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Original Research

Anterior Percutaneous-Assisted Total Hip Arthroplasty: Surgical Technique and Early Outcomes

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ABSTRACT

Background: Percutaneous-assisted arthroplasty was introduced to minimize complications traditionally associated with minimally invasive techniques, such as component malposition and periprosthetic fracture. Proponents of percutaneous-assisted techniques have more than 15 years of clinical utilization with good outcomes. This study reports our early experience, and outcomes, with an anterior percutaneous-assisted total hip arthroplasty (AnteriorPath).

Methods: A retrospective evaluation of a single-surgeon experience with the first 46 patients undergoing AnteriorPath using a cannula for acetabular cup instrumentation was compared with a similar-sized cohort undergoing traditional direct anterior (DA) total hip arthroplasty. Patients needed at least 2 postoperative visits for inclusion. Baseline preoperative characteristics, operative time, component positioning, and 6-week all-cause complications were evaluated. P values <.05 were considered statistically significant.

Results: Longer operative times were experienced with the AnteriorPath vs DA THA (93.6 minutes ± 38.6 vs 79.6 minutes ± 23.2, respectively, $P = .0503$). There were no significant differences in component abduction (40.14° DA vs 41.95° AnteriorPath, $P = .1058$). A statistically significant difference was found in component anteversion (32.8° DA vs 27.25° AnteriorPath, $P = .0039$). There were higher rates of short-term complications in patients undergoing DA THA (9.09% DA vs 2.5% AnteriorPath).

Conclusions: Early experience with an AnteriorPath demonstrates similar short-term outcomes compared with traditional DA THA. The use of a percutaneous technique has also allowed for a smaller incision, in-line acetabular cup reaming and impaction under direct visualization, and limited trauma to surrounding soft tissues. Further long-term studies with a larger sample size are needed to evaluate the potential benefits and complications of this novel technique

Introduction

Numerous minimally invasive surgical techniques have been described for total hip arthroplasty (THA), including modifications of the posterior, anterolateral, superior, and direct anterior (DA) approaches [1]. Reports of these procedures highlight possible advantages including decreased incision length, less postoperative pain, and faster recovery [1-3]. Prospective comparative studies, however, have not supported these early reported outcomes and have highlighted complications that may arise with smaller incisions [4-7]. Decreased intraoperative visualization, which can occur with minimally invasive techniques, has been associated with complications such as component malposition, periprosthetic fracture, and increased soft-tissue trauma [4,8-11].

Percutaneous-assisted total hip arthroplasty (PATH) using posterior and superior approaches was introduced in an attempt to minimize some of the complications reported with early minimally invasive techniques [12,13]. The first major series of PATH used a posterior approach [12]. This approach sought to address complications such as component malposition, increased blood loss, nerve injury, and intraoperative fractures while decreasing the soft-tissue trauma associated with prior minimally invasive techniques [12].

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The supercapsular approach with in situ preparation of the femur allowed for the subsequent introduction of a supercapsular PATH, known as the "SuperPATH" [13,14]. Through the use of an accessory port, both techniques allow direct in-line access to the acetabular cup via a portal outside of the main incision [12,13]. Proponents of these procedures now have more than 15 years of experience [12,13,15-19].

The DA approach has a long history of clinical utilization with excellent outcomes [20]. However, this approach presents some unique challenges including wound complications, lateral femoral cutaneous nerve injury, periprosthetic fractures, difficult femoral exposure and preparation, and the potential need for special instruments during acetabular reaming and cup placement [21-23]. These issues have previously hindered a surgeon's ability to shorten the length of the anterior incision. In an effort to limit these challenges through a smaller incision, we have used a percutaneous portal for acetabular reaming. This has allowed for wide visualization of the acetabulum, in-line acetabular reaming, and in-line cup impaction. The purpose of this study is to report our early experience and short-term outcomes with the anterior percutaneous-assisted total hip arthroplasty (AnteriorPath).

