

Direct anterior total hip arthroplasty: Comparative outcomes and contemporary results

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Abstract

Direct anterior total hip arthroplasty has become increasingly more popular among arthroplasty surgeons, in large part due to the use of an intramuscular interval and desire to reduce soft tissue damage. Several studies have now been published comparing the anterior

intramuscular to other commonly used approaches, and many studies have published complication rates on large series of patients. Review of comparative studies indicates direct anterior hips tend towards shorter hospital stays and high rates of patients discharged to home. Although some studies show evidence of early benefit in functional outcomes, there is no strong evidence that the anterior approach provides any long term functional improvements compared to other approaches. Additionally, evidence to support reduced damage to soft tissue may not translate to certain clinical significance. Rates of intra-operative femur fracture, operative time and blood loss rates are notably higher for those developing familiarity with this approach. However, when surgeons have performed a modest number of procedures, the complication rates tend to markedly decrease in most studies to levels comparable to other approaches. