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Original research

The ABLE Anterior-Based Muscle-Sparing Approach: A Safe and Effective Option for Total Hip Arthroplasty

Adam J. Rana, MD [a, *], Callahan M. Sturgeon, BS [a], Brian J. McGrory, MD [a], Michael V. Frazier, MD [b], George M. Babikian, MD [a]

[a] Division of Joint Replacement, Maine Medical Partners Orthopedics, Falmouth, ME, USA
[b] Maine Medical Center, Portland, ME, USA

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ABSTRACT

Background: The direct anterior and posterior approaches are well-researched options in total hip arthroplasty (THA). The less-studied anterior-based muscle-sparing approach, also known as the ABLE advanced anterior approach, centers on minimizing surgical trauma and medical costs while maintaining or improving patient outcomes.

Material and methods: THAs performed using the ABLE approach by 3 surgeons at a single institution between January 2013 and August 2020 were retrospectively assessed for outcomes pertaining to safety and performance intraoperatively, perioperatively, and postoperatively. Additionally, intraoperative and postoperative complications were evaluated, and patient-reported outcome measures and radiographic outcomes out to 1-year follow-up.

Results: There were 6251 THAs (5433 patients) eligible for inclusion. The mean surgical time was 65 minutes, mean intraoperative blood loss was 204 mL, and the transfusion rate was 0.5%. Patients had a mean length of stay of 1.4 days. Overall, 93.4% of patients were discharged home, 1.9% visited the emergency department within 30 days, and 2.9% had an unplanned readmission to the hospital within 90 days. The overall major surgical complication rate was 1.18%, with a dislocation rate of 0.13%, a deep infection rate of 0.19%, and a postoperative periprosthetic fracture rate of 0.37%.

Conclusions: The minimally invasive ABLE approach is a safe and effective surgical approach for patients undergoing THA. It can be performed efficiently and with limited complications, making it an appealing option for surgeons to utilize during this era of value-based care.

Introduction

Total hip arthroplasty (THA) has been described as the "operation of the century" for its proven ability to decrease pain and improve quality of life [1]. Surgical approaches to THA have evolved and been refined over time, [2–6] often to meet emerging patient concerns and expectations on issues of pain, length of recovery, functional abilities, and risk of transfusions [7]. Patients' expectations increased with the success of the surgery, which has led to less-invasive, muscle-sparing approaches, including the direct anterior approach (DAA), one of the most commonly performed muscle-sparing approaches for THA [8,9].

The DAA gained popularity over the past decade due to patients' desire for earlier functional recovery with less postoperative pain and less muscle injury [10–13]. However, the DAA also has notable disadvantages when compared with the posterior approach, including a steep learning curve, an increase in perioperative complications, higher blood loss, and a longer procedure duration [2,14–17]. Additionally, the surgeon or institution often uses a specialized operating room table for the DAA procedure, which increases the overall cost of care [18,19]. Finally, patients with a higher body mass index are frequently excluded from selection for DAA due to difficulty with exposure, implant placement, and surgical wound management [13]. These disadvantages have impacted surgeon adoption.

* Corresponding author. Department of Orthopedic Surgery, Maine Medical Partners, 5 Bucknam Road, Falmouth, ME 04105, USA. Tel.: +1 207 239 8849.
E-mail address: adam.rana@mainehealth.org

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The anterior-based muscle-sparing (ABMS) approach, also known as the ABLE approach, is a lesser known and less-researched muscle-sparing approach that utilizes the interval between the tensor fasciae latae posteriorly and the gluteus medius muscle anteriorly [5,20,21]. The ABLE approach has been previously described as the modified Watson-Jones or Rottinger approach [20,22,23]. Bertin described it in the supine position while Rottinger described the approach with the patient in the lateral position [5,22]. This approach has been shown to be safe and effective, with a minimal learning curve, accurate implant positioning, and intraoperative and postoperative complications comparable to those with the DAA and posterior approaches [18,20]. It can be performed with the patient in the lateral or supine position [18,20,22,23]. Despite the reported benefits of this approach, there is paucity of published research.

The purpose of this study is to evaluate perioperative results of the ABLE performed with the patient in the lateral position over the course of a 7.5-year period by 3 separate surgeons at a single institution. The secondary aim was to describe the complications, clinical improvements, and radiographic outcomes in patients undergoing THA with this approach at 1-year follow-up.

