



One-Stage Bilateral Total Hip Replacement is Cost-Saving

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Abstract

Many patients suffer from bilateral hip disease. For these patients two-stage bilateral total hip replacement (THR) is more common than a one-stage procedure because of fear of complications associated with one-stage surgery. However, many studies are in favour of one-stage bilateral THR in healthy and young patients.

We investigated costs, complications and patient-reported outcome related to one-stage bilateral THR. Unilateral THR was used as a reference. Thirty-two patients with one-stage bilateral THR were prospectively followed for six years (bilateral group). A matched reference population of 32 patients with unilateral THR was assembled (unilateral group). Medical records, individual data from the Swedish Hip Arthroplasty Register, the Swedish Social Insurance Administration and local data on cost per patient were used for the analyses. For non-retired patients, the duration and costs for sick leave during the first postoperative year were similar in both groups. The rate of complications and their severity were similar in both groups. Using cost data from this study in a theoretical model, comparing one- and two-staged procedures showed a 24% reduction in hospital and sick-leave costs in favour of the one-stage procedure. Our results indicate that the one-stage procedure is cost-saving compared to two-stage procedures for patients with indication for bilateral THR.

Keywords: One-stage bilateral total hip replacement; Patient-reported outcome measure; Health economic evaluation; Two-stage bilateral total hip replacement

Introduction

A substantial proportion of patients with hip disease suffer from a bilateral condition [1] and approximately 20% of all THR patients undergo surgery on the contralateral hip at some point [2]. Among all patients eligible for THR, the prevalence of a bilateral hip disease that meets the indication for surgery on both hips at a time is not known. In Sweden, less than 5% of all bilateral THRs are performed as one-stage procedures [2]. One major concern is the fear of complications associated with one-stage surgery [3]. However, most studies are in favour of a one-stage bilateral procedure in the healthy and younger THR population [4-12]. The reluctance concerning the one-stage procedure could partly be because lack of evidence; only one randomized study comparing one- and two-staged procedures has been conducted which showed advantage for one-stage surgery [13]. Attempts to investigate outcome, costs and other consequences for the one-stage procedure have focused on mortality, complications, various intra-operative measurements, length of hospitalization and direct medical costs. As far as we know no previous studies have focused on the indirect costs and health-related quality of life (HRQoL) following one-stage bilateral THR. Optimal allocation of public health care resources to provide maximum output requires valid comparisons of alternative interventions with regard to costs and utility as measured for example as improvement in HRQoL [14]. This study stems from a randomized clinical trial in which 32 patients had one-stage bilateral hybrid THR comparing highly cross-linked polyethylene liner and conventional polyethylene liner. These patients were their own controls [15]. From the same hospital and period we assembled a reference group of 32 patients with unilateral THR to match the one-stage bilateral patients with regard to age, sex, diagnosis, co-morbidity, type of implant and postoperative regime. This model assumed that each unilateral THR represented the first operation of a two-stage procedure. Patient-reported outcome measures (PROMs) are presented descriptively since the interventions were not compared with regard to these results. We calculated both direct medical and indirect non-medical costs for the two procedures.

Patients and Methods

We used the population from a randomized clinical trial and a matched control population from the same hospital. The study population consisted of 32 patients (21 women; 64 hips), mean age 51 (29-70) years, with bilateral primary or secondary osteoarthritis of the hip [15]. Patients with bilateral hip disease with indication for THR on both sides were recruited to that study. Medical contraindications for surgery were assessed according to ordinary local routines. The study protocol was approved by the Local Ethical Review Board in Gothenburg (decision S 257-00) and it was conformed to the Helsinki Declaration. This cohort received one-stage bilateral THR. The reference population (controls) consisted of 32 patients (20 women; 32 hips), mean age 51 (34-66) years with unilateral hybrid THR performed during the same time period as the one-stage bilaterally-operated patients. Matching by age, sex, co-morbidity, and diagnosis one unilateral control patient was selected for each bilateral patient using a hospital database including 129 possible patients (Table 1).

