Review Article

Recovery and outcomes of direct anterior approach total hip arthroplasty

Jeffrey J. Barry, John L. Masonis, J. Bohannon Mason

OrthoCarolina Hip & Knee Center, Charlotte, NC 28207, USA

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Correspondence to: J. Bohannon Mason. OrthoCarolina Hip & Knee Center, 2001 Vail Ave, Suite 200A, Charlotte, NC 28207, USA.
Email: bo.mason@orthocarolina.com.

Abstract: The adoption and utilization of the direct anterior approach (DAA) for total hip arthroplasty (THA) has increased significantly over the past decade. This review presents the available literature for early recovery and outcomes of the DAA THA. A growing body of evidence points towards superior early recovery and early functional outcomes with the DAA in experienced hands compared to posterior and lateral based approaches in regards to pain, opioid use, length of stay, and early markers of mobility. In an era of rapid recovery protocols, the DAA with its early pain and functional advantages can effectively deliver safe and effective value for the total hip population.

Keywords: Direct anterior approach (DAA); rapid recovery total hip arthroplasty; early outcome anterior hip

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Introduction

Total hip arthroplasty (THA) is recognized around the world as one the most successful surgical procedure in medicine, some even going as far as calling it the "surgery of the century." (1). For patients with debilitating arthritis of the hip, the ability of THA to relieve pain, improve function, and add to quality of life is unmatched (2). In the evolving era of value based care, it is a standard for other procedures (3,4). Yet, the overall success of THA equates a high standard for change to accepted practice, including surgical approaches used for THA.

Utilization of the direct anterior approach (DAA) THA has increased rapidly over the past 10–15 years. Recent efforts to perform hip reconstruction through tissue sparring means, hasten recovery, decrease costs, and improve outcomes has driven the rapid adoption of DAA for primary THA. The approach and interval is not new to the orthopaedic reconstruction community. The DAA was first described by Heuter in 1883 (5) and then reemerged with slight variations in the 1940's by Smith-Peterson (6) and Judet and Judet (7). Modern iterations of the inter-nervous, inter-muscular Heuter interval between the tensor fascia and sartorius muscles all address the desire to minimize muscle damage and potentiate functional gains postoperatively (8-15).

The topic of early recovery and function after a DAA THA has been debated in recent years (in part due to the marketing/industry implications—see separate article by Dr Martin in this journal edition). The literature is now replete with studies of varying design and rigor, making systematic reviews and meta-analyses necessary. With this review, our goal is to present the available cogent literature covering DAA THA early recovery and outcomes.

Length of surgery

Critics of the DAA often cite longer operative time compared to posterior or lateral based approaches. Numerous studies including all of the RCTs reported to

date found operative times for DAA to be longer than other approaches (16-24). A systematic review of 25 studies by Meermans *et al.* (25) found "consensus" that the posterior approach was quicker. Meta-analysis by Yue *et al.* (26) analyzing 12 studies comparing DAA to anterolateral/lateral approaches found DAA slower by an average 7.99 mins (95% CI, 2.38–13.6). Higgins *et al.* (27) in a meta-analysis of 17 total studies comparing DAA to posterior found a trend toward longer operative time but not significant (average 7.9 mins with 95% CI, –1.8 to 17.7 mins). Fewer studies have found no difference (28-31) or posterior to be longer (32).

The comparability amongst studies remains a limitation for many of the variables presented. Many studies have different surgeons performing the posterior/lateral and anterior approaches often with varying experience (24,29,32-41). Additionally, those studies that are consecutive nonrandomized series using single surgeons include surgeons who are well experience in posterior then transition to anterior or are just outside the anterior learning curve of 50–100 cases (16,28,30,42,43). As a result, the implications of the learning curve may be the main finding. This is illustrated by Zawadsky *et al.* (30) where a single surgeons first 50 cases were significantly longer than his posterior approach. His times equalized however for cases 50–100 of the DAA. In looking at many of the "founder" operative times (meaning those surgeons utilizing the approach as their standard approach prior to widespread adoption), surgical time is also similar to most of the published posterior approach results: Light *et al.* (12)—64 minutes on average cementing both components, Kennon *et al.* (10) 51 minute average, Matta *et al.* (14)—75 minutes on average. Rodriguez *et al.* (29) found when comparing operative times between experience surgeons of each approach, there was no significant difference in surgical time.