Material an methods

Ethics approval was granted by a local institutional review board. Over a 12-month period, a single surgeon in a total joint practice setting performed 46 DA THAs using a percutaneous-assisted (AnteriorPath) technique, utilizing a cannula for acetabular reaming and impaction of the acetabular component. This cohort was retrospectively compared against 48 patients who underwent traditional DA THA via a standard, single-incision technique in the immediate 12 months before the adoption of AnteriorPath. During the study period, all patients were examined by the senior author and deemed appropriate candidates for total hip replacement via an anterior approach (DA THA or AnteriorPath), without specific regard for age, gender, body mass index (BMI), or muscle structure. Patients with less than 2 postoperative visits and those with pre-existing spastic disorders were excluded from the study.

Baseline characteristics collected included age, BMI, operative site (left vs right), operative setting (inpatient vs outpatient), and preoperative diagnosis/indications for THA. Surgical outcomes of interest included operative time, component positioning (abduction and anteversion) on postoperative radiographs, and all-cause complications within a 6-week follow-up period.

Surgical technique

Preoperative planning, templating, and patient positioning

Preoperative digital templating (OrthoSize; Biomet, Inc.; Warsaw, IN) was performed from a standing anteroposterior (AP) radiograph of the pelvis with a radio-opaque size marker. Preoperative templating was used to plan for restoration of the hip center, leg lengths, offset, and implant sizing. The femoral stem template is positioned for a femoral neck cut that will start at the junction of the superior neck and the trochanter. The extent and direction of the neck cut with respect to the inferior femoral neck is determined by the size and position of the femoral stem on the template. The distance from the inferior femoral head to the templated cut on the inferior neck is measured and used intraoperatively. The senior author finds this to be more reproducible than measuring from the lesser trochanter, as the lesser trochanter is often difficult to palpate during anterior-approach hip surgery.

The patient is positioned supine on a Hana (Mizuho OSI, Union City, CA) table. Care is taken to ensure the pelvis sits neutral on the operative table. Preoperative radiographs were obtained before draping to confirm positioning and that appropriate radiographs could be obtained. We attempted to recreate the orientation of the pelvis found on preoperative standing radiographs for use as our AP radiographs during surgery. This sometimes required the position of the C-arm to tilt toward the feet or head, depending on the patient's native standing AP pelvis radiograph. The operative site is then prepped and draped superior to the anterior superior iliac spine (ASIS) and extending to the knee. Draping is kept medial and proximal to the ASIS, which will serve as a static landmark during the procedure.

Surgical approach

With the use of the cannula, we were able to make our incision more proximal and smaller than our typical incision for a standard anterior approach. This incision was started in line with tensor fascia latae (TFL), offset from the ASIS at 2 fingerbreadths (Fig. 1). From this position, the incision was taken distally as a straight line. The incision length is typically 4-5 cm and can be expanded depending on the case. The incision is through the skin and subcutaneous tissue and down to the fascia of the TFL. This fascial sleeve was entered, and the muscle peeled inferiorly as standardly described. Through this incision, palpation of the ASIS can be performed and then dropping the finger toward the floor marks the position of the superior neck and allows for superior retractor placement. A Meyerding retractor is then used to help elevate the sartorius and both heads of the rectus with electrocautery. Care is taken to coagulate the ascending branches for the lateral femoral circumflex artery, if visualized. An anterior retractor is now placed on the anterior rim of the acetabulum and a second retractor on the inferior femoral neck. A capsulectomy is then performed. The femoral neck cut is then made, followed by clearing of the labrum and pulvinar.

Acetabular preparation

A total of 3 retractors are used for acetabular visualization. Anterior superior and anterior inferior retractors are held by an ipsilateral side of the table assistant. An inferior acetabular retractor was also placed (Fig. 2). At this point, the MicroPort outrigger (MicroPort Orthopedics, Inc.; Arlington, TN) is used to aim and pass a cannula through a 1-cm incision (Fig. 3). This incision was typically distal and more lateral to our larger more proximal incision (Fig. 4). Care is taken to keep the hip and thigh in a neutral position of zero degrees of internal or external rotation. The cannula typically passes through the belly of the vastus lateralis. The external portal placement guide is removed, leaving the cannula in place (Fig. 5). Based on the preoperative template, a reamer

Figure 1. The patient is positioned supine; a 4-cm incision is made 2 fingerbreadths from the ASIS (the dot is marked medial to the incision).

