



Original research

Outcomes of Revision Hip Arthroplasty Using the Supine Anterior-Based Muscle Sparing Approach

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ARTICLE INFO

Article history:

Received 20 September 2021

Received in revised form

9 January 2022

Accepted 12 February 2022

Available online xxx

Keywords:

Revision hip arthroplasty

Anterior based muscle-sparing approach

Extensile approach

Outcomes

ABSTRACT

Background: In the United States, the number of revision total hip arthroplasty (THA) cases is projected to grow from 50,000 in 2014 to 85,000 by 2030. The anterior-based muscle sparing approach (ABMS) has been described as a viable approach for primary THA, but little has been written in the revision setting. This study compares the supine ABMS approach to alternative approaches in revision THA.

Material and methods: A retrospective review was performed on 149 revision THAs from 2016 to 2019. The ABMS, modified Müller Hardinge (MMH), and posterolateral (PL) approaches were studied. Age, reason for arthroplasty, length of operation, length of stay, blood loss, and complications were extracted. Clinical outcomes were measured by the Hip Disability and Osteoarthritis Outcome Score, Modified Harris Hip Score, University of California Los Angeles activity score, and Veterans RAND 12 Mental/Physical scores.

Results: Approaches included 52 ABMS (33.8%), 58 MMH (37.7%), and 39 PL (25.3%). Complexity of cases and patient demographics were equivalent for each cohort. Extensile approaches were used in 12 of the 52 ABMS, 26 of the 58 MMH, and 13 of the 39 PL revisions, including acetabular cages, open reduction internal fixation for periprosthetic fracture, extended trochanteric osteotomy, hardware removal, and/or pelvic discontinuity. There were no differences for blood loss, length of stay, complications, and outcome scores between approaches.

Conclusion: We found no difference in complications or clinical outcome scores between the ABMS, MMH, and PL approaches for revision THA. The supine ABMS approach provides adequate extensile exposure of the femur and acetabulum for complex revisions and is a reliable approach for revision THA. © 2022 The Authors. Published by Elsevier Inc. on behalf of The American Association of Hip and Knee Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Total hip arthroplasty (THA) is considered one of the most effective orthopedic procedures for relieving pain, restoring function, and improving the quality of life in patients with hip osteoarthritis. Modern improvements in THA have yielded shorter

hospital stays, better functional outcomes, and higher patient satisfaction scores [1–3]. In the United States, the demand for primary THA is estimated to grow from 208,600 in 2005 to 572,000 (174%) by 2030, stemming largely from an aging population that is living longer and retiring later [3]. Although the average age of patients receiving THA is 65 years, those living well into their 80s and even 90s are undergoing THA at a higher rate than previously. Additionally, THA rates are also increasing for patients younger than 60 years, comprising approximately 40% of annual cases [4]. As a result, THA revisions are also projected to grow from approximately 50,220 in 2014 to 85,500 by 2030 [1].

In 2004, Bertin and Röttinger published results of THA utilizing the standard Watson-Jones interval, or intermuscular plane, between the tensor fascia lata and gluteus medius muscles [5]. More

This study was approved by the Penn State College of Medicine Institutional Review Board. This work was performed at Penn State College of Medicine and Penn State Hershey Medical Center. There were no proprietary interests in the materials described in the article.

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<https://doi.org/10.1016/j.artd.2022.02.016>

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Table 1
Baseline characteristics and demographics.

Characteristic	ABMS	MMH	PL	P value
Age	61.2	67.9	68.1	.028
BMI	30.7	31.6	29.1	.17
Gender (male)	22 (42.3%)	26 (44.8%)	18 (46.2%)	.93
Smoking	28 (53.9%)	23 (39.7%)	18 (46.2%)	.33
Diabetes	11 (21.2%)	14 (24.1%)	5 (12.8%)	.39
Hypertension	35 (67.3%)	35 (60.3%)	25 (64.1%)	.75
CKD	0 (0.0%)	1 (1.7%)	1 (2.6%)	.55
Immunosuppression	5 (9.6%)	10 (17.2%)	4 (10.3%)	.42
Blood thinners	11 (21.2%)	39 (67.2%)	11 (28.2%)	<.001
Extensile approach	12 (23.1%)	26 (44.8%)	13 (33.3%)	.056
Explant infection	5 (9.6%)	5 (8.6%)	9 (23.1%)	.08
Head & liner exchange	8 (15.4%)	20 (34.5%)	8 (20.5%)	.054
Acetabular exchange	19 (36.5%)	11 (19.0%)	10 (25.6%)	.11
Femur exchange	10 (19.2%)	13 (22.4%)	2 (5.1%)	.07
All-component exchange	10 (19.2%)	9 (15.5%)	10 (25.6%)	.47

