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Original article

Enhanced recovery short-stay hip and knee joint replacement program improves patients outcomes while reducing hospital costs

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ABSTRACT

Introduction. – An attractive option to reduce hospital length of stay (LOS) after hip or knee joint replacement (THA, TKA) is to follow the Enhanced Recovery After Surgery principles (ERAS) to improve patient experience to a level where they will feel confident to leave for home earlier. The objective of this study was to evaluate the implementation of short-stay protocol following the ERAS principles.
Hypothesis. – We hypothesized that our ERAS THA and TKA short-stay protocol would result in a lower complication rate, shorter hospital LOS and reduced direct health care costs compared to our standard procedure.
Material and methods. – We compared the complications rated according to Clavien-Dindo scale, hospital LOS and costs of the episode of care between a prospective cohort of 120 ERAS short-stay THA or TKA and a matched historical control group of 150 THA or TKA.
Results. – Significantly lower rate of Grade 1 and 2 complications in the ERAS short-stay group compared with the standard group (mean 0.8 vs 3.0, $p < 0.001$). No difference was found between the 2 groups for Grade 3, 4, or 5 complications. The mean hospital LOS for the ERAS short-stay group decreased by 2.8 days for the THAs (0.1 vs 2.9 days, $p < 0.001$) and 3.9 days for the TKAs (1.0 vs 4.9 days, $p < 0.001$). The mean estimated direct health care costs reduction with the ERAS short-stay protocol was 1489 CAD per THA and 4158 CAD per TKA.
Discussion. – In many short-stay protocols, focus has shifted from ERAS goals of a reduction in complications and improved recuperation to use length of stay as the main factor of success. Implementation of an ERAS short-stay protocol for patients undergoing THA or TKA at our institution resulted not only in reduced hospital LOS, but also in improved patient care and reduced direct health care costs.
Level of evidence. – Level II.

1. Introduction

In recent years, there has been a shift toward outpatient and short-stay protocols for patients undergoing total hip arthroplasty (THA) or total knee arthroplasty (TKA). This is due, in part, to improvements in surgical technique and perioperative care, but also in response to pressure to reduce health care costs. Several retrospective studies have shown no significant differences in overall postoperative complications or hospital readmissions between outpatient/short-stay and inpatient THA or TKA [1–3]. There are few prospective studies comparing health and economic outcomes between short-stay and standard inpatient THA or TKA [4–7]. There are multiple ways of implementing a successful day surgery program. Returning patients home may be possible by transferring part of the in-hospital care to patients' home. However, the main goal of short-stay protocols, adhering to the principles of enhanced recovery after surgery (ERAS), is to improve patient recovery to a level where the patient will be able to leave the hospital sooner [8,9]. ERAS Short-stay protocols require the involvement of a multidisciplinary team, including anesthesiologists, surgeons, nurses, and physiotherapists, who adhere to specifically-designed protocols on perioperative care and adjusts their practices upon the evolving scientific knowledge.

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We developed a perioperative THA and TKA short stay protocol following the ERAS principles, aiming at optimizing patients' outcomes to reduce the hospital length of stay (LOS) < 24 h and allow discharging them directly home [8]. The key elements of our protocol were selected to be effective in reducing adverse events and felt to be applicable in our public hospital. We aimed at: reducing pain while minimizing opioids use and their side effects, avoiding patient sedation, improving patients' early function and mobilization, minimizing postoperative anemia, improving perioperative bowel function, decreasing wound complication and finally reducing the DVT risk.

Therefore, the goal of this study was to evaluate the implementation of our protocol in a prospective cohort of 120 patients undergoing THA or TKA by comparing the complication rate with a retrospective cohort of 150 patients meeting the same inclusion/exclusion criteria. Secondary objectives were to compare the hospital LOS and costs between these 2 groups. We hypothesized that our ERAS short-stay protocol would result in a lower complication rate and a shorter LOS and reduced direct health care costs of care compared to the standard procedure.

2. Patients and methods

2.1. ERAS short-stay group

This study was conducted at the Maisonneuve-Rosemont Hospital Center from June 2016 to August 2018. Patients 18 to 75 years of age, awaiting primary THA or TKA, treated by 6 surgeons (P-AV, MF, ML, VM, AR, and M-OK) were offered to undergo surgery using the ERAS short-stay protocol. The selected subjects were discharged home on the day of surgery for THA and < 24 h for TKA. Patients were included in the study if they were able to give informed consent and met the exclusion criteria.