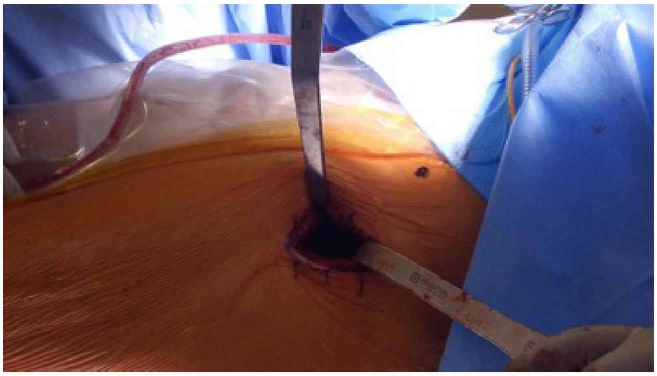

Figure 2. Acetabular visualization is achieved using a combination of retractors.

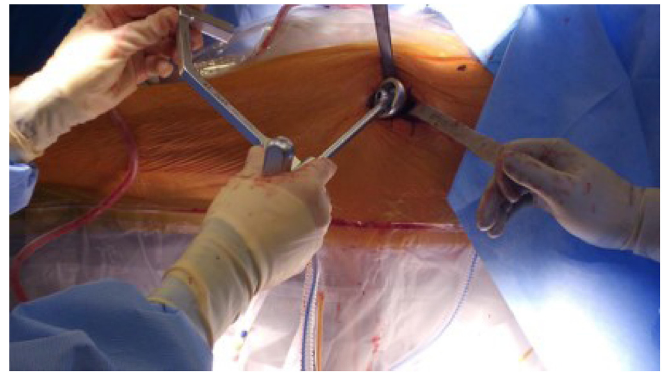

Figure 4. The acetabular component of the guide is introduced into the main incision, and the guide is used to plan a distal incision.

2 sizes smaller than the predicted size cup is placed into the acetabulum through the main incision and connected to the reamer drive shaft inserted through the cannula (Fig. 6). Care is taken to pass the sharp edge of the reamer basket over the inferior retractor to avoid soft-tissue damage. Direct visualization of the reaming process occurs easily through the main incision and can be checked fluoroscopically if needed (Fig. 7). After sequential reaming to size, the chosen acetabular implant is placed through the main incision and partially impacted using an impactor handle passed through the cannula. The polyethylene is similarly passed through the main incision and impacted through the cannula. All patients were implanted a Dynasty acetabular component with a standard polyethylene liner and a ceramic head of appropriate neck length (MicroPort Orthopedics, Inc.; Arlington, TN). Definitive impaction is completed through the cannula under fluoroscopic guidance. At this point, the cannula is removed and the incision is eventually closed as noted in the following sections.

Femur preparation and component implantation

The femur is prepared using a standard technique and entirely through the main incision. The Hana (Mizuho OSI, Union City, CA) table hook for femoral elevation is used to aid exposure. As the main incision using AnteriorPath can be made more proximal, the senior author subjectively finds femoral preparation to be easier than a more distal standard DA approach incision. Once an appropriate femoral trial size is found, a trial reduction was performed. The neck and head insertion on the femoral broach occurs through the main incision. An intraoperative fluoroscopic AP radiograph of the operative hip is printed, and using an overlay technique, comparison of leg lengths and femoral offset is performed. The final femoral component and head were then placed followed by final radiographs. All patients had implanted a Profemur Preserve or Profemur TL stem (MicroPort Orthopedics, Inc.; Arlington, TN), depending on preoperative templating. Stability evaluation occurs on the table with a shuck test and recording hip stability in internal and external rotations and evaluating for any dislocation or subluxation.

Wound closure

Closure of the main wound occurred via a layered fashion. Running suture was used for the TFL fascia. Subcutaneous closure with interrupted sutures is followed by skin closure with a topical skin adhesive mesh. The distal incision is closed with one or 2 interrupted subcutaneous sutures followed by topical adhesive mesh for the skin. Finally, sterile dressings are applied to the larger proximal incision, and to the smaller distal incision.