We conclude that the DAA THA has longer operative times during the initial learning period of the DAA. Surgical times move toward equalization as a surgeon gains experience with the approach.

Blood loss

The literature regarding estimated surgical blood loss (EBL) relative to approach is mixed. Studies documenting increased EBL with DAA are consistently the same studies that document increased operative times (16,17,21,22,28). Others found no difference (18,19,23,31,32). Meermans *et al.* (25) in their systematic review report they are unable to draw conclusions regarding blood loss. The two available meta-analyses also found no significant difference in blood loss variables yet when compared to posterior approach there was trend towards higher EBL in DAA and when compared to lateral approach a trend towards fewer transfusions in the DAA group (26,27).

Similar to operative time, the influence of surgeon experience on these results cannot be ignored. Additionally, accuracy of blood loss estimates are widely variable and collection mechanisms often flawed. Postulated reasons for increased EBL in DAA include the supine positioning of DAA allowing more blood loss after acetabular reaming, more difficulty controlling posterior femoral neck/capsular bleeding, longer OR time, the less extreme positioning of the femur that does not kink the vessels to the same degree (44). All of the above are minimized with surgeon experience and technique, regional hypotensive anesthesia, and tranexamic acid. It is our conclusion that EBL of the DAA is higher than that of the posterior approach during the initial learning period of the DAA but equalizes or the difference is clinically insignificant in experienced hands with modern anesthetic techniques.

Pain

Numerous studies ranging from retrospective comparisons to randomized controlled studies have found lower pain and/or decreased narcotic consumption at early postoperative time points with the DAA (17,19,21,22,24,30,39,45,46). With an approach that minimizes muscle trauma, decreased early postoperative pain has been proposed as an advantage of the DAA. All studies reviewed which reported superior early pain scores with DAA found equalization of scores by the 6-week mark except one comparison between DAA and direct lateral the pain advantage was significant up to 1 year (19). No studies have demonstrated superior pain scores with either the posterior or anterolateral/direct lateral approaches, although several did report no significant difference (29,40). Interestingly Zawadsky *et al.* (30) found more pain in their standard posterior approach compared to the DAA even during their learning curve of the first 50 cases when one might expect more tissue trauma or longer operative times.

The limitation of the above studies include variance in pain protocols and different surgeons. Additionally it is important to acknowledge that statistical difference in VAS scores may not always reach the reported minimal clinical important difference (MCID) (47). Despite these

limitations, the data points towards a decrease in the pain experience in the immediate postoperative period.

Markers of tissue damage

As the inter-nervous, inter-muscular DAA claims to be minimally invasive and soft tissue friendly, several studies have tried to quantify that claim using evaluations of muscle injury or serum markers of inflammation. Meneghini *et al.* (37) in a cadaveric study compared DAA versus posterior approach and found muscle damage did occur in both approaches though significantly more damage to the medius and minimus was found in the posterior approach. The DAA did have some damage to the TFL and rectus direct head. Additionally, while all the posterior had conjoint/piriformis release, half of the DAA patients had an intentional conjoint tendon release for femoral exposure. Bremer et al performed an MRI of DAA compared to trangluteal approaches one year post-operative and reported more fatty atrophy, tears and tendinosis of the posterior abductor musculature in the posterior group with no difference in the tensor fascia lata (48).

Three studies have found higher serum creatinine kinase (CK) levels in the posterior approach in the early postoperative period (22,32,39). While CK levels are markers of muscle damage, the clinical relevance of the absolute increase seen in these studies is unknown. Poehling-Monaghan *et al.* (39) found that CK levels did not correlate with functional outcomes or pain even though higher levels were seen in the mini-posterior group. Rykov *et al.* (23) found in their recent RCT no difference between DAA and posterior serum markers at all time points. They point out that their use of spinal anaesthetic, perioperative steroids and tranexamic acid may have contributed to their findings and minimized any true difference in muscle damage that may exist.