2.2. Exclusion criteria

- Contraindication to some drugs or procedures included in the protocol;
- Absence of relative or friend to help returning home;
- Locomotor or physical handicaps preventing safe post-op mobilization;
- Living further than 50 km from the hospital;
- Lack of home services offered by the local community service in the area;
- Need for long-term urinary Foley catheter post-op or at risk of urinary retention;
- Psychiatric disease limiting participation;
- Coagulation disorder;
- Current or in the past year, systemic corticotherapy (unless confirmation of cortrosyn test prior to surgery);
- Systemic disease necessitating special perioperative care (intensive care, multiple transfusion, dialysis, etc);
- Treatment with a major CYP3A4 substrate or potent CYP3A4 inhibitor;
- CLCR < 30 mL/min (Cockcroft-Gault Formula);
- Body mass index (BMI) > 40 kg/m^2.

2.3. ERAS Short-stay protocol

pdf documents available online in the Supplementary material: protocol description and patients information booklet.

Perioperative interventions were:

- patients evaluation and preparation in the preoperative assessment clinic (1–2 months before scheduled surgery day, see detailed description online in the Supplementary material section);
- food intake: Solid food was allowed until midnight and clear liquids until the surgery [10];
- preemptive medication within 2 hours before surgery (oral administration): acetaminophen 1 g, long acting oxycodone 10 mg, celecoxib 400 mg, pregabalin 150 mg for TKA and 50 mg for THA, Aprepitant 125 mg, scopolamine patch 1.5 mg [11–15];
- IV medications before surgery: selected prophylactic antibiotic, dexamethasone 6 mg IV, tranexamic acid, 1 g IV (max 15 mg/kg) before skin incision [16,17];
- anesthesia: Lumbar epidural anesthesia with xylocaine 2% (10–15cc) and deep propofol (diisopropylphenol) sedation [18]. In case of contraindication to or failure of epidural anesthesia, total intravenous anesthesia with propofol and remifentanil was used;
- application of intermittent compression legs device to the opposite side;
- surgery;
  - surgical approach left to the surgeon preference (all posterior),
  - TKA avoid the use of the tourniquet, but permitted for cementing [19],
  - THA large diameter (≥ 36 mm) bearing [20],
  - periarticular infiltration protocol (ropivacaine 400 mg, toradol 30 mg and adrenaline) [21],
  - closing the fascia with Stratafix 1.0 [22],
  - closing the skin with sub cuticular suture,
  - sealed wound with the Prineo Closure System™ [23],
  - 1 g IV tranexamic acid (max 15 mg/kg) prior to closing the surgical site,
  - epidural catheter removed in the operation room,
  - application of intermittent legs compression device to the surgical side,
  - TKA: positioning cushion keeping the knee bent at 60–70 degrees [24].

Post-operative interventions:

- pain control by a multimodal analgesia protocol (avoid SC or IV drugs and narcotics if possible):
  - Acetaminophen 1000 mg every 8 hours for 30–60 days,
  - Celecoxib 100 mg twice a day for 30 days,
  - Pregabalin 75 mg at bed time for 30 days only for TKA,
  - Tramadol 50–100 mg orally every 4–6 hours as needed, if insufficient, add oxycodone 5–7.5 mg orally every 3 hours;
- start feeding at patient's desire;
- applying ice 20 minutes every 2 hours as needed for THA and cryocompression 30 minutes every 2 hours for TKA [25];
- discontinue IV fluid if vital signs stable (3–5 h post op);
- no range of motion restriction of the operated joint;
- 3–4 hours after surgery remove bending cushion for TKA;
- 4–6 h first physical therapy session: First attempt to stand and walk, evaluate safety and autonomy during walking and transfers;
- thromboprophylaxis with rivaroxaban 10 mg orally to begin the day after surgery (14 days for TKA and 5 days for THA, followed by 80 mg aspirin PO for 30 days) [26].

Additional details of preoperative and postoperative phases can be found in the Supplementary material.

3. Control group

The selection of patients for the control group was carried out by reviewing medical records of 200 consecutive patients

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from Maisonneuve-Rosemont Hospital who were hospitalized between 2012 and 2015 for a primary THA or TKA. We selected the first 150 meeting the same inclusion and exclusion criteria applied for the ERAS short-stay patients. Interventions for this group varied between cases according to each collaborators' preferences and patient's particularities. A detailed description of the interventions for the control group can be found in the Supplementary Material Table S1 and represents our standard practice before the ERAS short stay protocol introduction.

