) participants of the ERAS-outpatient group and 10 (20.8%) of the STD group reported being unemployed or retired.			
****Twenty-two (45.8%) participants of the ERAS-outpatient group and 16 (33.3%) of the STD group reported being unemployed or retired.			

	ERAS- outpatient N = 48	STD- inpatient N = 48	P- Value
Walking without technical aid (in days)	16.1 (0-100.0, 21.0)	23.1 (1.0-120.0, 25.2)	< 0.001 ^a
Going up and down the stairs without technical aid (in days)	17.1 (0-100.0, 21.4)	24.3 (2.0-120.0, 25.4)	< 0.001 ^a
ADLs: dressing, toileting, walking indoor alone, etc. (in days)	5.5 (0-48.0, 7.9)	11.8 (0-90.0, 16.7)	< 0.001 ^a
iADLs: cooking, cleaning, shopping, etc. (in days)	14.2 (0-90.0, 17.0)	23.0 (0-120.0, 24.4)	< 0.001 ^a
Mild physical activities: cycling, swimming, walking, etc. (in weeks)*	6.1 (1.0-4.0, 7.0)	8.4 (1.0-50.0, 9.13)	< 0.001 ^a
Intense physical activities: running, playing tennis, skiing, etc. (in weeks)**	14.0 (3.0-40.0, 9.7)	19.1 (5.0-52.0, 13.5)	< 0.001 ^a
Return to light-duty work (in weeks)***	6.5 (1.0-21.0, 6.0)	9.2 (1.0-26.0, 6.7)	0.001 ^a
Return to regular work without limitation (in weeks)****	9.8 (1.0-24.0, 6.4)	11.8 (2.0-30.0, 7.8)	0.012 ^a
a: Wilcoxon rank-signed test, b: McNemar test			
*Four (8.3%) participants of the ERAS-outpatient group and 3 (6.3%) of the STD group reported not performing mild physical activity in their lifestyle.			
**Twenty-two (45.8%) participants of the ERAS-outpatient group and 20 (41.7%) of the STD group reported not performing intense physical activity in their lifestyle.			
***Seventeen (34.6%) participants of the ERAS-outpatient group and 10 (20.8%) of the STD group reported being unemployed or retired.			
****Twenty-two (45.8%) participants of the ERAS-outpatient group and 16 (33.3%) of the STD group reported being unemployed or retired.			

Table 6
PROMs at the Last Follow-up

	ERAS-outpatient N = 45	STD-inpatient N = 45	P- Value
Time after surgery in months	24.8 (9.0–46.0, 11.6)	112.8 (40.0-243.0, 47.3)	< 0.001 ^a
Patient Joint Perception			0.647 ^a
Natural joint	22 (48.9%)	23 (51.1%)	
Artificial joint without functional limitation	10 (22.2%)	10 (22.2%)	
Artificial joint with minimal functional limitation	11 (24.4%)	11 (24.4%)	
Artificial joint with signification functional limitation	2 (4.4%)	1 (2.2%)	
Non functional joint	0	0	
Forgotten Joint Score	82.5 (39.6–100.0, 17.7)	80.6 (22.9–100.0, 20.6)	0.369 ^b
HOOS			
Pain	93.6 (73.0-100.0, 8.6)	93.6 (58.0-100.0, 11.1)	0.837 ^b
Symptoms	90.2 (60.0-100.0, 11.8)	90.5 (60.0-100.0, 11.1)	> 0.999 ^b
Activities of daily living	94.7 (69.0-100.0, 8.3)	94.3 (68.0-100.0, 8.7)	0.990 ^b
Sports and activities	88.0 (44.0- 100.0,15.6)	88.5 (50.0-100.0, 14.6)	0.689 ^b
Quality of life	88.4 (63.0-100.0, 12.0)	88.2 (31.0-100.0, 14.6)	0.842 ^b
KOOS			
Pain	90.4 (69.0-100.0, 11.4)	92.5 (58.0-100.0, 12.4)	0.719 ^c
Symptoms	88.7 (71.0-100.0, 10.7)	92.3 (71.0-100.0, 9.1)	0.188 ^c