To summarize, there may be higher levels of direct muscle injury in the posterior approach. With the data available, the inflammatory and systemic response to that damage relative to true clinical recovery requires further study.

Length of stay

Hospital length of stay has been proposed as a surrogate marker for the speed of recovery postoperatively. Unfortunately, multiple variables often muddle conclusions regarding length of stay including different surgeons, different postop protocols, and different countries. It is difficult to make definitive conclusions in a modern reconstruction joints practice given the average length of stay and discharge to skilled nursing facility has decreased significantly in most centers since the implementation of rapid recovery protocols. However, the preponderance of data on length of stay favorably argues for shorter length of stay with DAA *vs.* posterior or direct lateral approach (17-19,22,30,38,45,46,49). Meta-analysis of the higher quality studies favor the direct anterior *vs.* the posterior approach [weighted mean difference 0.53 days (95% CI, −1.01 to −0.04 days)] and the lateral approaches [weighted mean difference 1.19 days (95% CI, −2.08 to −0.3 days)] (26,27). Location of discharge (home *vs.* placement) did not reach significance in meta-analysis of DAA *vs.* posterior but strongly trended towards favoring the DAA (RR 1.1, 95% CI, 0.97–1.23) (27). A recent study by Kamath *et al.* (49) found that in the Medicare population with rigorous matching criteria, experienced DAA surgeons (greater than 500 prior cases) had significantly shorter hospital LOS compared to other approaches (2.06 *vs.* 2.98, P<0.0001). Similarly, DAA patients of this experienced group utilized post-acute care resources at a much lower rate than other approaches (12% *vs.* 29% skilled nursing P<0.001).

Interestingly, if you analyze studies that only utilize the same surgeon (assumption being clinical experience, patient education, postoperative protocols being the same) all found advantages in shorter length of stay for the DAA (18,19,22,30). Martin *et al.* (18) in a retrospective non-randomized study reported shorter length of stay between DAA and posterior (2.9 *vs.* 4.0 days, P=0.001) with surgical approach predictive of length of stay in multivariate regression analysis (P=0.009). A few studies have reported no difference in length of stay (20,21,23,29,39). No studies have shown inferiority of the DAA relative to length of hospital stay.

Functional outcomes (walking distance, gait aids, gait analysis)

Note: Traditional quantitative outcomes of dislocations, restoration of leg length, and radiographic outcomes are covered in other articles of this journal edition.

Walking and activity

Many studies that have analyzed walking distance or

functional activity have found advantages in the early postoperative period following DAA (17,18,22,24,28,29,36). Rodriguez *et al.* (29) found DAA associated with better timed up and go (TUG) and M-FIT™ testing immediately postop and at 2 weeks that equalized by later time points. They also found in hospital milestones were met faster but outpatient milestones such as return to work and driving to be equivalent. Barrett *et al.* (17) in their RCT found more patients able to do stairs and unlimited walking at 6 weeks and 3months compared to the posterior approach that equalized at 6 and 12 months. Nakata *et al.* (28) found better walking speed for the DAA at 3 weeks as well as 1 week earlier ability to perform a single leg stance for 5 secs. In a randomized control trial comparing DAA *vs.* posterior in experience surgeons, Taunton *et al.* (24) found patients in the DAA group took more daily steps at 2 weeks postoperatively (3,897 steps/day DAA *vs.* 2235 steps/day mini-posterior, P<0.01) as well as spent a higher percentage of the day active postoperatively at 2 weeks (11% DAA *vs.* 7% mini-posterior, P<0.01) and 8 weeks (17% DAA *vs.* 13% mini-posterior, P=0.01).

Other studies found no difference between the DAA and other approaches for attainment of gait milestones such as the 10m walk test (21), walking unlimited distance (39,40,46), navigating stairs (39,40,46), or performing ADLs independently (39,40,46). Engdal *et al.* (33) found no difference between the major three approaches when using activity trackers for the first week postoperatively with all patient being very active at over 2,000 steps/day and an average of 3.5 hours upright/24 hrs. No studies have found activity advantages extending beyond the 3month mark.

