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In-Hospital Cost Analysis of Total Hip Arthroplasty: Does Surgical Approach Matter?

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ABSTRACT

The purposes of this study were to determine the impact of surgical approach on costs of total hip arthroplasty (THA) from a hospital perspective and to provide an updated cost estimation of THA. A prospective, microcosting analysis was performed on 118 patients undergoing a THA through an anterior, lateral, or posterior approach. We determined that overall costs (intraoperative costs and hospital stay) were significantly less for the anterior ($7300.22; 95% confidence interval [CI], 7064.49-7535.95) vs lateral ($7853.10; 95% CI, 7577.29-8128.91; $P =$ .031) and anterior vs posterior approach ($8287.46; 95% CI, 7906.42-8668.51; $P < .001$). A reduction in hospital length of stay when THA was performed through an anterior approach contributed significantly to an overall reduction in costs from a hospital perspective.

The disease burden of hip osteoarthritis continues to rise, largely attributable to improved management of chronic diseases and prolonged life expectancy [1]. The increasing prevalence of hip arthritis may overwhelm the available resources within health care systems to treat this debilitating condition. Despite the substantial financial resources consumed by total hip arthroplasty (THA) within any health care system, few studies have provided accurate cost estimations of this procedure [2,3].

In the United States, more than 300 000 THAs are performed annually [4]. In Canada, more than 40 000 THAs were performed in 2013, a number that is expected to rise gradually over years to come [5]. There are pressures to produce the best clinical outcome, while remaining fiscally responsible. Cost analyses have been used in the realm of THA to assess bearing surfaces, implant fixation, and new prosthetic designs [6–8]. Surgical approach may have an impact on costs for THA; however, it has never been evaluated using a rigorous, cost-analysis process.

Surgical approach in THA has been an area of interest in the orthopedic literature over the past decade. Many studies have examined the impact of surgical approach on multiple outcome measures including patient reported outcomes, hospital metrics such as operating room time and hospital length of stay (LOS), and tissue trauma analysis through cadaveric and imaging studies [9–14]. Several studies suggest that the anterior approach reduces LOS and promotes earlier restoration to function postoperatively [10,11,15,16]. However, whether the reduction in days spent in hospital translates into a cost reduction for the procedure has not been elucidated.

Our institution's early anecdotal experience with the anterior approach suggested that there was a significant reduction in hospital LOS compared with THAs performed through a posterior or lateral approach. Many of the studies reporting the impact of surgical approach on LOS in hospital have mixed methodologies (ie, case series and retrospective and prospective comparisons). The objectives of the current study were as follows:

1) To determine if surgical approach for THA causes significant differences in various hospital metrics such as operating room time and hospital LOS
2) To determine if there are significant cost differences for THA depending on which surgical approach is used
3) To provide an updated estimation of the cost of THA from a single academic institution

Methods

Patients meeting enrollment requirements were recruited consecutively from the clinics of 1 of 3 fellowship-trained arthroplasty surgeons at our institution after research ethics board approval was obtained. Participating surgeons performed only 1 of 3 surgical approaches to the hip: anterior (B.L.), posterior (J.H.), and lateral (E.V.). Informed consent for THA was attained for those patients whose hip arthropathy was deemed most appropriately treated with surgical intervention.

Patients were included if they consented to THA performed through either an anterior, posterior, or lateral approach; were 19 years or older; and did not meet any of the exclusion criteria. Patients were excluded if the body mass index (BMI) was greater than 40 kg/m^2; they had any

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previous hip surgery or cemented THA, bilateral THA cases, or decisions to change implants other than those standardized for the study; they were non–English speaking patients; they had cases performed by trainees (residents or clinical fellows); or they had hip arthropathy due to Legg-Calve-Perthes disease, slipped-capital femoral epiphysis, developmental dysplasia of the hip, or posttraumatic or inflammatory arthritis. Demographic characteristics including patient age, sex, and BMI at enrollment were recorded. The Charlson Comorbidity Index was calculated preoperatively to ensure that our cohorts were similar with regard to their risk of perioperative complications [17]. The primary diagnosis causing hip arthropathy was determined based on patient history and radiographic analysis.