Results

There were no statistically significant ($P > .05$) differences in baseline characteristics including age and BMI (Table 1). The majority of patients included in this study underwent surgery in an inpatient setting (95.8% DA THA vs 88.6% AnteriorPath). The most common preoperative diagnosis/indication was osteoarthritis (72.9% DA THA vs 84.1% AnteriorPath; Table 1).

Longer operative times were experienced using the AnteriorPath than when using the traditional DA THA (93.6 minutes ± 38.6 vs 79.6 minutes +/- 23.2, respectively), although this was not statistically significant ($P = .0503$) (Table 2). There was no

Figure 3. A readily available and standard MicroPort® outrigger guide was used for acetabular cannula placement.

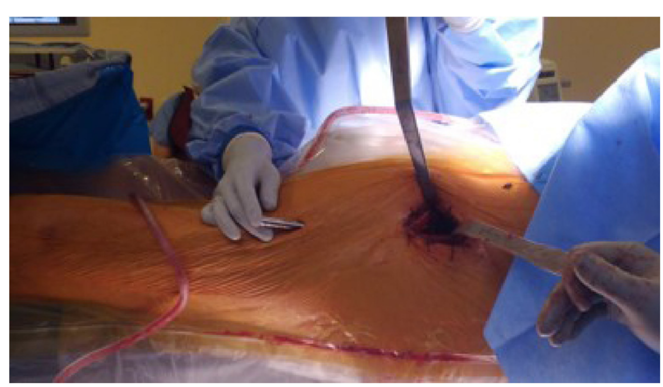

Figure 5. A 1-cm incision is made distal and lateral to the proximal incision. The guide is removed, and the cannula port is left in place.

Figure 6. Appropriately sized acetabular reaming cups are introduced via the main incision and connected to the reamer introduced via the distal cannula.

significant difference in component abduction (40.14° DA THA vs 41.95° AnteriorPath, $P = .1058$). However, a statistically significant difference was found in regard to component anteversion (32.8° DA THA vs 27.25° AnteriorPath, $P = .0039$). A higher rate of short-term complications were seen in the traditional DA THA group (6.2% DA vs 2.5% AnteriorPath, Table 2), including one revision for aseptic component loosening, one revision for heterotrophic ossification, and hip flexor tendonitis.

Discussion

Percutaneous-assisted surgical approaches to the hip were developed to overcome the challenges and augment the benefits of existing minimally invasive hip arthroplasty [13,14]. Proponents of these procedures including the PATH and SuperPATH have more than 15 years of clinical utilization experience with favorable outcomes including proper component positioning, low dislocation rates, and shorter lengths of stay, even during a learning curve period [12,13,15-19]. In this study, we report our early experience with an AnteriorPath showing similar short-term outcomes as compared with the standard DA approach.

The use of an anterior approach to the hip has been well described ever since its early introduction by Hueter and Smith-Petersen [20,24-26]. The success of this approach in the setting of THA has also been reported in large case series [20,24]. Multiple studies to date have reported significantly lower rates of hip dislocation and faster recovery times owing to the preservation of native musculature via the anterior approach [25-29]. Similar to other approaches, this technique has faced unique challenges including wound complications, lateral femoral cutaneous nerve injury, periprosthetic fractures, difficult femoral preparation, and cup malposition, which have been especially highlighted in overweight populations [21-23,27]. The use of a percutaneous acetabular reaming technique via the anterior approach has been reported once before in the current literature [25]. The authors of that study stated that this technique allowed for easier cup positioning in large and obese patients but did not provide individual results associated with this procedure in a more general population [25].

