Complications and pitfalls of direct anterior approach total hip arthroplasty

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Abstract: As the number of primary total hip arthroplasties (THA) utilizing the direct anterior approach (DAA) increases it is important to understand the complications and potential pitfalls of this approach. We review the literature for the learning curve, potential for nerve damage, fracture risk, revision risk, radiation exposure, potential for increased blood loss and wound complications or infection associated with the DAA. We suggest surgeons consider their training prior to adopting this approach to limit the learning curve associated and use careful patient selection to potentially limit wound complications and deep infection.

Keywords: Total hip arthroplasty (THA); direct anterior approach (DAA); learning curve; complications

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Introduction

The direct anterior approach (DAA) for total hip arthroplasty (THA) was developed as a intermuscular and internervous surgical approach utilizing the plane between the tensor fasciae latae and the sartorius muscle (1). The number of primary THAs performed utilizing the DAA is increasing (2,3), and it is important for surgeons adopting this approach to understand the potential complications and pitfalls in order to decrease the risk of failure and potential for patient harm. In this review, we will discuss; the learning curve associated with this approach, the potential for nerve damage, fracture risk, revision risk, intraoperative fluoroscopy and radiation exposure, the potential for increased blood loss, and wound complications or deep infection as associated with the DAA for THA.

Technical learning curve

The "learning curve" that is often cited in DAA for THA is not unique to this approach (4), however, it is important to consider as surgeons adopt the DAA into their practices. The anterior total hip arthroplasty collaborative (ATHAC) reviewed a multicenter cohort of 1,152 patients undergoing THA with a DAA and found a decline in complications in surgeons with greater than 100 case experiences (5). Masonis *et al.* also note a reduction in operative time and fluoroscopy after the initial 100 cases (6). Another study has broken down this early learning curve even further and found that within the first 100 cases proficiency improves after 40 cases with more marked improvement after 60 cases (7).

The learning curve for this approach may decrease based on how surgeons are trained on the DAA for THA. Spaans *et al.* did not observe any learning effect after 46 patients (8). However, the two surgeons in this study had internal education and training on cadavers that was supervised by a surgeon experienced in the DAA, and this surgeon assisted and supervised the early operations.

The learning curve described may also be due to previous generations of surgeons without residency or fellowship training in the DAA. Short term major complication rates of up to 9%, average surgical times of 164 minutes, and estimated blood loss of 858 mL have been described by community practice orthopaedic surgeons adopting this approach without residency or fellowship training in the DAA (9).

Nerve damage

The DAA has evolved since its original description by the German surgeon Carl Heuter in 1870 with modifications by Smith-Peterson and Judet and Judet (10). The continuing evolution of the DAA approach makes interpreting the literature on rates of lateral femoral cutaneous nerve (LFCN) injury difficult as there are wide discrepancies reported from 0.1% to 81% (11-14). This is likely related to the variability in skin incision and deep dissection described for the anterior approach (15). Restrepo *et al.* report a prevalence of 2% LFCN palsy in their prospective randomized study of DAA *vs.* direct lateral approach for THA (11). The authors attribute this low rate of LFCN injury to the modification of blunt dissection between the Sartorius and tensor fasciae latae. By using a more lateral incision away from the lateral border of the sartorius muscle as reported by Judet and Judet (16), careful dissection, and confining the DAA to the area inferior and lateral to the anterior superior iliac spine, the injury rate should not exceed 1/3 of cases based on the anatomical course of the LFCN (15).

Other authors have proposed the "bikini" incision to be used for the DAA (17), this modification utilizes a short oblique skin incision following the anatomic skin crease of the groin. Leunig *et al.* found equivalent rates of LFCN symptoms utilizing the so called "bikini" incision compared to a classic longitudinal incision with the DAA for THA with significantly shorter and narrower scars in the "bikini" incision group (17). These authors included thinner patients and more females in the study group which introduce selection bias confounding their results and they acknowledge that they present a feasibility study with preliminary results.

The LFCN is purely a sensory nerve and injury generally manifests as numbness in the anterolateral region of the thigh, however, patients may report burning or dysesthesia (15). Goulding *et al.* administered self-reported questionnaires to 132 patients who underwent DAA for THA (55 patients) or hip resurfacing (77 patients) and found rates of LFCN neuropraxia of 67% and 91% respectively (13). However, they also looked at functional limitation scores and reported no functional limitations in their patient's due to LFCN neuropraxia as measured by the SF-12, WOMAC and UCLA scores.

Branches of the superior gluteal nerve are at risk as well. The terminal branches of the inferior branch of the superior gluteal nerve innervates the tensor fasciae latae (18) and are at potential risk during the DAA. Care must be taken as insufficient exposure during broaching may lead to direct damage to the fibers of the tensor fasciae latae muscle including the motor nerve branches (19-21). Grob *et al.* performed an anatomical study with cadaveric dissection of the course of the nerve branch to the tensor fasciae latae muscle and found that coagulation of the ascending branch of the lateral circumflex femoral artery and placement of retractors during the DAA carry the potential for injury to its motor branches (22). In this same study, they present a case of post-operative atrophy to the tensor fasciae latae after the DAA. However, they question the clinical relevance of this complication as they state the patient had excellent clinical and functional results with merely a cosmetic difference.