Surgical methods and rehabilitation

All patients in both groups received hybrid THR (cemented stem and cementless cup; the same implants were used for all patients) and surgery was performed in a lateral position through an anterolateral, transgluteal approach. One-stage bilateral surgery started on the most painful side. After closing the wound on first side, patient was

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		One-stage bilateral	Unilateral control	p-value ¹
Number of patients	Patients (hips)	32 (64)	32 (32)	NA
Sex	Male/Female	11/21	12/20	0.79
Age	Median years (range)	51 (29 – 70)	51 (34 – 66)	0.87 ²
ASA score (1 – 5)	I	21	20	0.58
	II	10	9	
	III	1	3	
Charnley class	A	0	15	0.58 ³
	B	24	7	
	C	8	10	
Diagnosis	Primary osteoarthritis	18	18	0.92
	Rheumatoid arthritis	1	1	
	Childhood hip disease	8	9	
	Avascular necrosis	3	2	
	Other secondary osteoarthritis	2	2	

¹Two-sided Pearson Chi-square tests were used if not other indicated

²Mann Whitney *U* test

³Charnley class A and B were grouped for statistical testing

Table 1: Demography.

turned over to the other side and dressed before surgery started on the second hip. The patients were mobilized the day after the operation and were allowed as much weight-bearing as tolerated. Postoperative regime, including thromboembolic prophylaxis when they could walk independently.

Data collection and instruments used

Electronic medical records (covering all three public hospitals in the area) were investigated with regard to complications (per- and postoperative up to one year), type of anesthetics, blood loss, number of transfusions, analgesics, operative time and length of hospital stay. Preoperative comorbidity was collected according to the ASA classification. Cost of implants and the time spent in the operating theatre was retrieved from the local patient administration system.

The patients completed a ten item questionnaire including Charnley's functional classes (A, B, and C), a pain visual analogue scale (VAS) ranging from 0 (no pain) to 100 (unbearable pain), and the generic EQ-5D. These measures were employed preoperatively and at one and five to six years postoperatively (hereinafter referred to as 6-year follow up). This PROMs questionnaire is part of a nationwide routine used with all THR patients in Sweden which is approved by the Local Ethical Review Board in Gothenburg (decision S 067-02, 19 March 2002). The EQ-5D is a HRQoL instrument that evaluates subjects in five dimensions, namely mobility, self-care, usual activities, pain/discomfort and anxiety/depression [16]. Each dimension is divided into three levels of increasing severity generating 243 possible combinations of responses. The EQ-5D can be presented as a global health index with a weighted total value (UK tariff used) [17] for HRQoL; the minimum value is -0.594 and the maximum is 1.0. At follow-up patients also completed a VAS addressing satisfaction with the outcome of the hip replacement, ranging from 0 (satisfied) to 100 (dissatisfied). The mean follow-up period was 6.0 (4.8-7.8) years. For the one-stage bilateral patients the questionnaire regarded the overall impact on pain and HRQoL of both hips.

Cost-utility analysis

Cost-utility analysis is a form of cost-effectiveness evaluation that combines utility measurements, such as the HRQoL score, with survival and cost data. The incremental cost of one intervention over another is compared with the benefits, measured by the differing improvement in HRQoL scores. In this study we assessed the quality-adjusted life-years (QALY) gained for both one- and two-stage surgery compared

to a hypothetical non-surgical alternative assuming that patients would remain at the EQ-5D index value at base-line (preoperative) if they had not been operated. When the EQ-5D index is used for cost-utility analysis, all negative values are set to zero. The QALY was estimated using standard area under the curve calculations based on the EQ-5D values at pre-, one and six years postoperatively. Patients were considered to have reached their one-year EQ-5D level by a linear change at six months after the operation, and the change between one and six years also was also considered to be linear.

Costs

For cost calculation we used cost-per-patient databases (CPP), which contain standardized data from Swedish hospitals. Individual CPP values include the total sum of direct medical costs during the hospital stay in conjunction with the operation. However, costs such as rehabilitation after discharge from hospital, are not included. Individual records from the Swedish Social Insurance Administration concerning all 64 patients were collected to analyze the length and cost of sick leave to one year after surgery. The records include individual number of sick-leave days and an individual cost per day.