CKD, chronic kidney disease.

recently referred to as the anterior-based muscle sparing (ABMS) approach, this approach has recently risen in popularity due to its reported early functional recovery, minimally invasive approach, and excellent clinical results in primary THA [6–9]. Although some suggest that surgical approach is an independent predictor of early postoperative outcome in primary THA, it remains controversial whether one approach is superior to another [9–12]. However, little has been written about surgical approach, particularly the ABMS approach, relative to revision THA procedures. The purpose of this study is to report the operative and clinical outcomes of the supine ABMS approach compared with the lateral modified Mueller-Harding (MMH) approach and the posterolateral (PL) approaches in revision THA. We hypothesize that the ABMS approach is versatile, can be safely used in the revision setting, and complications and outcomes are equivalent to the more traditional PL and MMH approaches.

Material and methods

This study was approved by the College of Medicine Institutional Review Board. A retrospective chart review was conducted on 154 patients who underwent revision THA between 2016 and 2019. Four surgical approaches were utilized: Direct anterior approach (DAA), supine ABMS, PL, and MMH. A series of consecutive patients utilizing each approach during the given time period were selected for review. Five joint arthroplasty surgeons, all practicing at the same tertiary academic center and each performing at least 100 hip arthroplasties (primary and revision) per year at the time of the study, contributed cases to the series. All DAA procedures were performed on a HANA SC Mizuho OSI table (Mizuho OSI, Tokyo, Japan), MMH and PL procedures in the lateral decubitus position on a standard table, and ABMS in a standard table.

Data extracted included age, gender, body mass index (BMI), smoking history, chronic medical conditions (diabetes, hypertension, chronic kidney disease, and/or immunocompromised), reason for revision THA, anesthesia type (general or spinal), THA approach, length of operation (LOO), estimated blood loss (EBL), blood transfusion (units), complications, and length of hospital stay (LOS). The institutional indication for postoperative blood transfusion is symptomatic low hemoglobin level that does not respond to adequate fluid resuscitation. Indications for specific individual's transfusions were not recorded consistently in the records. Clinical outcomes were measured by the Hip Disability Osteoarthritis Outcome Scores, University of California, Los Angeles, Veterans RAND 12 Mental/Physical, and Modified Hospital for Special Surgery patient-reported outcome scores at both

preoperative and 1-year follow-up. Revisions requiring an extensile approach were also identified, including acetabular cages, open reduction internal fixation for periprosthetic fracture, extended trochanteric osteotomy (ETO), hardware removal, pelvic discontinuity, and/or extensile incision proximally or distally to expand the anatomical planes.

Baseline characteristics and demographics were summarized using descriptive statistics (means, standard deviations, frequencies, and percentages). Means of continuous baseline measures were compared among approaches by analysis of variance, and distributions of categorical measures were compared by chi-square tests. The distribution of each outcome measure was evaluated to determine the best approach for analysis, either applying the natural log transformation or categorizing the ordinal measures where appropriate. Continuous outcomes were compared among approaches with adjustment for baseline characteristics by analysis of covariance, and results were reported in *P* values, model-adjusted means, and 95% confidence intervals. Binary outcomes were compared by logistic regression models with adjustment for baseline characteristics, and results were reported in *P* values, adjusted odds ratios, and 95% confidence intervals. Significance was defined as *P* < .05. Statistical analyses were performed using SAS statistical software version 9.4 (SAS Institute Inc., Cary, NC).