Material and methods

Institutional review board exemption was obtained. Patients were identified through the institution's electronic medical database (EMR). All patients who underwent a primary elective unilateral THA used the ABLE approach (described in Appendix A) between January 1, 2013, and August 31, 2020. Patients were eligible for inclusion if they had a preoperative diagnosis of osteoarthritis, avascular necrosis, rheumatoid arthritis, or dysplasia. Patients were excluded if their primary diagnosis was femoral neck fracture, impending pathologic fracture, or if they had prior operative fixation with subsequent posttraumatic arthritis or avascular necrosis. All 3 surgeons followed the same preoperative and postoperative multimodal pain management pathways that included a periarticular injection with bupivacaine and the use of acetaminophen, nonsteroidal anti-inflammatory drugs, pregabalin (patients <70 years old), and oxycodone pro re nata. In addition, all 3 surgeons followed the same postoperative pathway for activity allowing patients to be weight-bearing as tolerated following surgery with no hip precautions, progressing from a walker to a cane as tolerated and then off the cane as tolerated. Tranexamic acid was introduced as an adjunct to minimize blood loss in 2016 with each surgeon following the same pathway regarding its use of 1 gram prior to incision and 1 gram during closure.

Patient demographics (gender, age, American Society of Anesthesiology rating, body mass index), primary diagnosis, anesthesia type, procedure duration, intraoperative estimated blood loss, length of hospital stay, and discharge disposition were retrieved from the patient database. Thirty-day emergency department (ED) visits and 90-day unplanned readmissions were recorded. Postoperative complications were obtained via the EMR from a report built by an internal analyst using the Centers for Medicare and Medicaid Services codes and definition that identified both index admission complications and postdischarge complications. Based off this definition, if a patient had the same complication twice, it was only accounted for once. All patients with a length of stay greater than 4 days had a manual chart review for added evaluation of hospital course. These are limited to attendance within affiliated hospitals.

Patient-reported outcome measures (PROMs) were obtained from 2 databases, ORTech (Ontario, Canada), which was used by the institution for PROM data entry before 2018, and RedCap (Vanderbilt University, Tennessee), which was used for PROM data entry after 2018. Patients completed PROM questionnaires preoperatively and postoperatively at 6 weeks, 6 months, and 1 year. Patients completed the Hip disability and Osteoarthritis Outcome Score for Joint Replacement, visual analog scale pain, single assessment numeric evaluation, University of California and Los Angeles, the Patient-Reported Outcomes Measurement Information System 10-Question Short-Form, and postoperative satisfaction.

Abduction angle, heterotopic ossification, and femoral component subsidence were evaluated using preoperative and postoperative radiographs in IMPAX (London, United Kingdom). Heterotopic ossification was assessed by comparing the 1-year postoperative radiograph with the patient's immediate postoperative radiograph. If the patient did not have a 1-year or greater follow-up radiograph, they were excluded from radiographic analysis of heterotopic ossification. Subsidence was determined by evaluating and comparing the immediate postoperative radiograph with the first follow-up radiograph. As the immediate radiograph is non–weight-bearing and the follow-up radiograph is weight-bearing, up to 2 mm of "settling" of the femoral component was considered within normal limits. Greater than 2 mm of caudal movement of the femoral stem component was considered abnormal and indicative of subsidence.

Demographic data, intraoperative surgical assessments, and postoperative patient outcomes were summarized based on case numbers using descriptive statistics. All statistical calculations were made using the Microsoft Excel 2013 (Microsoft, Inc., Seattle, WA) software. Statistics were considered significant if the $P < .05$.

Results

There were 6251 primary THAs (5433 patients) identified as being eligible for inclusion, representing 97.4% of the patients operated on with the ABLE approach during the study period (Table 1). Of these, 191 (3.1%) had a cemented femoral stem placed. With 97% of patients undergoing general anesthesia with complete paralysis, the surgeon is able to achieve consistent and reproducible feedback with regards to ease of reduction and dislocation. The surgeons have found that with the ABLE approach, in conjunction with a spinal anesthetic, there is a significant amount of muscle spasm when using electrocautery, and therefore, the impact to soft

Table 1
Patient demographics.