Surgical technique

The anterior approach was performed using a modified Hueter approach [18]. The patient was positioned supine on a specialized operating table (Hana fracture table; Mizuho OSI, Union City, California). All anterior approaches were performed using a general anesthetic. The posterior approach used the technique popularized by Moore [19]. Either a general or spinal anesthetic was based on the discretion of the anesthetist and the patient. Finally, the lateral approach was performed using the technique described by Hardinge [20]. The anesthetist and the patient determined the type of anesthesia used. A detailed outline of each surgical approach technique can be found in a recently published article by the authors [21]. All patients received a periarticular anesthetic injection of either ropivicaine with morphine and ketorolac, or plain ropivicaine if there were contraindications to nonsteroidal anti-inflammatories, prior to wound closure.

A single surgeon was designated to perform every case using the surgical approach of their expertise. There were no cases performed by trainees (ie, residents or fellows). Each patient received standardized implants: a collared, hydroxyapatite-coated, cementless femoral stem (Corail stem; DePuy Orthopaedics Inc, Warsaw, Indiana), a cementless acetabular cup (Pinnacle Sector II acetabular cup; DePuy Orthopaedics Inc), a highly cross-linked polyethylene liner (AltrX polyethylene liner; DePuy Orthopaedics Inc), and a cobalt chrome femoral head (Articul/eze cobalt chrome; DePuy Orthopaedics Inc). Cancellous screws (DePuy Orthopaedics Inc) were inserted in order to augment acetabular fixation at the surgeon's discretion.

Cost analysis

All costs were acquired prospectively using a microcosting method reported in 2013 Canadian dollars [22]. The cost analysis was from the perspective of a public health care payer (Ontario Ministry of Health).

The total cost of the operating room time was calculated from the moment patients entered the room to the time they left the room to recover in the postanesthetic care unit (PACU). A per-minute direct and indirect operating room cost was acquired from the costing department at our institution. Costs applicable to the billing surgeon and anesthetist were acquired through the Ontario Ministry of Health's schedule of benefits [23]. The Inventory Control Clerk for our institution provided the cost of implants and operating room supplies such as drapes and sutures. The procedure time, which was time from the skin incision to wound closure, was also recorded.

There were some items that were used specifically for the anterior approach. Intraoperative fluoroscopy was monetized on a per-minute basis, capturing the direct and indirect costs of the technician and use of the C-arm fluoroscopic machine. The cost of the radiologist reading the film postoperatively was acquired from the Ontario Ministry of Health's schedule of benefits [23]. Lead aprons were required during all anterior approach procedures in order to protect against fluoroscopic radiation. The cost of each lead apron was distributed on a per-case basis using 1 year as the longevity of the item.

The traction table (Hana fracture table; Mizuho OSI) was also incorporated into the final cost based on 5-year longevity, as recommended by the manufacturer.

After each operation, the patient was transferred to the PACU. Patient care and resource use costs in the PACU were represented on a per-minute basis in consultation with the London Health Sciences Centre costing department. The length of each PACU admission was determined as the time leaving the operating room to the time of admission to the inpatient ward. This information was gathered from paper and electronic chart review.

After discharge from the PACU, the patient was admitted to the inpatient orthopedic ward. Each patient received 24 hours of postoperative antibiotics. Dalteparin or rivaroxaban was used for prophylaxis against deep vein thrombosis. Analgesia was managed by our institution's acute pain service. Narcotic consumption (acetaminophen-tramadol, acetaminophen-oxycodone, hydromorphone) was recorded during the hospital stay. All patients were permitted to weight bear as tolerated with the use of a gait aid as needed. All patients received standardized, unblinded physiotherapy in accordance with our institution's hip arthroplasty discharge pathway.