Results

One hundred forty-nine patients were included in the primary analysis (66 males, 83 females). Five revisions performed using the DAA were also identified. However, due to the low frequency of the DAA approach, these cases were not included in the primary analysis. The baseline characteristics and demographics are shown in Table 1. The average age was 65.6 years (range, 21 to 94 years), and average BMI was 30.6 (range, 16 to 50). The median number of chronic medical conditions was 1 (range, 0 to 3), including smoking (69), diabetes (30), hypertension (95), chronic kidney disease (2), and immunocompromised (19). The distributions of LOO and EBL were found to be log-normal; therefore, the natural log transformation was used for these variables, and geometric means are reported as summary measures. LOS was summarized using nonparametric statistics and modeled as a categorical variable with a threshold of 2. The average LOO (geometric mean) was 162.4 minutes (range, 51 to 475 minutes), and median LOS was 1.0 day (range, 1 to 23 days).

Of the 149 cases included in the primary analysis, surgical approaches included 52 ABMS (34.9%), 58 MMH (38.9%), and 39 PL (26.2%). Anesthesia included 132 general with or without

Table 2
Indications for revision arthroplasty.

Indication	ABMS	MMH	PL	Total, %
Adverse local tissue reaction	3	10	2	15, 10.1
Aseptic loosening	14	13	4	31, 20.8
Bearing surface wear (poly wear)	3	5	0	8, 5.4
Failed hemiarthroplasty	3	1	1	5, 3.4
Infection, explant	4	13	11	28, 18.8
Instability	10	6	10	26, 17.4
Pelvic discontinuity	1	0	2	3, 2.0
PPF	7	5	4	16, 10.7
Infection, reimplant	7	5	5	17, 11.4

PPF, periprosthetic fracture.

periarticular injection (88.6%), 14 spinal + periarticular injection (9.4%), and 3 general + spinal (2.0%). Of the spinal anesthetics, 12 were in ABMS patients, 1 in MMH, and 1 in PL. The 3 general + spinal cases were spinals that did not function adequately and then converted to general prior to incision. Patients undergoing revision ABMS were slightly younger than the other 2 groups ($P = .028$). Patients undergoing revision MMH were more likely to be on blood thinners preoperatively ($P < .001$). The indications for revision surgeries by approach are illustrated in Table 2. The component exchange types and complex revision subtypes are summarized in Table 3. Results categorized by surgeons are reported in Table 4.

The average model-adjusted EBL (geometric mean) was 411.0 mL (coefficient of variation 0.78) and ranged from 421.8 for PL to 541.4 for ABMS. Eighty-eight patients received 1 or more units of blood postoperatively, averaging 2.7 units (range, 1 to 9 units).

Complications occurred in 20 of 149 patients (13.4%). Overall, there were no significant differences among approaches with respect to the probability of complications ($P = .55$), LOO ($P = .93$), EBL ($P = .61$), LOS ≥ 2 days ($P = .21$), or having 1 or more transfusion units ($P = .08$), after adjusting for age, BMI, smoking, preoperative blood thinners, and chronic conditions. The most common complications were deep infection (10, 6.5%), periprosthetic fracture (5, 3.2%), and nerve injury (4, 2.6%). There was no significant difference between complications rates relative to approach ($P = .55$) or surgeon ($P = .96$). Complications are summarized in Table 5.

Average postoperative outcome scores improved for each group of patients compared with preoperative scores. In comparing the change in preoperative and postoperative clinical outcome scores, we found no significant differences in the average improvement in scores, after adjusting for age, BMI, smoking, preoperative blood

thinners, and chronic conditions. The means, confidence intervals, and P values for outcome scores are reported in Table 6.

We attempted to identify cases in which the revision approach differed from the primary approach. However, this information was not consistently recorded in the electronic record, and in many cases, this information was not available due to the patients being referred without prior records. Because the MMH incision lies between the ABMS and PL incisions, and thus could be confused with either approach, we did not think the location of the prior incision could reliably indicate the type of approach in all cases.

Discussion

The choice of surgical approach for revision THA can be challenging. Surgeons must consider the complexity of the problem, the goals of the procedure, patient factors such as obesity or prior surgery, as well as surgeon experience and comfort level with various approaches. Although our data do not indicate that one approach is superior to another, they do indicate that the ABMS approach can safely and effectively be used for most revision THA indications, including extensile exposure of both femur and acetabulum. Compared with the PL and MMH approaches, our data demonstrate that a surgeon who is experienced with the supine ABMS approach can expect equivalent outcomes, even in complex cases.