Variable (mean ± SD)	
Age	65.3 ± 10.2
Sex[a]	
Female	2963 (55%)
Male	2470 (45%)
BMI	29.4 ± 6.0
BMI categories[a]	
Underweight	52 (0.8%)
Healthy weight	1462 (23.4%)
Overweight	2227 (35.6%)
Obese	2510 (40.2%)
Class 1 obese (low risk, 30-34.9)	1472 (58.6%)
Class 2 obese (moderate risk, 35-39.9)	692 (27.6%)
Class 3 obese (high risk, ≥40)	346 (13.8%)
ASA rating	2.1 ± 0.5
Primary diagnosis[a]	
Osteoarthritis	6139 (98.2%)
Avascular neurosis	87 (1.4%)
Dysplasia	10 (0.2%)
Posttraumatic arthritis	8 (0.1%)
Rheumatoid arthritis	7 (0.1%)

ASA, American Society of Anesthesiology; BMI, body mass index; SD, standard deviation.
[a] N (%).

tissues is greater than when the patient is completely paralyzed during general anesthesia. Additional surgical and postoperative data are provided in Table 2.

Intraoperative or postoperative complications that required surgical intervention were noted in 74 cases out of 6251 THAs performed (1.2%). The most-common postoperative complications were periprosthetic fracture, all of which were femur fractures, and infection (23 episodes each). Intraoperative calcar fractures (16 total, 0.3% incidence) were treated by extending the incision distally, placing either 1 or 2 cerclage cables above and below the lesser trochanter and either using a press-fit or cemented femoral stem. Postoperative fractures that occurred within 90 d of the index procedure (23 total, 0.37% incidence) were all addressed using the index incision, extending it distally to better visualize the fracture pattern, reducing the fracture with cerclage cables, and then using either a press-fit or cemented femoral stem. Deep infections were treated with irrigation and debridement, head liner exchange, and then intravenous antibiotics followed by oral antibiotics. Superficial infections were treated with irrigation and debridement followed with intravenous then oral antibiotics. The incidence of postoperative dislocation was 0.13% (Table 3).

Compared with the preoperative baseline, patient-reported outcome scores were statistically significantly improved for all metrics at all follow-up periods. Specifically, patients showed statistically significant improvement for all measures at the 6-week postoperative follow-up, specifically illustrating patient's ability to improve their physical health and increase their activity level with the ABLE approach even in the recovery period. Improved health and function were maintained for the entire duration of follow-up as there was statistically significantly improved patient-reported outcome scores for all metrics at the 1-year follow-up when compared to baseline. Patient-reported outcomes were compared within each measure by follow-up period, and results are reported in Table 4. All patient satisfaction levels were rated high ($\geq$9) at 6 months and 1 year (Table 4).

A total of 6248 cases had preoperative and postoperative follow-up radiographs that were reviewed. The average abduction angle of the prosthetic acetabular cup was 45.1° (standard deviation, 3.7°; range, 30°-65.9°). Radiographic evidence of subsidence was noted in 2.0% (n = 125) of cases. Of the 4221 patients with a 1-year follow-up radiograph, 13.5% (n = 570) had evidence of heterotopic ossification. Only 1 patient underwent excision of heterotopic ossification more than 1 year after the operation due to stiffness.

Table 2
Surgical and postoperative data.

Variable	N (%)
Anesthesia type	
General	6065 (97%)
Spinal	186 (3%)
Length of surgery[a]	65 ± 18
Estimated blood loss (mL)[a]	204.1 ± 68.9
Transfusion rate	
Within 7 d of surgery	31 (0.5%)
Within 90 d of surgery	43 (0.7%)
Length of stay[a]	1.4 ± 0.7
Discharge disposition	
Home/self-care	3789 (60.6%)
Home with home health services	2051 (32.8%)
Rehab facility	60 (1.0%)
Skilled nursing facility	351 (5.6%)
ED visits (within 30 d)	116 (1.9%)
Readmissions (within 90 d)	179 (2.9%)
Procedure required	
Medical	60 (1.0%)
Surgical	119 (1.9%)
Type of readmission	
Direct to hospital, unplanned prior to admission	100 (56%)
Admitted from ED	79 (44%)

[a] Mean ± standard deviation.

Table 3
Complications.