Cost comparison between one- and two-stage procedures

In order to compare the observed costs for one-stage procedures to calculated costs if the one-stage patients should have had two-stage procedures, a theoretical model was created. To adjust for differences among study and control population, we used the regression function from a multivariable linear regression analysis only including cases from the unilateral control population. This regression function was applied on the one-stage bilateral patients. Thus we determined the individual expected values for the cost with CPP as dependent variable and age, sex, Charnley class (A and B versus C) and diagnosis (OA versus other diagnoses) as independent. This enables an estimation of costs for the theoretical two-stage model using the regression function of observed data from the unilateral control cases. We assumed that the total hospital cost of a two-stage procedure would equal the expected (E) hospital cost of one unilateral operation (Y) multiplied by two.

$$\text{Estimated cost for two-stage bilateral THR} = 2 \cdot E(Y)$$

For calculations of costs associated with productivity loss (indirect costs) we assumed the appropriate interval between the first and second operations of a staged procedure would be 90 days. Thus, sick-leave between the first and the second operation cannot exceed 90 days, but there is no corresponding restriction for the second operation. The

expected number (E) of sick leave days in the two-stage model was calculated from the function below, where z is the observed number of sick days when performed unilaterally.

$$E(\min(z, 90)) + E(z)$$

A logistic regression model was used to assign individual probabilities (P) for sick leave less than 90 days. Age, sex, Charnley class (A and B versus C) and diagnoses (OA versus other diagnoses) were used as independent variables. S represents the linear combination of variables plus a constant obtained by the logistic regression.

$$P = 1 / (1 + e^{-S})$$

The expected sick-leave days for the first 90 days of the period (the period between operations) was calculated from the probabilities according to:

$$P \cdot (\text{mean days if below 90}) + (1 - P) \cdot 90$$

For productivity loss after 90 days (after the second operation), a similar multivariable linear regression function determined from the unilateral control population, as described above, was applied on the one-stage patients. Hereby, the expected number of sick-leave days after the initial 90 day period was calculated, i.e. the number of expected sick-leave days after the second operation. The total cost for sick-leave was then calculated as the product of the total number of expected sick-leave days and the individual observed cost per sick-leave day reported from the Swedish Social Insurance Administration.

Definition of complications

Complications were categorized according to when they occurred (perioperative, before discharge from hospital or during the first postoperative year) and whether they were local or systemic. According to severity, the events were sub-categorized into major and minor complications. Potentially life-threatening complications and those requiring advanced medical or surgical interventions were regarded as major. Any other complication that led to medical treatment or extraordinary observation was regarded as minor. Complications were traced through reviewing the hospital medical records; all visits and admissions to Sahlgrenska University Hospital one year after surgery were reviewed through computerized medical records. All patients had a one-year follow-up visit to an orthopedic surgeon.

Statistics

Comparisons between groups were performed cautiously because the populations and the interventions were not considered similar in all perspectives. Two-tailed probability values (p -value) less than 0.05 were considered significant. The Chi square or the Mann-Whitney U tests were used to evaluate as appropriate any differences between the groups. The non-parametric Wilcoxon Signed Rank Test was used to evaluate differences within a sample. SPSS 17.0 (©SPSS Inc, Chicago, IL) was used for all statistical analyses.

Results

Peri- and postoperative measurements (Table 2)

Central neural axis block was used equally in both groups. Cell-saver was used for all patients with bilateral surgery and for half of the patients in the unilateral group. Tranexamic acid was administered intravenously in most patients. As expected, the mean perioperative blood loss for bilateral patients was twice as high as for the unilateral

patients. Mean surgery time and time spent in theatre for the bilateral group were about double those for the control group.

For the patients in the control group that received blood from cell-saver, the mean transfusion volume was one half of the cell-saver transfusions to the bilateral study group. Postoperative blood loss was estimated by calculating the total amount of blood from drainage. For the bilateral group the mean total blood loss through drainage was 186 mL (bilateral 60-1350, unilateral 0-1400) more than that for the unilateral group. Bilateral patients required on average 1.16 (bilateral 0-5, unilateral 0-4) units more blood transfusion than the unilateral patients did. Mean hospital stay was 2.6 (bilateral 8-18, unilateral 5-17) days longer for the bilateral patients.

Complications (Table 3)

No statistically significant differences in the number of minor or major complications were detected ($p=0.4$ and $p=0.3$ respectively, Chi square test), despite low power. In the bilateral group there was one non-fatal pulmonary embolism and in the unilateral group one patient had recurrent dislocations and subsequent diagnosed deep infection requiring revision surgery.

Patient-reported outcomes measures (Table 4)

All the patients completed a PROMs questionnaire preoperatively and at the one-year follow-up. At the six-year follow-up one patient in the bilateral group and two patients in the unilateral group had died from causes not related to hip surgery. Two patients from the bilateral group and one from the unilateral group did not respond to the six-year follow-up questionnaire.