4. Methods of assessment

For the ERAS short stay group, the data (pain level, length of stay, complications, satisfaction, clinical scores, etc.) was collected prospectively by one researcher (KP) by direct observation during the hospital stay, by telephonic interview on postoperative day 1, 2 and 3 and, in person during post-operative patient's visit at 6 weeks, 3 months, 6 months and 1 year. Complications were categorized using the Clavien-Dindo classification [27] where Grade 1 are minor events requiring no therapy (with exceptions of analgesic, antipyretic, anti-emetic, antibiotic for superficial wound infection or urinary tract infection, etc.); Grade 2 complications require pharmacological treatment with drugs other than such allowed for grade 1 or other interventions as bladder catheter, blood transfusion or close reduction of a dislocated THA for examples; Grade 3 complications require surgical intervention (deep joint infection or displaced fracture for examples) and may lead to lasting disability; Grade 4 complications are life-threatening and require intensive care management and finally; Grade 5 complications are leading to patient death.

For the control group, data (length of stay, complication, etc.) was retrieved from the patients' files by KP. Duration or severity of the grade 1 or 2 complications could not quantify with precision, so they were recorded as present or absent.

Health care costs difference between both groups was calculated using only direct costs see Table S2 in Supplementary material). We included costs for additional materials or drugs in the ERAS short stay protocol and not used in our control group (aprepitan, scopolamine patch, flexion pillow, skin glue for examples); costs of hospital care (each day on the orthopedic floor: 944 CAD, ambulatory surgery unit for day 0: 1384 CAD); costs of the physical therapy coordinator (3 h per ERAS short stay patient) and; costs related to the unexpected emergency (916.25 CAD) or outpatient clinic (124.50 CAD). Home care being exactly the same for both groups, so no specific cost was included regarding that matter. We did not include the treatment of each complication cost neither the potential economical benefits linked to a faster recovery in the ERAS short-stay group (time to return to work, for example).

5. Statistical analysis

Continuous variables are presented as mean, standard deviation (SD), minimum, and maximum, while categorical variables are presented using frequencies. Comparisons of the 2 groups of continuous data were analyzed using the Student-T tests. For comparisons of more than two groups, ANOVAs were performed. Categorical data was compared with a Chi-square. A significance level of $\alpha = 0.05$ (two-sided) was used for all tests. The analyses were performed using the SPSS software version 25. With an adverse event rate of 3.0 (SD 2.0) per patient, the estimated sample size needed to detect a reduction of 25% with 80% statistical power was 218 patients (109 in each group) with the alpha level set at 0.05.

This research project was approved by the Scientific and Ethics review board of Maisonneuve-Rosemont Hospital (#15044) and was registered on ClinicalTrials.gov (NCT03028779).

6. Results

In the ERAS short-stay group, 120 patients were recruited, of which 6 withdrew from the study before their surgery, leaving 114 patients. Patients' demographics and pre-existing conditions of the ERAS short-stay and the 150 controls are summarized in Table 1. No significant differences were noted between the 2 groups except a lower mean age at surgery in the control group (54 versus 58, $p = 0.002$).

6.1. Complications

The rate of Grade 1 and Grade 2 complications according to the Clavien-Dindo classification was significantly lower in the short-stay group than in the control group (0.8 complications/patient versus 3.0 complications/patient, respectively, $p < 0.001$). No difference was found between the 2 groups in the rate of Grade 3 and Grade 4 complications per patient (0.03 versus 0.04 for the short-stay and control groups, respectively, $p = 0.5$). Grade 1 events were observed in 90% of patients in the control group compared to 49% in the ERAS short-stay group. Detailed description of each complication per grade can be found in Table 2. The number of patients with 1 or multiple complications is described in Table 3.

6.2. Failures, length of hospital stay and unexpected visits

Four THA (4%) and 3 TKA (14%) in the ERAS short-stay group failed to meet discharge criteria to leave the hospital the same day for THA or within the first 24 hours after surgery for TKA. The reasons for failure to discharge were due to dizziness ($n = 2$), urinary retention ($n = 1$), excessive wound discharge ($n = 1$) or orthostatic hypotension ($n = 4$). ERAS short-stay THA mean LOS was significantly shorter (0.1 day, SD 0.5, range 0–5) compared with the control group (2.9 days, SD 1.2, range 0–7) ($p < 0.001$). Similarly, mean LOS ERAS short-stay TKA was significantly shorter (0.95 day, SD 0.6, range 0-2) compared the control group (4.9 days, SD 1.4, range 3–8) ($p < 0.001$).