a: Marginal homogeneity test

b: Paired T-test

c: Wilcoxon signed-rank test

	ERAS-outpatient N = 45	STD-inpatient N = 45	P- Value
Activities of daily living	93.2 (74.0-100.0, 8.8)	94.3 (75.0-100.0, 7.9)	0.500 ^c
Sports and activities	68.3 (25.0-100.0, 24.3)	69.6 (25.0-100.0, 25.2)	0.330 ^c
Quality of life	79.8 (63.0-100.0, 14.7)	84.5 (63.0-100.0, 14.9)	0.656 ^c
WOMAC score	93.6 (69.8–100.0, 8.3)	93.6 (64.6–100.0, 8.9)	0.790 ^c
a: Marginal homogeneity test			
b: Paired T-test			
c: Wilcoxon signed-rank test			

Satisfaction and Recommendation

Participants were significantly more satisfied with hospital stay, pain management, recovery, wound management, and surgical experience, and recommended the ERAS-outpatient program significantly more often (Tables 7 and 8).

Table 7
Patients' Satisfaction on a Visual Analog Scale (0-100)

Question	ERAS- outpatient N = 47	STD- inpatient N = 47	P- Value
How satisfied are you with your time at the hospital (including the anesthesia, the surgery and physiotherapy)?	96.0 (50.0- 100.0, 9.0)	84.6 (0.0- 100.0, 23.1)	< 0.001 ^a
How satisfied are you with the pain management after your surgery?	93.2 (18.0- 100.0, 13.5)	86.4 (0-100.0, 21.4)	0.002 ^a
How satisfied are you with your recovery (speed and ease of resuming your usual activities) after your surgery?	95.5 (70.0- 100.0, 6.8)	84.4 (1.0- 100.0, 19.9)	< 0.001 ^a
How satisfied are you with your surgical wound closing method (sutures/glue/staples and bandage)?	94.8 (18.0- 100.0, 13.2)	85.1 (0.0- 100.0, 18.2)	< 0.001 ^a
In general, how satisfied are you of your surgical experience as a patient?	97.1 (75.0- 100.0, 30.3)	88.3 (24.0- 100.0, 16.2)	< 0.001 ^a
a: Wilcoxon rank-signed test			

Table 8
Recommendation of a THA/TKA Protocol

Question	ERAS- outpatient N = 47	STD- inpatient N = 47	No preference N = 47	P- Value
Which surgical protocol between the one you had on your right or left hip/knee would you recommend for a total hip/knee replacement*	40 85.1%	3 6.4%	4 8.5%	< 0.001 ^a
a: Chi ² test				
* Answers were converted to ERAS-outpatient and standard-inpatient post-hoc.				

Discussion

Outpatient THA and TKA, by reducing hospital LOS, increases bed availability and reduces direct health care costs.¹¹ Most studies comparing outpatient to inpatient programs conclude that outpatient surgeries did not increase complication or readmission rates, and, overall, were not inferior.¹⁵ We aimed to determine if combining ERAS principles to an outpatient program could reduce adverse event rate and improve patient outcomes including postoperative pain, functional recovery and satisfaction. We found that compared to STD-inpatient practice, ERAS-outpatient program reduced complications by half while not resulting in more unplanned episodes of care. Moreover, it resulted in less opioid consumption, faster early functional recovery, and higher satisfaction.

Limitations

Our results should be interpreted in light of our study limitations. Although our single subject design eliminates selection bias by controlling for interindividual confounders, all ERAS-outpatient surgeries were performed secondly. Nevertheless, studies on staged bilateral joint arthroplasty showed no clear advantage for the second surgery over the first one.¹⁶ On the other hand, for the ERAS-outpatient surgery, patients were 7 years older and had more comorbidities (higher ASA score) which could have negatively impacted the outcomes. Secondly, the health care team might have presented the ERAS-outpatient protocol as an “optimized care” and patients might expected superior results from the second surgery. As counterpart, those higher expectations required better results to achieve similar satisfaction which disfavoured the ERAS-outpatient pathway.¹⁷ Third, the retrospective data retrieved from patients’ medical record may have been incomplete which potentially reduced the number of adverse events. However, this limitation was present for both sides. Last, although our sample size was rather small limiting our study power, we were able to detect a statistically significant difference in most of our secondary outcomes.