Bilateral patients reported worse HRQoL and more pain preoperatively. However, they improved by 0.77 units on the EQ-5D index at one year compared to 0.40 units for the unilateral patients. This improvement was maintained at similar levels at the six-year follow-up for both groups. Pain as reported on VAS was reduced by 62 units for the one-stage bilateral patients and by 45 units for the unilateral patients at one year. For pain, the results were maintained at the six-year follow-up. Mean satisfaction VAS was similar in both groups at one year and maintained at the six-year follow-up.

Costs (Table 5)

Medical costs in conjunction with the operation (mean cost per patient) were € 14470 for bilateral surgery and €9060 for unilateral surgery. Mean sick-leave and social insurance administration costs were similar in both groups. Costs do not include expenses related to complications after discharge.

Cost utility aspects (Table 5)

QALYs and cost-per-QALY outcomes were superior for both the bilateral procedure and the unilateral procedure compared to the hypothetical non-surgical alternative.

Cost comparison between one- and two-stage procedures (Table 6)

The regression functions from the analyses of the unilateral cases were used to assign expected CPP and number of sick-leave days for the bilateral patients in a simulated two-stage model. On the assumption that the two-stage bilateral procedure would generate hospital costs equaling those of two unilateral operations, the one-stage bilateral procedure reduced hospital costs by 20%. In the model assuming a 90-day interval between staged procedures, reduction of sick-leave costs was estimated to 30%.

		One-stage bilateral (SD)	Unilateral control (SD)
Anaesthesia	Spinal/epidural	29	29
	General	1	3
	General + spinal/epidural	2	0
Blood loss	Peroperative mL mean	1181 (627)	574 (302)
	Postoperative mL drainage mean	539 (377)	353 (302)
Transfusion	Cell saver used	32	15
	Cell saver transfusion mL mean	344 (196)	172 (126)
	Transfusion units mean	1.63 (1.43)	0.47 (0.98)
Operation	Minutes in operation theatre mean	410 (56)	206 (51)
	Minutes operating time mean per hip	133 (20)	119 (40)
Recovery	Hospital stay mean days	10.2 (2.0)	7.6 (2.1)

Table 2: Surgery measurements.

		One-stage bilateral (n=32)	Unilateral control (n=32)
Perioperative	None	28	28
	Major local <i>Proximal femur fracture</i>	-	1
	Minor systemic <i>Cardiac arrhythmia</i>	-	1
	<i>Anaesthetic complication</i>	3	1
	Minor local <i>Minor surgical complication</i>	1	1
Postoperative	None	29	30
	Major systemic <i>Deep vein thrombosis (clinical)</i>	0	1
	Minor systemic <i>Urinary retention</i>	1	-
	<i>Minor respiratory complication</i>	-	1
	<i>Fever of unknown origin</i>	1	-
	<i>Other infection</i>	1	-
First year postoperative	None	28	27
	Major local <i>Dislocation and deep infection</i>	-	1
	Major systemic <i>Non-fatal pulmonary embolism</i>	1	-
	Minor local <i>Trochanteric pain</i>	3	3
	<i>Superficial wound infection</i>	-	1

Table 3: Complications.

		One-stage bilateral mean (SD) [n]	Unilateral control mean (SD) [n]
Preoperative	EQ-5D index	0.14 (0.21) [32]	0.31 (0.34) [32]
	Pain VAS	70 (11) [32]	62 (17) [32]
1-year postoperative	EQ-5D index	0.91 (0.18) [32]	0.71 (0.32) [32]
	Pain VAS	8 (12) [32]	17 (23) [32]
	Satisfaction VAS	10 (17) [32]	16 (25) [32]
6-year postoperative	EQ-5D index	0.89 (0.23) [29]	0.73 (0.32) [29]
	Pain VAS	7 (14) [29]	21 (26) [29]
	Satisfaction VAS	7 (16) [29]	12 (19) [29]

Table 4: Patient-reported outcome measures.

	One-stage bilateral (interquartile range) (n)(SD)	Unilateral control (interquartile range) (n)(SD)
Hospital costs € (CPP)	14 470 (13 370 – 15 430) (32)(1 510)	9 060 (8 180 – 9 690) (32)(1 400)
Total days off work 12 months	230 (147 – 349) (21)(94)	226 (96 – 365) (19)(122)
Social insurance administration costs €	10 030 (5 790 – 14 840) (21)(5 320)	9 980 (5 380 – 13 380) (19)(6 100)
QALYs gained at 1 year	0.56 (32)(0.18)	0.28 (32)(0.26)
Cost per QALY gained € first year	25 840	32 360
QALYs gained at 6 years	4.14 (29)(1.76)	2.24 (29)(1.99)
Cost per QALY gained € after 6 years	3 495	4 045

Table 5: Costs, sick-leave and QALYs.