Visits to the ER occurred among 2 (1.1%) patients in the control group (both TKA; 1 for deep infection and 1 for pain) versus 3 (2.4%) in the ERAS short-stay group (all 3 THA; 1 inconsequential heartburn, discharged the same day; 1 vagal shock requiring ambulance, but inconsequential, discharged the same day; and 1 deep infection). Unexpected visits to the orthopedic clinic occurred among 13 (11%) patients in the ERAS short-stay group and 8 (5%) patients for the control group ($p = 0.07$). Reasons for consultations in the ERAS short-stay group were 3 stitch abscesses, 8 for the adjustment of pain medication, 1 for a wound dehiscence without infection and 1 for the appearance of a benign prominence at the level of the wound. In the control group, all consultations were for the adjustment of pain medication.

6.3. Direct health care costs

Direct costs (coordinator, materials and medications) related to the ERAS short-stay protocol were 215.38 CAD for THA and 326.52 CAD TKA in addition to the usual costs for these procedures (detailed calculation can be found in Supplementary Materials, Table S2 and S3). Comparing the expenses in the short-stay and control groups, the mean cost reduction for the ERAS short-stay group was 1489 CAD for THA and 4158 CAD for the TKA.

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Table 1
Patient Demographics and pre-existing conditions.

Characteristics	Control ($n = 150$)	ERAS Short-Stay ($n = 114$)	p-value
Gender			0.3
Male	68 (45%)	59 (52%)	
Female	82 (55%)	55 (48%)	
Mean age ± SD, years (range)	54.3 ± 11.1 (22–71)	58.0 ± 9.8 (27–77)	0.002
Mean BMI ± SD, kg/m^2 (range)	28.3 ± 4.6 (17.4–40.0)	27.5 ± 4.3 (14.5–38.3)	0.1
Type of surgery, *n* (%)			0.3
THA	115 (76.7)	93 (81.6)	
TKA	35 (23.3)	21 (18.4)	
ASA score, *n* (%)			0.3
1 (normal, healthy)	61 (40.7)	54 (47.4)	
2 (moderate systemic disease)	89 (59.3)	60 (52.6)	
Side operated, left:right			0.8
THA	50: 65 (43%: 57%)	42: 51 (45%: 55%)	
TKA	17: 18 (49%: 51%)	12: 9 (57%: 43%)	
Pre-existing conditions	*n* (%)	*n* (%)	
Arterial hypertension	37(25%)	32 (28%)	0.5
Asthma	16 (11%)	12 (11%)	1.0
Dyslipidemia	20(13%)	23(20%)	0.1
Type 2 diabetes	5 (3%)	9 (8%)	0.1
Sleep apnea	6(4%)	2 (2%)	0.5
Hypothyroidism	5 (3%)	10 (9%)	0.06
Migraine	3 (2%)	1 (0,9%)	0.6
Previous orthopedic surgery	53(35%)	40 (35%)	1.0
History of cancer	4 (3%)	5 (4%)	0.5
Spine injury with or without surgery	6 (4%)	10 (9%)	0.1
Heart disease	8 (5%)	10 (9%)	0.3
Renal disease	5 (3%)	3 (3%)	1.0
Urinary system impairment	3 (2%)	2 (2%)	1.0

SD: standard deviation from the mean.

Table 2
Complications rates per group according to Clavien-Dindo classification.

Complication	Control ($n = 150$)	ERAS short-stay ($n = 114$)	p-value
Grade 1			
Pain	67%	13%	< 0.001
Nausea	42%	12%	< 0.001
Vomiting	25%	1%	< 0.001
Dizziness	15%	4%	0.006
Headache	4%	0%	0.04
Constipation	8%	0%	0.002
Hypotension	26%	11%	0.003
Anemia (HB < 80)	8%	0%	0.002
Edema of the operated limb	9%	1%	0.005
Persistent lameness	4%	0	0.04
Ecchymosis	5%	0	0.011
Pruritic requiring medication	3%	0	0.072
Hematoma	3%	0	0.072
Fall without consequence	3%	5%	0.539
Grade 2			
Urinary retention	13%	4%	0.006
Anemia with transfusion	8%	0%	0.002
Deep vein thrombosis	3%	0	0.072
Stitch abscess	2%	0	0.261
Cellulitis	1%	1%	1.0
Sciatic nerve palsy (temporary)	1%	0	0.507
Grade 3			
Deep infection	0.7%	0.9%	1.0
Grade 4			
Severe respiratory depression	0.7%	0	1.0
Grade 5			
Death	–	–	