Complications

Our ERAS-outpatient protocol was specifically designed to reduce common complications that increase LOS, such as dizziness, nausea/vomiting, pain, and urinary retention.¹⁸ Compared to STD-inpatient practice, it successfully decreased the number of complications per patient by 52.4% (2.1 vs 4.4 $p < 0.001$) and overall postoperative morbidity (CCI) by 35.7% (12.3 vs 19.1, $p < 0.001$). This reduction in the complication rate was better than what was reported in meta-analyses of ERAS joint replacements (23–26%).¹⁹ However, considering the heterogeneity of ERAS protocols,¹⁹ the difference between our results and those in the literature is probably multifactorial, making it impossible to pinpoint one element specifically. Meta-analyses comparing adverse event rates between inpatient and outpatient THA/TKA reported either increased complication rate after outpatient procedures²⁰ or did not find a difference (outpatient considered to be non-inferior).¹⁵ These results contrast with ours, raising the point that outpatient programs may not be equal, and demonstrating the important impact of including ERAS principles in an outpatient program. Our current results are similar to our previous study comparing 114 unilateral ERAS-outpatient cases to a historical cohort of 150 matched STD-inpatient surgeries, where we

found a complication rate reduction of 50%.² In the current study, each patient being his own control reduces the potential selection bias, and thus further supports the efficacy and safety of our ERAS-outpatient program. Our selected interventions successfully prevented multiple potential adverse events. We avoided gastrointestinal complications such as nausea and vomiting by minimizing opioids, using preventive methods such as aprepitant,²¹ dexamethasone,²² and scopolamine patch,²³ and by implementing a nutrition protocol that allows clear liquids until 2h before surgery and encourages rapid postoperative oral feeding.²⁴ Anemia was minimized by preoperative screening²⁵ and perioperative blood saving interventions (tranexamic acid,²⁶ adrenaline in LIA,²⁷ and postoperative knee flexion²⁸).

Unplanned Episodes of Care

Our ERAS-outpatient program significantly decreased hospital LOS and achieved the discharge of 90% of patients in the prescribed time. Failure rate to discharge and their reasons are similar to those described by Shapira et al.²⁹ To improve success, future work should focus on interventions that address specific problems preventing discharge. Similar to other studies, our ERAS-outpatient protocol did not result in more unplanned episodes of care than STD-inpatient practice.^{19,3,15,20} The 90-day readmission and reoperations rates of our groups are comparable to the current literature (0-4.2% and 0–4%, respectively).¹⁸ Our 3-month unplanned care episode rate is higher than that reported in similar studies (0.9%-11.2%).¹⁸ However, most unexpected visits in the ERAS-outpatient surgeries were for minor problems that did not require intervention. We believe that the ERAS-outpatient cases were provided more proactive care, where professionals were more easily accessible than for standard care procedures. These situations demonstrate the need to better educate patients on complications that truly require a consultation.

Pain Management & Opioid Consumption

Patient-reported pain levels on POD 0 were very low (1.3–1.8/10) and were similar between ERAS-outpatient and STD-inpatient surgeries.^{2,7,8} However, the ERAS multimodal approach in the outpatient group achieved pain control with significantly less opioids in the first 8 hours (9.3 vs 26.5 MME, $p < 0.001$). The systematic use of pre-emptive analgesia, dexamethasone, LIA, epidural-sedation anesthesia, and other multimodal interventions (tourniquet avoidance, cryotherapy, etc.) may explain this observation, unlike results reported by other authors.^{30,31} The reduced intake of opioids in the ERAS group led to significantly lower incidences of related complications such as nausea, vomiting, headache, urinary retention, and dizziness (Table 3).