Variable, N (%)	Medical	Surgical
Intraoperative fractures		
Calcar fracture	—	16 (0.3%)
Greater trochanter fracture	—	2 (0.03%)
Postoperative complications		
Myocardial infarction (7 d)	8 (0.13%)	—
Pneumonia (7 d)	3 (0.05%)	—
Sepsis/shock (7 d)	—	—
Pulmonary embolism (30 d)	3 (0.05%)	—
Death (30 d)	1 (0.02%)	—
Mechanical loosening (90 d)	—	2 (0.03%)
Periprosthetic fracture (90 d)	—	23 (0.37%)
Dislocation (90 d)	—	8 (0.13%)
Joint infection—deep (90 d)	—	12 (0.19%)
Wound infection—superficial (90 d)	—	11 (0.17%)
Total	15 (0.23%)	74 (1.18%)

Discussion

This study evaluated perioperative and short-term outcomes of the largest consecutive cohort of patients known to date undergoing THA with the ABLE approach. It was found that the surgical time was efficient, required few transfusions postoperatively, had low intraoperative and postoperative complications, and had minimal emergency room visits and readmission rates.

With the patient in the lateral position, the average 65-minute procedure duration (incision start to incision close) favorably compared to other published studies. There was variation between surgeons; surgeon-specific average procedure duration was 57 minutes, 65 minutes, and 84 minutes. One surgeon takes an intraoperative radiograph and reacts to the findings, which may account for the deviation from the average.

We sought to compare our results against those in highly cited articles with the DAA and other popular approaches [24]. Sibia et al. (2017) compared the DAA to the posterolateral (PL) approach among 5 surgeons (1457 THAs using DAA vs 1241 THAs using PL) and found an average procedure duration of 90.4 and 86.3 minutes, respectively, [13]. Conversely, Martin et al. (2011) compared the Rottinger approach to the standard lateral transgluteal Hardinge approach and found the former to have a slightly longer operating time of 114.12 minutes than the latter with 95.78 minutes [25]. When compared to a variety of procedure approaches with a patient population greater than 100, there was a reported range of 58 to 130 minutes [3,8,13,18,20,26–34].

One possible explanation for the lower average blood loss encountered in the current study (204 mL) is that the surgeon encounters only peripheral branches of the lateral circumflex femoral artery, which are visualized and more easily coagulated [25] Only 0.5% of patients required a transfusion within 7 days postoperatively, increasing to 0.7% in the first 90 days postoperatively. Klasan et al. (2019) compared a matched group of DAA and the ABMS approach with 396 patients each [29]. The DAA group reported an average blood loss of 450 mL, and the ABMS group reported 469 mL. Furthermore, they reported transfusion rates of 14.1% vs 5.8%. When compared to a variety of procedure approaches with a patient population greater than 100, there was a blood loss reported range of 138-405 mL and a transfusion rate between 3% and 40% [3,8,13,18,20,26–34].

Table 4
Patient-reported outcomes data.

Variable (mean ± SD)	Preoperative, N = 3131	6 Wk, N = 3086	6 Mo, N = 413	1 Y, N = 1612	*P* value (preoperative vs 1 y)
HOOS Jr. Interval Score	41.0 ± 15.5	76.5 ± 13.1 ($P \leq .0001$)	86.8 ± 15.3 ($P \leq .001$)	88.0 ± 14.3 ($P = .056$)	≤.001
VAS pain	5.6 ± 2.2	1.5 ± 1.7 ($P \leq .0001$)	0.95 ± 1.6 ($P \leq .0001$)	0.90 ± 1.7 ($P = .256$)	≤.001
SANE	41.6 ± 21.3	77.1 ± 18.0 ($P \leq .0001$)	89.8 ± 15.3 ($P \leq .0001$)	90.2 ± 15.6 ($P = .277$)	≤.001
UCLA	4.3 ± 1.8	4.9 ± 1.4 ($P \leq .0001$)	6.1 ± 1.9 ($P \leq .0001$)	6.4 ± 1.9 ($P = .002$)	≤.001
PROMIS-10					
Mental	50.4 ± 7.4	51.6 ± 7.0 ($P \leq .0001$)	51.4 ± 6.9 ($P = .192$)	52.0 ± 7.2 ($P = .0162$)	≤.001
Physical	39.9 ± 5.3	45.0 ± 5.5 ($P \leq .0001$)	46.9 ± 6.2 ($P \leq .0001$)	47.4 ± 6.3 ($P = .0377$)	≤.001
Satisfaction					
Pain	N/A	8.9 ± 1.7	9.4 ± 1.3	9.4 ± 1.3	
Functional improvement	N/A	8.6 ± 1.7	9.3 ± 1.4	9.3 ± 1.3	
Meeting expectations	N/A	9.0 ± 1.7	9.4 ± 1.5	9.4 ± 1.4	

HOOS Jr., Hip disability and Osteoarthritis Outcome Score for Joint Replacement; N/A, not available; PROMIS-10, Patient-Reported Outcomes Measurement Information System 10-Question Short-Form; SANE, single assessment numeric evaluation; SD, standard deviation; UCLA, University of California and Los Angeles; VAS, visual analog scale.