7. Discussion

Shorter hospital LOS after THA and TKA increases bed availability in a restricted environment and is favorable economically for the care provider. One attractive option to reduce hospital LOS is to follow ERAS principles to optimize patient recovery, minimize the complications [28,29] and overall, to improve patient experience to a level where they will feel confident to return home earlier [8]. In our study, we showed that the implementation of our ERAS short-stay protocol was linked to a significant reduction in the complication rate by 50% (0.6 vs 1.2, $p < 0.001$) while achieving outpatient THA and < 24 h hospital LOS for TKA. Furthermore, our ERAS short stay program lowered direct health care costs compared to the standard inpatient procedure.

Our study presents limitations. This is a cohort study with a historical comparison group that can introduce a selection bias. However, by using the same inclusion/exclusion criteria in selecting patients, our two groups had similar patient characteristics, with no significant difference except for the short-stay group being older. In theory, being older would be a potentially negative factor for this group's results. The use of a retrospective cohort also implies that the search for efficacy measures such as adverse events was carried out from a file review and not prospectively as in the experimental cohort. It is likely that this minimized the number of real events. This, again, would have a negative impact on the results of the ERAS short-stay group. Another limitation is that the occurrence of perioperative complications was recorded, and not their frequency, intensity, or duration. However, this was done for both groups. Although there might be many different alternatives to the selected interventions in the study, the results of our study represent this unique combination. Specific weight effect of each measure cannot be determined or extrapolate from our data. We are linked to the results of a multimodal approach [30].

Our ERAS protocol was very efficient at reducing frequent patient's complication like pain, nausea, vomiting, dizziness, headache, constipation, hypotension, anemia, edema, lameness, and urinary retention ($p < 0.001$–0.04). Many interventions differences may explain our improved results with the ERAS short-stay protocol versus our historical standard practice (Supplementary material

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Table 3
Number of patients without complication or with multiple occurrences according to the Clavien-Dindo Classification.

Clavien-Dindo grade	Number of complications	Control group ($n = 150$)	Short-stay group ($n = 114$)	p-value
Grade 1	0	15 (10%)	58 (51%)	< 0.001
	< 3	60 (40%)	51 (45%)	
	3 to 5	63 (42%)	5 (4%)	
	> 5	12 (8%)	0 (0%)	
Grade 2	0	112 (75%)	107 (94%)	< 0.001
	< 3	37 (25%)	7 (6%)	
	3 to 5	1 (1%)	0 (0%)	
	> 5	0 (0%)	0 (0%)	
Grade 3	0	147 (98%)	109 (96%)	0.3
	< 3	3 (2%)	5 (4%)	
	3 to 5	0 (0%)	0 (0%)	
	> 5	0 (0%)	0 (0%)	
Grade 4	0	149 (99%)	114 (100%)	–
	< 3	1 (1%)	0 (0%)	
	3 to 5	0 (0%)	0 (0%)	
	> 5	0 (0%)	0 (0%)	
Grade 5	0	150 (100%)	114 (100%)	–

NB: if a patient had more than 1 event and in different categories, the events were counted individually.

S1). First, the important variations and the unsystematic approach of regular clinical practice involving multiple professionals may not provide the best treatment options for all patients. Secondly, our ERAS protocol was built with specific interventions aiming to prevent the most common post-operative complications. Of particular interest to us, were the complications of pain, nausea, and dizziness as these complications impact a patient's ability to be discharged [31–33]. The rates of these complications in our control group were similar to those reported by others [34–36] while the rates in the ERAS short-stay group were significantly lower.

7.1. Pain control

We believe the lower rate of pain control problem in the ERAS group may be attributed to the use of a multimodal approach including a pre-emptive medication cocktail, dexamethasone, an epidural-sedation anesthesia combination, LIA, and tourniquet avoidance for TKA. Minimizing opioids and sedatives is a protection to prevent dramatic event as the severe respiratory depression secondary to opioid overdose in the control group (grade 4 complication) which required a resuscitation intervention.

7.2. Gastro intestinal function

Multimodal approach including an improved pre-surgery feeding protocol [10], dexamethasone, aprepitant, scopolamine patch, opioids avoidance and early mobilization may explain the lower nausea, vomiting and constipation rates in the ERAS group.