There are few studies reporting the outcomes relative to the more common PL and MMH approaches in revision THA [13–16], and we were only able to locate one limited study reporting results using the ABMS approach for revision THA [17]. Shigemura et al. reported 2 patients who had successful isolated liner exchanges for

Table 3
Component exchange type and complex revision subtypes by THA approach.

Exchange type	ABMS	MMH	PL	Total, %
Explant for infection	5	5	9	19, 12.7
Head & polyethylene liner exchange	8	20	8	36, 24.2
Acetabular exchange	19	11	10	40, 26.8
Femoral exchange	10	13	2	25, 16.8
All-component exchange	10	9	10	29, 19.5
Complex subtype	ABMS	MMH	PL	Total
Acetabular augments	0	0	4	4
Acetabular cages	3	4	1	8
Extended trochanteric osteotomy	4	10	7	21
Hardware removal	1	4	1	6
PPF: acetabulum	1	0	0	1
PPF: femur	5	7	3	15
Extensile approach	12	21	11	44

PPF, periprosthetic fracture.

Table 4
Perioperative findings by surgeon.

Surgeon	Cases	THA approach(es)	Experience (y)	LOO geometric mean (min)	LOS median (d)	EBL geometric mean (mL)	Complications
1	57	55 MMH, 2 PL	>15	171.7	1.0	445.0	9 (15.8%)
2	9	9 PL	>15	160.1	1.0	271.3	1 (11.1%)
3	14	14 PL	0-5	180.4	3.0	360.9	2 (14.3%)
4	58	52 ABMS, 3 MMH, 3 PL	>15	144.8	1.0	397.6	7 (12.1%)
5	11	11 PL	0-5	206.8	2.0	513.6	1 (9.1%)

polyethylene wear utilizing the ABMS approach [17]. Both patients had PL approaches for their primary procedures [17]. In our study, we report no difference in likelihood of developing a complication among the ABMS, MMH, and PL approaches, but our data include revision for all causes, including infection, periprosthetic femur fracture, and extensile femoral exposure. Blackburn et al. grouped the surgical approach for primary THA with subsequent revision approaches to measure overall outcomes using the Western Ontario and McMaster Universities Arthritis Index and Oxford Hip Score scales [15]. They found that patients had better scores if they had a posterior approach for both their primary and revision THAs than when both primary and revision surgeries were performed in the lateral approach as well as a primary lateral approach and revision THA posterior approach [15]. In our study, there was no difference in outcome scores between approaches with respect to average change from baseline. Although many of the cases in our study used a different approach from the original primary approach, we were unable to reliably identify from the record the original primary approach for all cases. Thus, we were unable to evaluate the effect of using the original primary approach vs a new approach. Given that we found no difference in complications, further study is warranted regarding this issue.

In our series, an extensile surgical approach was necessary for many cases. Our data show that the ABMS approach could be successfully utilized for a wide variety of surgical reconstructive problems, including acetabular cages and extended trochanteric osteotomies, and we did not identify any limitations for the ABMS approach in this regard compared with the PL and MMH approaches. It has been established that both the PL and MMH approaches are able to accommodate ETOs in revision THA cases, allowing wide exposure to the acetabulum, femoral component exposure and removal, canal preparation and femoral reconstruction, and correction of proximal femoral deformities [18–20]. Our data suggest that ETO and extensile femoral and acetabular exposure can be effectively utilized with the ABMS approach as well. As far as complication rates for each approach relative to specific indications for revision, we did not have sufficient numbers to adequately address this question statistically.

One particular advantage to the ABMS approach is that it can be done in the supine position. Although we did not report any complications related to positioning in either group, we find supine positioning to be easier than lateral positioning, with less pressure

Table 5
Complication types by revision THA approach.