Gait aids

Multiple studies have found a faster time to discontinuation of assistive devices (24,28,30,40,46). Three prospective randomized controlled trials, Christensen *et al.* (46), Taunton *et al.* (40), and Taunton *et al.* (24) found sooner discontinuation of assistive devices with DAA compared to posterior when specific activity logs were kept (33 *vs.* 43 days, P=0.03; 22 *vs.* 28 days, P=0.04; and 17 *vs.* 24 days, P=0.04 respectively). Taunton et al(24) in their RCT found DAA patients discontinued use of a walker 5 days sooner than mini-posterior patients (10 *vs.* 15 days, P=0.01) and were able to navigate stairs sooner as well (5 *vs.* 10 days, P<0.01). Zawadksy *et al.* (30) and Nakata *et al.* (28) found fewer patients requiring aids at 2 weeks/6 weeks and 3 weeks respectively with the DAA compared to posterior. Zawadsky *et al.*'s (30) work would suggest the learning curve played no effect in this advantage as well as both learning curve and post-learning curve groups held this gait aid advantage over posterior approach patients in their study.

Gait analysis

Four studies examining spatiotemporal gait analysis have not seen any difference between the DAA, posterior or lateral approaches postoperatively (34,35,41,50). All studies were performed beyond 6 months postoperatively with the exception of Reininga *et al.* (41) that started at 6 weeks. It is possible the early advantages to gait were missed by the later time points analyzed. These studies also interestingly point to persistent gait abnormalities in all groups compared to healthy controls even at 1 year postop. The authors suggested that the mechanism of these lasting abnormalities was altered gait mechanics and muscle mass preoperatively which carried over into the postoperative period even after elimination of pain.

Patient reported outcomes

Many papers have looked at patient reported outcomes scores after direct anterior hip arthroplasty. Time points of assessment, as well as outcome scores assessed, are variable across studies. The most commonly collected validated scores were Harris Hip Score (HHS) (51), Western Ontario and McMasters Universities osteoarthritis index (WOMAC) (52), SF-36 (53), hip disability and osteoarthritis outcome score (HOOS) (54). The vast majority of studies have found equally excellent postoperative scores after THA regardless of approach ranging from 2 weeks postoperatively to 5 years postoperatively (18,21,23,24,29, 34,36,39,40,55). Two studies found a significant advantage between the DAA and the lateral approach (19,56). Restrepo *et al.* (56) reported higher WOMAC and HHS scores that lasted up to 2 years postoperatively. Ilchmann *et al.* (19) also found higher HHS scores compared to the lateral approach at 6 weeks, 12 weeks and 1 year postoperatively. Zhao *et al.* (22) is the only study to report higher HHS scores at 3 months for the DAA compared to the posterior approach in their RCT. This difference however disappeared by 6 months postoperatively. Interestingly, when DAA THA patients were compared to healthy controls, the HHS scores equalized by 6 months and the SF-36 physical component scores improved up to 1 year postoperatively to just short of the control group (57). Our interpretation of the above data is that the anterior approach, similar to the posterior approach, offers an excellent patient experience in improvement in function and pain postoperatively. There

may be an advantage over the lateral approach likely related to abductor disfunction that is experienced by the patients during recovery. Some of the ambiguity in patient reported outcome measures may be attributable to the insensitivities of this mode of testing. Additionally, a ceiling effect of many of these scoring metrics may prevent differentiation between groups.