7.3. Early ambulation motor function

Early function and mobilization are also key factors for success of a short stay program. Avoiding autonomic disturbance like orthostatic hypotension prolonged motor block linked to spinal anesthesia [37], quadriceps weakness linked to peripheral nerve blocks [38] and reducing knee hematoma formation by keeping the knee flexed in the postoperative period were also potentially helpful [24]. The combined epidural/sedation anesthesia technique used in our study with LIA avoid complete motor block. Patients can move their feet during the surgical procedure. When the deep sedation is ceased, patients can do lower limb mobilization in bed and soon stand and walk (2–3 hours after surgery) [18]. In addition, avoiding benzodiazepine use likely improved patient awareness and responsiveness.

7.4. Blood conservation

Pre-operative hemoglobin optimization, systemic tranexamic acid, careful hemostasis, keeping the TKA flexed 3 h postoperative, and adrenaline in the LIA helped minimizing blood loss and avoided the need for transfusion in our ERAS short-stay group [17,19]. Since postoperative hemoglobin level follow up is not easily accessible once at home, avoiding severe anemia is of primary importance when patients are sent home early after surgery.

7.5. Factor of success

To be effective, ERAS protocol should be applied systematically, and a team approach is essential. In most cases, it involves important practice modifications and following a common goal is the key. Moreover, it should simplify postoperative care as much as possible. One example is to favor oral anticoagulant instead of injected ones [39], which avoids the need for self-injection education. Second implementation is to improve wound management by using skin glue to seal the wound: reduced wound discharge, no dressing change needed, patient can shower, no staples to be removed and less superficial infection [40–42] but requires a subcuticular skin closure and 2–3 minutes of glue drying time.

7.6. Costs saving

According to Antoniou et al. [43], the estimated costs for hospitalization in Canada for a THA between 1997 and 2001 were approximately 6080 USD for an average LOS of 7.2 ± 4.7 days. The study concluded any reduction in the LOS would have a significant impact on the hospitalization costs for THA or TKA. In our study, the number of hospitalized days decreased by an average of 2.8 days for ERAS short-stay THAs and 3.9 days for the TKAs. The estimated cost reduction linked to the ERAS short-stay resulted in savings of 1489 CAD for THA and 4158 CAD for TKA. Applied broadly systematically, these savings would have a major impact for our hospital environment. The impact on indirect health care costs (time to return to work for example) remains to be evaluated, but nonetheless any reduction of the direct health care costs while insuring similar clinical outcomes is beneficial.

7.7. What is the goal?

In many recent short-stay studies and clinical practices, increasing bed availability by reducing LOS was the main motivating

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factor [44,45]. Success for patients includes improved well-being, improved function, and reduced complication rate. Achieving outpatient surgery is a secondary objective of ERAS. As suggested by Vehmeijerfor et al., 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" [46]. A decreased LOS linked with increased readmission rate, re-operation rate and or post discharge spending would be non-desirable [1–3,47].

8. Conclusions

Our ERAS short-stay protocol for THA and TKA, improved patient outcome by reducing the adverse event rate by 50% compared to the standard procedure while achieving a hospital LOS below 24 h. In addition, this protocol was linked to a significant cost-by-case reduction for our institution. It is an all win situation.

Disclosure of interest

P-AV reports consultancy for Medacta, Microport, Stryker and Ethicon; grants from Medacta, Ethicon, Stryker and Zimmer; payment for lectures including service on speakers' bureaus from Medacta, and Stryker and Ethicon; royalties from Microport for Profemur and Preserve femoral stem; and payment for development of education presentations from Ethicon and Johnson and Johnson for Project Move, a day surgery program, all outside the submitted work.

VM reports consultancy for Zimmer; grants from Medacta, Ethicon, Stryker and Zimmer; payment for lectures including service on speakers' bureaus from Stryker and Zimmer, all outside the submitted work.

ML reports consultancy for Microport and Zimmer; grants from Medacta, Ethicon, Stryker and Zimmer; payment for lectures including service on speakers' bureaus from Zimmer; royalties from Microport for Profemur and Preserve femoral stem, all outside the submitted work.

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Contributors

PAV, KP, LFF were involved in study design, data collection, data analyses and drafting of the manuscript. FD, VM, ML, CL, JF were involved in study design and reviewing of the draft manuscript. PAV was the senior author and responsible for the final manuscript version. All authors have approved the final article.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.otsr.2019.08.013.

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