Complication	ABMS	MMH	PL	Total
Dislocation	0/52	1/58	0/39	1/21
Prosthetic joint infection	3/52	4/58	3/39	10/21
Iatrogenic nerve palsy				4/21
Femoral	1/52	0/58	0/39	
Peroneal	0/52	0/58	1/39	
Sciatic	1/52	1/58	0/39	
Periprosthetic fracture	1/52	3/58	1/39	5/21
Pulmonary embolism	0/52	0/58	1/39	1/21

points in need of added protection or padding and less lifting strain for hospital staff. The majority of the spinal anesthetics in this study were for ABMS cases. Anecdotally, we find that anesthesiologists are more reticent to utilize spinal anesthesia in the lateral position for revision surgery, citing the risk of the spinal anesthesia wearing off if the revision goes longer than planned. However, in the supine position, it is easier to convert to general anesthesia intraoperatively, if necessary, than it is in the lateral position. Therefore, we have found anesthesiologists more willing to utilize spinal anesthesia in the supine position, for appropriate cases.

In our series, only 5 patients were revised using the DAA, including 4 isolated head exchanges/polyexchanges and 1 acetabular component revision. Due to the low number of DAA cases, they were not included in the analysis. Therefore, our analysis focuses mainly on comparing the ABMS with the MMH and PL approaches. Others have reported potential challenges associated with revision THA via the DAA approach [14,16]. Hasler et al. looked at postoperative complications and reoperation rates following the DAA for revision THA [14]. Their main indications for revision were liner and head exchange and acetabular cup revision. At 18 months of the follow-up, the overall complication and reoperation rates were 14.3% and 12.7%, respectively, and the mean postoperative Hospital for Special Surgery score at 1 year was 91 (range, 74–100). They concluded the DAA offers appropriate exposure for the limited indications of exchange of mobile liners and acetabular cup revision.

Limitations of this study include all those inherent in retrospective reviews relative to fidelity and accuracy of the electronic medical record. Results from a single institution study and select

Table 6
Mean-adjusted change in outcome score (preop vs 1-year postop).

Outcome score	Model-adjusted mean	95% Confidence intervals	P value
HOOS			.55
ABMS	13.6	−8.7 35.8	
MMH	17.4	4.8 29.9	
PL	30.2	6.9 53.4	
UCLA activity score			.30
ABMS	0.26	−1.18 1.70	
MMH	1.12	0.340955 1.93	
PL	1.88	0.406003 3.38	
HSS			.72
ABMS	21.2	0.52 41.9	
MMH	13.7	0.07 27.4	
PL	23.2	−2.12 48.5	
VR mental			.67
ABMS	−4.56	−16.7 7.6	
MMH	1.07	−6.2 8.3	
PL	−2.11	−14.5 10.3	
VR physical			.12
ABMS	7.2	−3.8 18.2	
MMH	3.7	−2.8 10.2	
POST	17.6	6.4 28.7	

HOOS, Hip Disability Osteoarthritis Outcome Scores; VR, Veterans RAND; HSS, Hospital for Special Surgery; UCLA, University of California, Los Angeles; ABMS, anterior based muscle sparing approach; MMH, modified Meuller-Harding approach; POST, posterolateral approach.

group of surgeons, such as this one, cannot necessarily be applied to all institutions and surgeons. Due to the low number of surgeons, factors such as LOO, LOS, and EBL may also be affected by intangible factors such as individual surgeon preferences and protocols, which cannot be completely accounted for in this study. The sample size may be too small to detect subtle differences in rare complication rates. Larger studies, including multicenter studies and perhaps registry data, will be helpful in better understanding the utility and efficacy of the various approaches in revision THA.

To summarize, for a surgeon experienced with the approach, the ABMS approach is a versatile, safe, and effective option for revision THA. Surgeons who encounter patients who had the ABMS approach for their primary procedure can safely use the same approach if they so choose and can expect equivalent outcomes to PL and MMH approaches. Advantages of the ABMS approach in revision THA include supine positioning, muscle sparing interval, preservation of the posterior pseudocapsule, the ability to extend the exposure for complex revisions, and no differences in complication rates compared with PL and MMH approaches.

Conclusion

We found no difference in perioperative complications or clinical outcome scores between the ABMS, MMH, and PL approaches for revision THA. The supine ABMS approach provides adequate exposure of the femur and acetabulum for complex revisions and is a versatile, safe, and effective approach for revision THA.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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