Functional Recovery and PROMs

Our patients demonstrated significantly better early function following ERAS-outpatient THA/TKA in comparison to contralateral surgery performed with STD-inpatient care (Table 6). This finding is likely multifactorial and linked to the specific ERAS interventions. Minimizing postoperative pain, orthostatic hypotension, anemia, motor blockade, and urinary retention, enabled rapid mobilization, which led to faster overall recovery. Pre-emptive medications,³² dexamethasone,²² LIA,²⁷ cryotherapy,³³ early first rise,

and optimized wound closure are associated with faster functional recovery. Moreover, combined epidural-sedation opioid-free anesthesia avoided prolonged and complete motor blockade, reduced cases of urinary retention, and enabled patients to walk soon after surgery. Our ERAS interventions had very important impacts on patients' function. Patients could perform activities of daily living, shower, practice physical activities, and return to work sooner, even though they were older and had more comorbidities. To our knowledge, no other studies reported lasting effects of ERAS procedures regarding the time needed to regain important functional abilities. Yet, some studies did find better PROMs in the first few months,^{9,10,11} supporting the possible superiority of ERAS interventions on recovery in the acute and subacute postoperative period. However, the benefits of ERAS procedures seemed to vanish with time. Like other trials^{7,12,13}, we did not find any difference between groups on PROMs 9 months or later after surgery. Berg et al.¹⁰ did discover slightly better PROMs in its fast-track cohort at 1 year. However, this difference was not clinically significant and multiple cofounders might explain their results, thus limiting the validity of their findings.

Patients Satisfaction and Recommendation

Our previous study² found that our multimodal approach achieved better pain relief. Thus, it can explain why patients were more satisfied with pain management following our ERAS interventions even though we did not find a difference on the day of surgery. Patients preferred the surgical glue to seal their wound probably because they could shower earlier and did not need to have the staples removed. The faster return to their home and to their activities surely contributed to them being more content with the outpatient protocol as satisfaction is directly correlated with shorter LOS.³⁴ Like many studies, we found that patients were very satisfied of their ERAS-outpatient experience (97% vs. 85–94%)³⁵ and highly recommended it (85% vs 80–96%).^{36,37} Nevertheless, our study is the first to demonstrate that patients were significantly more inclined to recommend the ERAS-outpatient pathway after having personally experienced both outpatient and inpatient protocols.

Conclusion

Compared to the STD-inpatient care, our ERAS-outpatient protocol proved to be safer, result in better early functional outcomes, and improve patients' satisfaction. Complication rate was reduced by half, while not resulting in more unplanned episodes of care, patients required fewer opioids for pain relief and recovered faster. Results of this study highlight the importance of following ERAS principles when implementing an outpatient THA/TKA program.

Abbreviations

- CCI: Comprehensive Complication Index
- ERAS: Enhanced Recovery after Surgery
- FJS : Forgotten Joint Score

- HOOS: Hip disability and osteoarthritis outcome score
- KOOS: Knee Injury and Osteoarthritis Outcome Score
- LIA: Local infiltration analgesia
- LOS: Length of Stay
- POD: Postoperative day
- PJP: Patient Joint Perception
- PROMS: Patient Reported Outcome Measurement Study
- MME: Morphine milligram equivalents
- NRS: Numeric rating scale
- THA: Total hip arthroplasty
- TKA: Total knee arthroplasty
- STD: Standard
- WOMAC: Western Ontario and McMaster Universities Arthritis Index

Declarations

Ethics approval and consent to participate

The ethical approval for this study was obtained from the *Comité d'éthique de la recherche du CIUSSS de l'Est-de-l'Île-de-Montréal* #2021–2420. The informed consent was obtained for all participants approved by *Comité d'éthique de la recherche du CIUSSS de l'Est-de-l'Île-de-Montréal*. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

P-AV reports grants and personal fees from Medacta, grants, personal fees and other from Microport, grants, personal fees and other from Stryker, grants, personal fees and other from Ethicon, grants from Zimmer, grants, personal fees and other from Johnson and Johnson; all outside the submitted work. All authors declare that they have no competing interests.

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Authors' contributions

AH as the first author was involved in conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources and software management, validation, visualization and writing the original draft. MC was involved with investigation. KP contributed to conceptualization and investigation. FD & CL helped with conceptualization, methodology, supervision and validation. P-AV as senior author contributed to conceptualization, formal analysis, investigation, methodology, project administration, resources, supervision, validation and writing the original draft. All authors contributed to final editing and review of the manuscript. All authors have read and approved the final version submitted.

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