Fracture risk

Evolution of specialized instrumentation has facilitated most minimally invasive approaches to the hip, and this is not unique for the DAA (23). Modified fracture tables are commonly used in the DAA for THA which has a mobile foot attachment for rotation of the leg. The use of these specialized tables must be done with great care as fractures attributable to their use have been reported. Matta *et al.* report on a series of 437 patients with the DAA on a modified fracture table, and noted three ankle fractures and two femoral shaft fractures potentially attributable to the use of the table (24). Woolson *et al.* report on a group of five community hospital surgeons, four of whom trained on this approach by visiting and observing the DAA and the other had no formal training, in this study they found that with the use of a fracture table there was a 0.8% (2/247) rate of femoral shaft fracture and 5.7% (14/247) rate of proximal femoral or greater trochanteric fracture (9). De Geest *et al.* evaluated their first 300 cases of DAA for THA and found two femoral perforations, three calcar fractures and three greater trochanter fractures with using a modified table (25). They also noted that the complication ratio decreased through their series, attributable to the learning curve of the approach and the familiarity to the specialized table utilized. Similarly, Jewett and Collis describe their experience with 800 THA performed with the DAA on a fracture table and note the main intraoperative complications of trochanteric fractures and perforations occurring mostly early in their series (26).

Post-operative periprosthetic femoral fracture incidence ranges from 0.47% to 7.1% for primary cementless THA across a variety of approaches (27). Advanced age, female sex, and body mass index (BMI) (23,27,28) have been reported as risk factors for periprosthetic fractures. In a review of 500 THAs performed through the DAA, Hartford *et al.* found a rate of 2% (10/500) post-operative periprosthetic femur fractures and risk factors were female sex and body mass index (BMI) >40 (29). The authors also note that while they found a decline in the rate on intraoperative fractures noted after the first 100 patients the rate of post-operative fracture remained steady throughout the series.

While great care should be taken to avoid any fracture during the DAA for THA, we found only one study which evaluated the risk of early post-operative periprosthetic fractures with the DAA with a surgeon outside of his learning curve and the authors found a low, 0.9% (26/2,869) periprosthetic fracture rate (23). They found that increasing age was the only risk factor associated with fracture, and after logistic regression analysis the age-fracture association was only found with female sex. The authors suggest that the DAA for THA is a safe technique in a suitable patient population and careful consideration for different femoral stem design or approach in elderly female patients.

Revision risk

While there is a concerning trend of increasing early THA failures rates within 5 years of the primary procedure in the last decade (30,31) the literature is unclear how that relates to the increase in DAA for THA. Meneghini *et al.* retrospectively reviewed 478 early revision THA cases performed within 5 years post-operatively at three academic centers and found revisions due to early femoral failure more common in patients with the DAA (57/112; 50.9%) than the direct lateral approach (39/112; 34.8%) or the posterior approach (16/112; 14.3%) (32). However, they also found revision for acetabular component failure more common in patients with a posterior approach (13/30; 43.3%) than with the DAA (11/30; 36.7%) or the direct lateral approach (6/30; 20%). The authors also acknowledge that surgical approaches may vary geographically to an unknown extent, affecting proportions of early revisions.

A similar study by Eto *et al.*, evaluated 30 revision cases with the primary procedure performed elsewhere compared to 100 non-anterior revision cases and found revision of the femoral component for aseptic loosening more commonly associated with the DAA group (33). They also acknowledge that they are limited as they lack a denominator reflecting the total number of cases performed at referring institutions. As well, the DAA group had a greater number of failures secondary to metallosis making it unclear if the association was actually due to the approach or bearing surface choice.

A 2015 study of the Kaiser Permanente Total Joint Replacement Registry evaluated a total of 42,438 primary THA's and found no differences in risk of septic or aseptic revision between the DAA, anterolateral or posterior approach for THA (34). They also found the DAA and the anterolateral approach to have a lower risk of dislocation relative to the posterior approach. This study did have a denominator to compare approaches, and calls into question the results found by Meneghini *et al.* (32) and Eto *et al.* (33)

Intraoperative fluoroscopy and radiation exposure

The supine position for the DAA allows for ease in the use of intra-operative fluoroscopy allowing surgeons the ability to directly observe pelvic positions and assess implant positioning in real-time. Beamer *et al.* compared 57 patients with acetabular components placed with fluoroscopy and 52 without and found that the use of fluoroscopy increased the success of placement in the Lewinnek safe zone (35). Rathod *et al.* retrospectively compared 825 THAs (372 posterior without fluoroscopy and 453 DDA with) and found that the use of fluoroscopy decreased variability of acetabular cup inclination and anteversion (36). Lin *et al.* compared post-operative radiographic measurements using prospective cohorts for DAA and posterior approach THAs and found that the DAA with fluoroscopy was associated with lower odds of unacceptable inclination angle with no differences in anteversion, leg length discrepancy, or offset (37). However, the use of intraoperative fluoroscopy comes with some dose of radiation exposure to the patient and surgeon.