Nursing care costs were based on an average hourly wage. Administered medications, care items (ie, dressing changes and urinary catheterizations), and investigations performed were recorded from paper and electronic chart review prospectively throughout each patient's hospital stay. These costs were acquired from the costing department and pharmacy. The Ontario Ministry of Health's schedule of benefits was used to determine costs for consultations from other physicians (ie, acute pain services, internal medicine, infectious diseases, and radiology) [23]. Allied health resources such as physiotherapy, occupational therapy, and social work were assigned a per-hour cost based on information from the costing department. The time allotted for each allied health assessment was retrieved from paper chart review. Clearance for discharge occurred when patients met all required milestones outlined in our institution's THA discharge pathway. Our institution's target time to discharge for THA is postoperative day 2. The total LOS in hospital, including time in the operating room, was recorded from the patient's electronic chart. The in-hospital costs were dependent on time spent in day surgery preoperatively and time spent in PACU, plus time on the inpatient orthopedic ward.

Complications occurring in-hospital and after discharge were recorded up to 3 months postoperatively. Any readmissions and care occurring after discharge were not included in the cost analysis, as this would change the perspective of the analysis.

Statistical analysis

The association between the anterior, posterior, and lateral approaches was evaluated by means of a nonparametric Pearson χ^2 for categorical data. A 1-way analysis of variance (ANOVA) was performed for continuous demographic variables such as age and BMI.

A 1-way ANOVA was used to compare the various hospital metrics and cost data of the 3 surgical approaches, including operating room time, operating room costs, in-hospital costs, hospital LOS, and total costs of the procedure. Post hoc analysis was performed using the Scheffé test to determine significant differences between the groups when necessary. Statistical significance was set at $P < .05$. The SPSS v.22 (SPSS Inc, Chicago, Illinois) was used for all analyses.

Results

A total of 178 consecutive patients were referred to the 3 study surgeons during the recruitment period. After exclusions, 118 patients were enrolled in the study (Figure). Patient demographics were similar across all 3 cohorts (Table 1). All patients had complete intraoperative and in-hospital cost data.

There were statistically significant differences between the groups for procedure time and total time in the operating room (Table 2).