Survivorship

With the relatively recent adoption of DAA techniques, it is not surprising that comparative long-term survivorship data of the DAA is lacking in our literature. It will be exciting to follow the approach through the growing registries across the globe as more data and follow-up becomes available. Specific complications of the DAA will be covered in a separate article of this journal series. Angerame *et al.* (58) in their review of 2,431 DAA hips by experienced DAA surgeons found an early revision rate (<5 years postoperatively) of only 1.69% with no statistical difference compared to posterior hips from the same institutions. The anterior total hip arthroplasty collaborative investigators reported in their early series of DAA THA from some of the early adopters of the approach a revision rate of 2.7% (59). de Steiger *et al.* (42) reported a 3% revision rate at 4-year follow-up when analyzing one hip system from the Australian registry. Reichert *et al.* (55) found in their retrospective series of their institutional experience only 1 revision in 85 patients at an average 3.7 years of follow-up. Müller *et al.* (43) reported 5-year survivorship from the DAA 94.6%. They however demonstrated an interesting caveat regarding the learning curve. Their senior surgeons first 20 cases survivorship was only 78.9% then improved to 96.8% at 5 years for subsequent cases. The junior faculty however, having learned from the senior surgeon, had a 97.7% 5-year survival which they argued may point to being able to teach the lessons of the learning curve to training surgeons. We would also caution close interpretation of studies such as Eto *et al.* (60) and Meneghini (61) where they report high rates of revision after the anterior approach without any way of identifying the overall sample population numbers. Long term survivorship data from registries and large studies should be available in the near future and warrants close interpretation for surgeons interested in utilizing the DAA.

The learning curve

As it is always brought up in discussion about the DAA, we felt it prudent to address the learning curve of the DAA as it relates to recovery and outcomes. Most of the literature points to the first 20–50 cases constituting the learning curve of the DAA (30,42,43,59). It is during this time period that higher complications can be seen by surgeons adopting the approach when compared to more experienced surgeons or to themselves with approaches with which they are more familiar. We feel this likely would be seen with any surgeon performing any procedure for the first time and so comparisons between experts and novices can be misleading. The majority of surgeons are exposed to the posterior approach during residency and so the learning curve occurs under the guidance of attending physicians. Lee *et al.* (31) evaluated his first 50 cases (25 DAA, 25 posterior) after fellowship training in both approaches and found no significant difference in variables assessed. As mentioned previously, Müller *et al.* (43) found better survivorship for junior surgeons without evidence of a learning curve phenomenon when they had trained from a senior surgeon outside his learning curve. Comparing the first 50 posterior approaches of a novice surgeon to an experience DAA surgeon would likely have vastly different results than comparing experienced surgeons in both approaches. It is our belief that moving forward experiences such as reported by Woolson *et al.* (16) will be less frequent as DAA training and the learning from a post-training environment shifts towards the safety of residency and fellowships like the majority of orthopaedic surgical procedures.

Conclusions

A growing body of evidence points towards superior recovery and early functional outcomes with DAA in experience hands compared to posterior and lateral based approaches.

- Length of surgery is comparable to other approaches though increased surgical duration may persist even in expert hands given the utilization of intraoperative fluoroscopy. (The advantages of fluoroscopy for component position accuracy should be weighed against surgical time increases).
- Blood loss is equivalent to other approaches when utilizing modern anesthetic and surgical techniques.
- Pain and narcotic usage are decreased during the first 6 weeks postoperatively with DAA compared to other approaches.
- Many studies indicated less muscle injury with DAA compared to posterior or lateral approaches, though

further study of the impact on clinical recovery implication is needed.

- ❖ Length of stay is decreased with DAA with a trend towards more frequent discharge to home.
- ❖ Discontinuation of gait aids occurs approximately 1 week sooner with DAA and patients walking distance and functional activity is higher during the early postoperative period.
- ❖ Current patient reported outcome measures are similar between approaches, however this may be a function of metric limitations and a ceiling effect, and further study is indicated.
- ❖ Early implant survivorship is both excellent and equivalent to other approaches though long term (>5 year) data is lacking.
- ❖ With more widespread adoption and integration into residency education, the learning curve and its effects on measurable variance will diminish.

In a modern orthopaedic total joint practice, rapid recovery protocols are becoming widespread and increasingly incentivized. The DAA with its early recovery and functional benefits can effectively deliver safe and effective value-based care for the total hip population.

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Footnote

Conflicts of Interest: JL Masonis, Consultant and Royalties: Medacta, Zimmer/Biomet, Smith & Nephew. JB Mason. Consultant for DePuy Synthes and Receives Royalties for intellectual property transfer unrelated to the subject of this article.

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