Radiation exposure can have health implications and the use of fluoroscopy in orthopaedic procedures has increased significantly (38). The technical advantage afforded by fluoroscopy should be weighed against the radiation exposure. McNabb *et al.*, evaluated the radiation exposure to both patient and surgeon in the DAA and demonstrated that no surgeon demonstrated a detectable radiation entrance surface dose, the mean patient entrance dose at the pubic symphysis and the sternal notch is not detectable in most patients, and the mean patient exposure was 178 mrem, which is less than a single pelvic radiograph (39). The authors conclude that the DAA does not pose undue radiation exposure risk to the patient or surgeon.

Blood loss

Evaluating blood loss after THA may be done in various ways, this can be based on the surgeon estimation of intra-operative blood loss (EBL), post-operative drain output, the number or necessity of transfusion, or change in serum hemoglobin or hematocrit levels. This heterogeneity in evaluating blood loss makes already conflicting literature on if the DAA is associated with increased blood loss even more difficult to interpret.

Nakata *et al.* compared patients with a DAA *vs.* a mini-posterior approach for THA and found intraoperative (as measured by cell saver collection volume) and post-operative (as measured by drain output) to be increased in the DAA group (40). In contrast, Bergin *et al.* evaluated 29 patients treated with a DAA for THA *vs.* 28 with a posterior approach and found no differences in cumulative hematocrit decrease (9.7% DAA *vs.* 8.5% posterior), estimated blood loss (360 mL DAA *vs.* 312 mL posterior) or transfusion (0.96 DAA *vs.* 0.59 posterior) (41). Similarly, Martin *et al.* compared 41 DAA *vs.* 47 posterior THAs and found no difference in operative blood loss (388 mL DAA *vs.* 423 mL, P=0.46), units transfused (0.28 units DAA *vs.* 0.37 units posterior, P=0.59) or reduction in hemoglobin in first 24 hours (3.0 DAA *vs.* 3.7 posterior, P=0.59) (42). It is therefore difficult, given the available literature, to draw any conclusions about increased blood loss with one approach versus another for THA.

Wound complications and infection

Reducing wound complications and deep surgical site infection is paramount for any arthroplasty surgeon. The literature is unclear if the DAA has an increased rate of wound complications or deep infection compared to the anterolateral or posterior approaches for THA. Jewett *el al.* evaluated a single surgeon series of 800 THAs performed through the DAA and found a 4.6% rate of serious wound healing complications with a 1.6% reoperation rate for wound infections and wound necrosis (26). They did not have a control group of alternate approaches to compare with and conclude that this may be related to different properties of the skin anteriorly, however their deep infection rate was comparable to series of alternative approaches at 0.8%. Similarly, Christensen *et al.* compared THA performed though a DAA or posterior approach and found a greater number of wound complications that required reoperation in the DAA (1.4%; 7/505) than the posterior approach (3/1,288; 0.2%) (43).

In contrast to the results of the previous studies, Poehling-Monaghan *et al.* evaluated the DAA *vs.* a mini-posterior approach for THA and found fewer wound problems in a DAA group compared to a mini-posterior group (44). Watts *et al.* compared the DAA *vs.* posterior approach for THA and found similar wound complication rates, 1.7% in the DAA group and 1.9% in the posterior group (45). However, the authors also evaluated obesity as a risk factor for wound complication and did find that obesity was a stronger risk factor for wound complication in the DAA group [hazard ratio (HR), 4.3; P=0.018] than the posterior approach group (HR, 1.4; P=0.018).

Obesity has been shown to be a risk factor for wound complications and surgical site infection in THA regardless of approach (46-48). However, this association may be attenuated by the proximity of the anterior incision to the inguinal skin crease with overlying abdominal pannus in obese individuals. Jahng *et al.* evaluated risk factors for wound complications in DAA for THA and found that reoperation for wound complication was significantly associated with morbid obesity, BMI >40, [odds ratios (OR), 27.86; 95% CI, 8.09–95.93] (49). Purcell *et al.* evaluated 1,621 consecutive THAs performed through the DAA and found increased rates of post-operative infection requiring revision in patients with a BMI ≥35 kg/m^2 (50). This suggests careful consideration of a patient's body habitus when determining the appropriate approach for THA.

Conclusions

Understanding the potential complications and pitfalls of the DAA for THA can help surgeons decrease risks for their patients. Surgeons should thoughtfully consider their own training prior to utilizing the DAA. For surgeons who were not familiarized to this exposure during residency or fellowship training, they should consider training on cadavers and having surgeons experienced in the DAA available to assist in an effort to reduce the learning curve associated with this approach. Proper patient education about LFCN injury and setting expectations along with careful planning of incisions and dissection should mitigate the concerns about this nerve injury. Conflicting evidence in the literature makes it difficult to draw conclusions about the DAA and increased fracture risk, revision risk or blood loss. Additionally, the use of fluoroscopy during the DAA does not pose an undue radiation exposure risk to patient or surgeon and has been shown to improve component positioning. Finally, careful patient selection for obesity may help to reduce wound complications and deep infection.

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Footnote

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