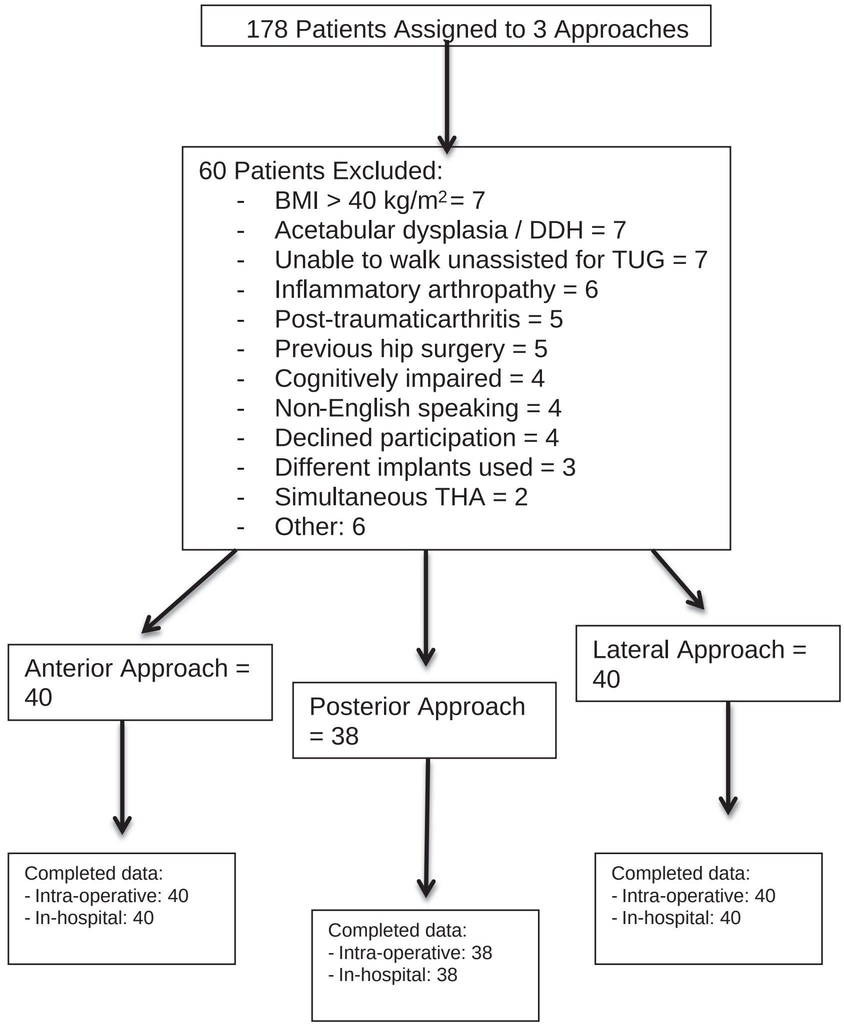

Figure. Schematic outlining patient recruitment and exclusions.

Table 1
Patient Demographic Data.

Demographic	Anterior Approach	Posterior Approach	Lateral Approach	*P*
Age (y)				
Mean	66.9	66.7	65.5	.79
SD	9.5	9.2	10.4	
Range	42-86	44-84	42-92	
Sex				
Female	25	24	26	.97
Male	15	14	14	
BMI (kg/m^2)				
Mean	27.9	28.2	29.1	.54
SD	4.3	5.3	5.6	
Range	20.8-36.4	16.2-39.9	19.9-39.9	
Operative side				
Left	22	18	18	.65
Right	18	20	22	
Primary diagnosis				
Osteoarthritis	37	33	38	.42
Avascular necrosis	3	5	2	
Age-adjusted Charlson Comorbidity Index				
Mean	3.0	2.9	2.7	.78
SD	1.9	1.4	1.4	

P values are for 1-way, between-group ANOVA.

Post hoc testing demonstrated significantly shorter procedure time for the lateral vs anterior and posterior approach ($P \le .001$ and $P < .001$, respectively). The procedure time was also significantly shorter for the posterior vs anterior approach ($P = .005$). Total time in the operating room was significantly shorter for the lateral vs anterior and posterior approach ($P < .001$ and $P = .008$, respectively).

There were statistically significant differences between the groups for both operating room time costs and total procedural costs (Table 3). Post hoc testing determined that the cost of the operating room time was significantly less for the lateral vs anterior and posterior approach ($P < .001$ and $P = .008$, respectively). The total cost of the procedure was significantly less for the lateral vs anterior and posterior approach ($P < .001$ and $P = .001$, respectively), and the posterior vs anterior approach ($P = .008$).

There were also statistically significant group differences for hospital LOS, as well as associated inpatient costs (Table 4). Post hoc testing revealed a statistically significant shorter LOS for the anterior vs posterior and lateral approach ($P < .001$ for both pairwise comparisons). Length of stay was comparable between the posterior and lateral approach ($P = .95$). The total inpatient costs were significantly less for the anterior vs lateral and posterior approach ($P < .001$ for both pairwise comparisons). Total inpatient costs were similar between the posterior and lateral approach ($P = .73$). Pharmaceutical costs were similar between the 3 cohorts. Patients in the anterior approach group consumed significantly

Table 2
Intraoperative Procedure Time and Total Time in OR.

	Anterior Approach, Mean (95% CI)	Posterior Approach, Mean (95% CI)	Lateral Approach, Mean (95% CI)	*P*
Procedure time (min)	69.3 (66.1-72.6)	61.6 (57.6-65.5)	49.0 (46.4-51.5)	<.001
Total time in OR (min)	105.7 (101.9-109.4)	99.6 (93.6-105.5)	87.7 (81.7-93.7)	<.001

P values are for 1-way, between-group ANOVA.
OR, operating room.

fewer narcotics (mean, 8.7 tablets; 95% confidence interval [CI], 7.0-10.4) than the posterior (mean, 15.6 tablets; 95% CI, 12.2-19.0; $P < .001$) and lateral cohorts (mean, 19.4 tablets; 95% CI, 16.1-22.6; $P < .001$).