The ABLE approach exhibited a reduced length of stay (1.4 days) compared to existing literature on other approaches and was consistent with other ABMS literature reporting less than 2 days of stay [18,25,35]. There was minimal variation with the length of stay between 2013 and 2019 although we saw a decrease to 1.2 days in 2020 likely in part due to the COVID-19 pandemic. It is hypothesized that the reasons behind the relatively short length of stay are multifactorial, including the fact that the surgery is muscle-sparing, has less blood loss than other approaches, and has less postoperative pain during the index stay (not a variable explored in this study). When compared to a variety of procedure approaches with a patient population greater than 100, there was a reported length of stay in the range of 1.53-10 days [3,8,13,18,20,26–34].

Although the study demonstrated a short length of hospital stay, we did not find a higher-than-average rate of return to the ED. Only 1.9% of patients presented to the ED within 30 days of surgery. Maldonado-Rodriguez et al. (2020) summarized available literature (27 studies; 1,484,043 patients) on ED visits after total hip and knee replacements, finding on average a 6.5% rate of 30-day ED visits [36]. Finnegan et al. (2017) reported that ED visits occur more frequently than readmissions and often just for pain [2,3,18,20,26,29-34, 37–39].

Our results show that 2.9% of patients were readmitted to the hospital within 90 days of surgery, with 56% of those patients having a direct admission that was unplanned prior to surgery and 44% being readmitted from the ED. By comparison, Schairer et al. (2014) reported on 988 patients that underwent a primary THA at a single institution and found a readmission rate of 4.4% [33]. Thirty-day ED visits and 90-day readmissions are important outcome variables as they represent the quality of the surgery in relation to perioperative care and time to discharge [2,3,18,20,26,29–34,37–39].

Maldonado-Rodriguez et al. (2020) emphasized the importance of designing management strategies to reduce ED visits in order to keep overall costs low for the patient and hospital, but it extends further than just ED visits [36]. The key to rapid rehabilitation and postoperative progress is dependent on the patient's expectations aligning with their care teams, including their anesthesia and surgical teams [4,8]. Perioperative and postoperative outcomes are favorable or comparable to those of other highly-cited and respected orthopedic literature, confirming that the ABLE technique is safe, effective, and has a short learning curve, [3,5,18,20,35] all of which allows for easy adoption.

Perioperative complications following THA are a key contributor to hospital readmission, patient morbidity, and increased costs [40]. In the current series, the incidence of major perioperative complications requiring surgical intervention was approximately 1.2%, which is highly favorable when compared with large-scale registry results following THA, [41,42] in line with that observed with ABMS [43]. In comparison, recent meta-analysis data indicate that the DAA has a higher rate of intraoperative and postoperative complications, as well as a trend toward greater femur fracture, vs posterior approaches [44]. One explanation for the low incidence of femoral periprosthetic fractures both intraoperatively (0.3%) and postoperatively (0.37%) with the ABLE approach is the excellent exposure and visualization achieved of the femur. The reproducible exposure allows for consistent broaching and appropriate sizing of the femoral component to minimize perioperative femoral complications. The incidence of dislocation (0.13%) with the ABLE approach compares favorably with the DAA and PL approaches. The muscle sparing technique is 1 reason why the rate of dislocation is lower than that with the PL approach. Regarding a comparison with the DAA approach, the exposure to the femur with the ABLE approach possibly requires fewer releases to gain appropriate exposure of the femur which can lead to improved stability. Although we did not collect data on the incidence of lateral femoral cutaneous nerve paresthesias or neuromas, we did not have any cases of painful neuromas. Due to the more lateral, as opposed to anterior, position of the ABLE incision, the incidence of encountering the lateral femoral cutaneous nerve would be expected to be less with this approach than with the DA approach. Therefore, the ABLE approach would likely have a reduced incidence of paresthesias or neuromas.