The results of our single-surgeon experience with the first 46 AnteriorPaths demonstrates slightly longer operative times but similar component positioning and short-term clinical outcomes compared with a traditional DA THA. Interestingly, lower rates of short-term all-cause complications were experienced in this series using the AnteriorPath (6.2% DA THA vs 2.5% AnteriorPath, Table 2). Acetabular positioning was noted to be similar in abduction (40.14° DA THA vs 41.95° AnteriorPath, $P = .1058$, Table 2) but slightly less anteversion (32.8° DA THA vs 27.25° AnteriorPath, $P = .0039$, Table 2). This may be attributed to direct in-line reaming of the acetabular cup allowed by the accessory portal.

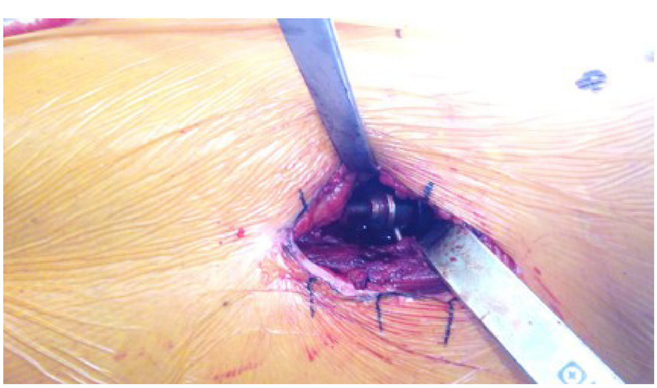

Figure 7. Acetabular cup reaming is carried out via the distal cannula port, allowing for direct in-line visualization in addition to the standard fluoroscopic guidance.

Table 1
Preoperative patient demographics.

Patient characteristics	Direct anterior THA	AnteriorPATH	*P* values
	Total n = 48	Total n = 44	
Age (y)	63.90	68.50	.0512
SD (±)	11.83	9.36	
Age range	28-83	48-93	
Height (cm)	1.70	1.69	.5274
SD (±)	0.10	0.11	
Weight (kg)	83.11	82.71	.9267
SD (±)	17.66	21.89	
BMI	28.68	28.78	.9374
SD (+/-)	5.44	5.86	
Left side	15	22	
Right side	33	22	
Inpatient	46	39	
Outpatient	2	5	
Preoperative diagnosis or indication			
Osteoarthritis	35	37	
Paget's disease	0	1	
Avascular necrosis	11	0	
Malignant tumor or metastasis	0	2	
Benign tumor	0	2	
Conversion THA	2	3	
Revision THA	0	1	

Table 2
Surgical outcomes and complications.

Outcome	Direct anterior THA	AnteriorPATH	*P value*
Operative time (minutes)	79.61	93.68	.05028
SD (±)	23.21	38.67	
Component abduction	41.95	40.14	.10582
SD (+/-)	4.41	5.31	
Component anteversion	32.80	27.25	**.00386**
SD (±)	7.23	7.89	
All-cause 6-week complications			
Dislocation	0	0	
Component loosening	1	0	
Intraoperative fracture	0	1	
Heterotopic ossification	1	0	
Hematoma or seroma	0	0	
Hip flexor tendonitis	1	0	
Proximal wound dehiscence	0	0	
Cannula port dehiscence	0	0	
Total	3 (6.2%)	1(2.5%)	

Statistically significant *P*-values ($P < .05$) are given in bold.

Potential weaknesses of this study include its single-center, single-surgeon design with a relatively small group of patients and short-term follow-up. In addition, one major limitation in this study is its retrospective design, and we acknowledge that a randomized controlled trial would allow for stronger conclusions. Long-term studies with a larger sample size are needed to further evaluate any potential benefits and complications of this modified technique.

Conclusions

The purpose of this study is to present a proof of concept for a novel technique in THA, which may benefit patients and aid the surgeon. The use of percutaneous techniques has allowed us to limit the size of our incision and permitted in-line reaming under direct visualization, all while limiting trauma to the surrounding soft tissues. Although we did note longer operative times during implementation of the new technique, the short-term results presented here were similar to those of a cohort studied just before transition.

Conflict of interests

M.J. Seidel is a consultant for MicroPort (hardware used in this study). However, no royalties were received in relation to this study; he is also a paid speaker for Microport Orthopedics to teach the technique described in this article; all other authors declare no potential conflicts of interest.

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