Finally, there were statistically significant differences between the 3 surgical approaches for total THA costs (Table 5). The anterior approach cost significantly less than both the posterior and lateral approach after post hoc testing ($P < .001$ and $P = .031$, respectively). The difference in costs between the lateral and posterior approach was not significant ($P = .12$).

Table 6 provides a summary of the complications documented across all 3 cohorts. There was a statistically significant difference in the number of nerve palsies observed in THAs performed through an anterior vs lateral or posterior approach ($P = .001$). All 7 cases were injury to the lateral femoral cutaneous nerve resulting in symptomatic paresthesias. All cases were managed expectantly with no additional medications, therapy, or investigations.

A single case of periprosthetic infection occurred in the anterior approach group. The patient was a 72-year-old man with a BMI of 35.56 kg/m^2 and a primary diagnosis of avascular necrosis. The infection was diagnosed 18 days postoperatively. The patient was admitted to hospital and treated with removal of the femoral stem, femoral head, and polyethylene liner, irrigation, and debridement, followed by implantation of a new Corail femoral stem, cobalt chrome femoral head, and highly cross-linked polyethylene liner. Intraoperative cultures grew *Staphylococcus epidermidis*. He received a 6-week course of intravenous cefazolin through a peripherally inserted central catheter. His latest erythrocyte sedimentation rate and C-reactive protein were 8 mm/h and 0.9 mg/L, respectively, 3 months after the irrigation and debridement.

The periprosthetic fracture occurred in a lady after a fall from standing height onto the operative hip 11 weeks postoperatively. Plain radiographs diagnosed a minimally displaced Vancouver A_L periprosthetic fracture. The fracture was treated nonoperatively with weight-bearing restrictions and went on to heal without further complication.

The wound complication in the anterior approach group was a stitch abscess diagnosed 4 weeks postoperatively. It was successfully treated with an incision and drainage, community dressing changes, and 2 weeks of oral cephalexin. The patient in the lateral approach group had a small dehiscence of the proximal aspect of their incision that required routine local wound care. This patient received 10 days of oral cephalexin and required no further intervention.

The complications occurring in the “Other” category were intraoperative injuries in the anterior approach group. One patient sustained an ipsilateral knee sprain during limb manipulation using the Hana fracture table. A postoperative radiograph ruled out fracture around the knee, and a magnetic resonance imaging did not identify any intra-articular or soft tissue injury. The patient was successfully treated with rehabilitation. The second case was an intraoperative ankle sprain also sustained during limb manipulation. Plain radiographs did not identify any fracture, and this patient also recovered well with rehabilitation.

Discussion

The purposes of this study were to determine the impact of surgical approach on costs associated with a THA from the perspective of the payer and to provide a precise cost estimate of the procedure. The total cost of a THA was significantly less when performed using an anterior vs posterior or lateral approach. The mean cost savings per case when compared with the lateral and posterior groups amounts to approximately $550 to $1000, respectively. Over the course of a calendar year, that would amount to significant cost savings to a hospital.

Our study is not without limitations. First, the lack of randomization does introduce selection bias and the risk of committing a type 1 error. However, our groups were homogenous across many independent variables (age, BMI, sex distribution). Second, the generalizability of the data can be questioned. The cost data are taken from a single academic institution within a publically funded health care system, which would undoubtedly vary from one hospital to another and one health care model to another. Third, the anterior approach was performed using a specialized traction table and intraoperative fluoroscopy, and all patients received a general anesthetic. Several authors have demonstrated that this approach can be performed without the use of a specialized table or intraoperative fluoroscopy, which may have reduced costs even further [24–26]. Fourth, a single surgeon from a single academic institution performed each surgical approach. Undoubtedly, other surgeons may use different instrumentation (ie, the traction table for the anterior approach) or use different steps from outlined in our study (ie, retractor choice, trialing, and wound closure), thus reducing the external validity of the study. A difference in surgeon workflow introduces performance bias, which impacts not only procedure time but also the overall cost of the procedure. Fifth, the cost data are also presented using a small sample of patients with hip arthritis. Operating room time and LOS in hospital may vary for other primary diagnoses, such as inflammatory arthropathy, posttraumatic arthritis, or developmental dysplasia of the hip [27]. Finally, physiotherapy assessments and treatment were unblinded. This could have introduced expectation bias, thus influencing LOS in hospital. However, weight-bearing status and discharge milestones were standardized as per our institution's discharge pathway, again emulating our institution's routine practice.