The current study's radiographic findings support the advantageous qualities and reproducibility of the approach. One benefit of this approach is consistent direct visualization during placement of both the acetabular and femoral components. This is illustrated radiographically by a consistent abduction angle of 45.1° (standard deviation, 3.7°; range, 30°-65.9°). In addition, the visualization allowed during femoral broaching permits appropriate evaluation of the femoral canal diameter and version, which correlates with more appropriate sizing of the femoral prosthesis and dialing in the correct anteversion of the stem. This finding is supported by the fact that we saw only a 2.0% incidence of subsidence postoperatively.

This retrospective study does have limitations. It evaluates results from a single institution, where we were limited to the single EMR database. Therefore, we were restricted to capturing ED visits, readmissions, and complications within the affiliated hospitals. However, our institution is part of a larger health-care system that includes 10 other hospitals in the state which are all on the same EMR. Therefore, we were more likely to capture emergency room visits or readmissions. An additional limitation is that the study did not have a control group, which does not allow us to compare our rates with a group that underwent the same preoperative routine.

Conclusions

This study demonstrates the ABLE anteriorly-based muscle-sparing approach is a safe and effective one for performing THA. This approach results in an efficient surgical time, minimal blood loss, short length of stay, high percentage of patients returning home, and a low incidence of complications. These results are comparable or superior to those of other THA approaches described in the literature. Although the current study reports outcomes from the approach performed in the lateral position, it is possible to perform it in the supine position as well. Given the outcomes reported in this study across a 7.5-year period at a tertiary care center, the ABLE approach can be considered a safe and effective option for orthopedic surgeons during this era of value-based health care.

Conflicts of interest

Dr. Babikian and Dr. McGrory receive royalties from Smith & Nephew, Inc. and Innomed, Inc. and are in the speakers' bureau of and/or gave paid presentations for Smith & Nephew, Inc. Dr. McGrory receives research support as a principal investigator from Institutional and Smith & Nephew, Inc.; receives royalties from Springer Nature; is in the editorial or governing board of Emeritus and *Arthroplasty Today*; and is a board member in American Association of Hip and Knee Replacement Surgeons and *Arthroplasty Today*. Dr. Rana is a paid consultant for Smith & Nephew, Inc.; receives royalties from Smith & Nephew, Inc.; and is the Health Policy and Advocacy Chair for American Association of Hip and Knee Replacement Surgeons and Membership Chair for Eastern Orthopedic Association.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.06.007.

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Appendix A

Surgical technique—Appendix A

The patient is placed in the lateral decubitus position on a standard operating table. The pelvis is positioned perpendicular to the floor and secured utilizing the modified pegboard and bean bag. The bed is angled at a moderate degree of Trendelenburg to allow easier access to the femoral canal for broaching.

The operative hip is prepped and draped in a sterile fashion. The anterior-superior iliac spine and the anterior femur are landmarks for the linear incision. A line is drawn connecting 2 points, 1 inch posterior of the anterior-superior iliac spine and a position 2 inches distal to the tip of the trochanter about the anterior one-third of the femur. This distance averages 5 inches in length. A shorter distance is encountered with varus hips and is a sign that exposure to the femur may be more challenging, therefore requiring additional releases for exposure. The incisional length can be altered depending on the patient's size. It can be translated distally to avoid pannus in larger patients that may irritate the proximal incision and lead to superficial wound-healing problems.

The incision is carried down to expose the deep fascia. The interval between the gluteus medius, posteriorly, and the tensor fascia lata, anteriorly, is developed moving distal to proximal exposing the hip joint. A superior curved retractor is placed to retract the anterior border of the abductor. An inferior retractor is placed below the neck of the femur. A fat pad is visualized and excised to expose the capsule and the vastus intermedius, which will be a landmark for the femoral neck cut. During the approach, the lateral circumflex femoral artery is not encountered and is a theoretical reason for why this approach results in less blood loss and a lower incidence of transfusions.