	Hospital costs € mean (SD)	Sick-leave costs € mean (SD)	Total costs € mean (SD)
One-stage bilateral THR*	14 470 (1 510)	6 590 (6 460)	21 050 (6 960)
Two-stage bilateral THR†	18 190 (680)	9 410 (8 000)	27 600 (9 160)
<i>Wilcoxon Signed Rank Test</i>	<i>p</i> <0.001	<i>p</i> =0.004	<i>p</i> <0.001

*Based on observed individual values. †For each individual the expected costs were determined by applying regression functions as described in the Patients and methods section.

Table 6: Comparison between one- and two-stage model of bilateral THR procedures

Discussion

In our study, patients eligible for one-stage bilateral THR surgery had worse pre-operative HRQoL and reported more pain than those awaiting unilateral surgery. We found an exceptional gain in patient-reported HRQoL following one-stage bilateral THR. We also found a superior cost-effectiveness for a one-stage procedure compared to a simulated two-stage procedure. Both hospital costs and those for productivity loss were reduced by altogether 24% in this model based on individual cost data. We found no differences in complications between the bilateral group and the unilateral group, although the groups were too small to provide sufficient power for analyzing such diverse and rare events. However, our results tally with those of Parvizi et al. [9] who demonstrated that one-stage bilateral THR is safe in young and healthy patients.

Mc Bryde et al. [18] compared one-staged bilateral hip resurfacing surgery to a two-staged procedure. The one-stage procedure appeared to be beneficial from both the patients' perspective and from an economic perspective, with 35% lower hospital costs for the one-stage procedure. A study with a similar design to ours showed a 24% reduction in hospital costs for one-stage THR compared to a simulated staged, matched procedure using the results from unilateral THR [19].

A comparison of a one-stage bilateral procedure to unilateral surgery could potentially be misleading. The ideal set-up would be to compare one-stage to staged procedures, preferably in a randomized study. For this reason we simulated a two-stage procedure, using data of a regression function from unilateral procedures applied on the one-stage bilaterally operated patients. Thus, the comparison concerns both observed data and individually estimated data for the same patients. Theoretically such a model could include surgery measurements and complications but we concentrated on costs.

One may argue that in a two-stage procedure, both the patient and the surgeon have learned from the first operation. Consequently, the results of the second operation may become better. On the other hand, the advantage of the surgical experience from the first operation is likely to be most evident immediately after the first operation. Hip disease incurs other costs than the direct medical cost and the indirect cost for productivity loss. Non-medical costs such as those for informal care, home-help and other municipality services were not analyzed. It is reasonable to estimate that those costs would also be lower with a shorter total rehabilitation time. One major concern for health care is how to reduce productivity loss and other economic consequences attributable to hip disease. For patients with end-stage bilateral hip disease the one-stage procedure appears to be successful in this respect. Moreover, longer sick-leave is associated with decreased return to work [20], which further supports the one-stage procedure.

Our control group was small. Nevertheless, the matching of the control group was successful. In particular, all the patients underwent surgery at the same centre during the same period using identical implants (except for randomization of different polyethylene liners

in the bilateral group). We acknowledge the presence of disparities in the distribution of Charnley classes between groups. However, those differences were attributable to unilateral or bilateral disease while the proportion of Charnley class C patients was similar between groups. Moreover, the presence of individual data on all costs adds to the strength of our study.

A confounding factor is that patients in the bilateral group were extraordinarily well informed and meticulously taken care of because of the original study protocol. This confounder may possibly affect the satisfaction and to some extent other patient-reported outcomes, but probably not the cost related to surgery and sick-leave.

Conclusion

The combination of lower total hospital costs and shorter total sick-leave along with no differences in complication rate strengthen the support for the one-stage procedure. We conclude that one-stage bilateral THR should be considered in healthy patients for economic reasons.

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Ethical Approval

The clinical trial was approved by the Local Ethical Review Board in Gothenburg (decision S 257-00). We also used data from the Swedish Hip Arthroplasty Register which continuously collects nationwide prospective observational data regarding all hip replacement surgery in Sweden. The Registry holds general approval from the Local Ethical Review Board in Gothenburg (decision S 067-02, 19 March 2002).

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