Our study has several strengths. To our knowledge, this is the first study examining the impact surgical approach has on costs associated with THA. The prospective, microcosting method ensured that cost data were captured accurately with a high level of precision. This data

Table 3
Operating Room Costs.

	Anterior Approach	Posterior Approach	Lateral Approach	*P*
Cost of operating room time (2013 Canadian dollars)				
Mean (95% CI)	1729.90 (1668.14-1791.66)	1629.92 (1532.29-1727.55)	1435.24 (1336.83-1533.65)	<.001
Range	1407.82-2062.62	1145.90-2553.72	965.83-2259.06	
Total cost of procedure (2013 Canadian dollars)				
Mean (95% CI)	5799.79 (5718.52-5881.06)	5560.24 (5439.42-5681.05)	5274.39 (5158.55-5390.24)	<.001
Range	5412.19-6432.15	4959.43-6577.39	4735.21-6223.16	

P values are for 1-way, between-group ANOVA.

Table 4
Inpatient LOS and Associated Costs.

	Anterior Approach	Posterior Approach	Lateral Approach	*P*
Hospital LOS (h)				
Mean (95% CI)	33.9 (29.6-38.2)	65.8 (56.7-74.8)	64.2 (56.7-71.7)	<.001
Range	24.9-98.4	29.1-171.4	30.5-144.8	
Total cost of inpatient stay (2013 Canadian dollars)				
Mean (95% CI)	1500.43 (1281.80-1719.05)	2727.22 (2394.38-3060.07)	2578.71 (2338.40-2819.01)	<.001
Range	1099.06-4994.27	1255.88-5865.66	1625.95 - 5008.66	
Pharmaceutical costs (2013 Canadian dollars)				
Mean (95% CI)	94.21 (82.57-105.85)	89.08 (76.87-101.30)	91.08 (78.96-103.20)	.97
Range	44.77-243.19	36.94-261.23	21.87-239.02	

P values are for 1-way, between-group ANOVA.

study can provide a reference for gross-costing analyses in future cost-effectiveness analyses. Standardizing the implants and thus standardizing the cost of the implants eliminated the tremendous variability in implant costs from influencing the results [28]. The detailed analysis regarding intraoperative time and inpatient LOS will help decision makers determine where they can invest resources in order to improve efficiency within their own institution.

Some of the purported disadvantages of the anterior approach are the added costs associated with using a specialized operating room table, such as the Hana fracture table in this study, as well as costs of using intraoperative fluoroscopy. These factors, along with prolonged mean operating room time, contributed to increased procedural costs observed in the anterior group. Hospital administrators may be reluctant to implement such a procedure due to the expensive up-front costs of the specialized table ($120 000 in 2013 Canadian dollars). However, the anterior approach can be performed safely without the use of a specialized table and intraoperative fluoroscopy [24,29]. Increased operating room time has been reported in other studies when comparing the anterior approach to other surgical approaches [10,11]. Therefore, administrators must decide if the benefits of a reduced hospital stay and reduced overall cost of this approach outweigh the potential for completing fewer cases, or running the risk of paying hospital staff overtime for prolonged cases. However, we have not observed a reduction in the number of cases when a THA is performed through an anterior approach, or a difference in the total length of each operative day.