A z-capsulotomy is performed, allowing access to the femoral neck. By performing a capsulotomy instead of a capsulectomy, the joint capsule is recreated at the end of surgery, thereby reducing the risk of dislocation. The superior limb of the capsulotomy is from the tip of troch to the 1-o'clock position on the acetabulum. Care is taken to not disrupt the reflected head of rectus during the capsular release along the acetabulum, which can be a source of hip flexor tendinitis postoperatively. The second limb is carried along the intertrochanteric line. The third limb is carried along the superior acetabulum to the 11-o'clock position. Superior and inferior retractors are placed inside the capsule. The leg is brought into a relaxed figure-of-four position. The provisional femoral neck osteotomy is performed using a reciprocating saw angled at approximately 45° to allow the femur to slide up into the wound; this can be facilitated with an osteotome that can serve as a "skid."

One retractor is placed behind the trochanter underneath the gluteus medius and minimus and another above the lesser trochanter. The leg is then brought into the assistant's bag. The surgeon defines the saddle about the femur. With the femur parallel to the floor, a cut is made along the femoral neck using the intertrochanteric line and vastus intermedius as a guide, while simultaneously protecting the neurovascular structures and the medius and minimus. With the operative hip placed in a neutral version in slight abduction, the osteotomy fragment is removed, and the quality of the cancellous bone is evaluated to determine if the hip is to be cemented or noncemented. A drill or meniscal clamp is used to excise the femoral head fragment.

A partial posterior capsular release is performed from the medial trochanter posteriorly. If the femur is stiff or contracted, or in large patients, additional releases may be necessary to better visualize the proximal femur for future broaching. The sequence of releases includes the obturator internus followed by the piriformis tendon followed by the inferior capsule. During the release, the assistant places a proximal and adducting directed force to further slide the femur into the wound for better exposure and visualization.

The acetabulum is addressed next. A retractor is placed in the superior-posterior quadrant, in the 3-o'clock position on the acetabulum, retracting the femur posteriorly. A second retractor is placed in the anterior quadrant, in the 8-o'clock position, protecting the tensor fascia lata. A final retractor is placed gently under the minimus and medius, in the 12-o'clock position. With the 3 retractors placed directly on the bone, the neurovascular structures are protected. The acetabulum is circumferentially exposed and prepared by removing osteophytes, calcified labrum, and inferior synovium. The reflected head of the rectus is visualized, and care is taken not to disrupt it to reduce the risk of postoperative hip flexor tendinitis. The inferior capsule may be released, if needed, to allow more complete visualization of the acetabulum.

In the acetabular fossa, the pulvinar is debrided to visualize the medial wall. The acetabulum is then medialized and reamed in 1-millimeter increments until bleeding cancellous bone is encountered. The retractors are used as "skids" to protect the soft-tissue structures as the reamers are taken in and out of the wound. With the femur abducted to relax the muscles, the real shell is brought into the field and impacted with 40°-45° of abduction and 15°-20° of anteversion. A depth gauge is used to confirm the shell is completely seated. One screw augmentation is then utilized.

With the femur dislocated posteriorly, a #3 retractor and #1 retractor are utilized behind the trochanter and at the calcar to expose the calcar region. The assistant places the leg in the bag and adducts and externally rotates the femur to present the femur at a version that is parallel to the floor. To ensure the femoral cortex is not breached, the femoral canal can be entered using a blunt tipped canal finder. The visualization of the femur obtained with this approach allows for all stem types to be implanted. Starting with the smallest broach, the femur is broached to achieve a press fit in 10°-15° of anteversion (when implanting a noncemented femoral component). Using the appropriate femoral head and neck components, a trial reduction is performed. A systematic approach that includes testing shuck (ideally 1-2 mm), checking for impingement with flexion to 90° and internal rotation to >70°, tightness of the fascia lata, and applying a combination of extension and external rotation is taken to determine stability. The ease or difficulty with reduction and dislocation using a bone hook is another metric used to evaluate stability and sizing of components. One surgeon obtains intraoperative radiographs to confirm implant positioning.

The trial components are removed, and the final stem is impacted followed by the femoral head. The hip is reduced, and the capsule is closed with 2 interrupted 0 absorbable sutures. Reestablishing an anatomic capsular closure is another check for recreating length and offset and theoretically aids in improving overall hip stability and proprioception postoperatively. A running and locking suture is placed in a distal-to-proximal fashion in the fascia lata layer and the gluteus medius fascia incorporating the subcutaneous fat. The superficial wound is closed followed by the skin. A dry, sterile dressing is placed.

Video: https://youtu.be/wZ6QhDkonaQ.