A significant reduction in hospital LOS for the anterior approach cohort translated into significant cost savings overall from a hospital perspective. Several other studies have found that having a THA performed through an anterior approach results in a significant reduction in days spent in hospital [10,11,15,16]. Reasons for earlier discharge may include reduced postoperative pain, earlier restoration of more normalized gait, less reliance on assistive devices, decreased muscle trauma, and sparing of the abductor complex [12,13,15,30,31]. Our study supports the claim of reduced postoperative pain due to the significant reduction in narcotic consumption in the anterior approach group. However, we did not standardize our postoperative pain regime; thus, group differences could be because of patient characteristics and the effectiveness of other secondary analgesics (nonsteroidal anti-inflammatories, neuroleptic agents).

Therefore, to reduce costs, hospital administrators need to look at either improving operating room efficiency or reducing the number of days patients spend in hospital. Examining the data closely, approximately 40 minutes was spent in the operating room not operating on patients. This time would include time to administer and reverse the anesthetic, and patient positioning. The literature suggests that dedicated operating room units (ie, anesthesia and nursing staff facile in a certain procedure) can reduce operating room time and patient turnover [32]. Time spent waiting in the operating room due to patient turnover incurs tremendous costs, as the per-minute rate for the operating room is substantially higher than that of the PACU or orthopedic ward. Also, dedicated rehabilitation protocols for specific procedures such as THA have been shown to reduce LOS [33]. A study by Poehling-Monaghan et al [34] demonstrated that when patients undergoing a THA through an anterior or posterior approach were subjected to a rapid rehabilitation protocol, both groups demonstrated no difference in LOS. Thus, the aggressiveness and standardization of physiotherapy is likely a profound confounding variable in LOS discrepancies between the surgical approaches reported in the literature.

There was a difference in complication rates observed between the approaches. Nerve palsies of the lateral femoral cutaneous nerve were consistent with rates reported in the literature for the anterior approach [35]. These cases were managed expectantly with no added intervention or costs. There was one readmission during the study period in the anterior approach group. Although we did not review post–acute care costs in this study, this is an important future direction. Outpatient costs are variable across regions and health care systems, and we plan on reporting prospectively collected outpatient costs in our cohort. These data will certainly influence decisions to choose a particular approach for at-risk patients (ie, avoiding the anterior approach in patients with substantial truncal obesity) in order to minimize complications and escalating outpatient care costs [36].

Conclusion

Total hip arthroplasty continues to be the cornerstone treatment modality for painful and functionally debilitating hip arthritis. To our knowledge, this is the first study of its kind performing a cost analysis on the effect of surgical approach for THA. The costs of a THA performed through an anterior approach are less than a posterior or lateral approach cohort from the perspective of the payer. The prospective, microcosting method used in this study provided accurate data that will prove useful in future cost-effectiveness analyses. Although the generalizability of the data can be questioned, the principles of cost reduction remain the same, as variables such as operating room time and LOS in hospital are universal. Future directions include capturing outpatient cost data with long-term effectiveness measures (ie, quality-adjusted life years) in order to perform a cost-effectiveness analysis from a societal perspective.

Table 5
Surgical Approach and Total Cost of THA.

	Anterior Approach	Posterior Approach	Lateral Approach	*P*
Total cost of THA (2013 Canadian dollars)				
Mean (95% CI)	7300.22 (7064.49-7535.95)	8287.46 (7906.42-8668.51)	7853.10 (7577.29-8128.91)	<.001
Range	6657.86-10 677.25	6797.83-12 443.05	6587.21-10 206.72	

P values are for 1-way, between-group ANOVA.

Table 6
In-Hospital and Post-Discharge Complications.

	Anterior Approach (n = 40)	Posterior Approach (n = 38)	Lateral Approach (n = 40)	*P*
In-hospital complications				
Blood transfusions	0	2 (5.0%)	0	.148
Deep vein thrombosis	0	0	0	N/A
Pulmonary embolus	0	1 (2.7%)	0	.332
Other	2 (5.0%)	0	0	.148
Postdischarge complications				
Nerve palsy	7 (17.5%)	0	0	.001
Dislocations	0	0	0	1.000
Periprosthetic infections	1 (2.5%)	0	0	.388
Periprosthetic fracture	0	1 (2.7%)	0	.332
Wound complications	1 (2.5%)	0	1 (2.5%)	.628

N/A, not applicable.

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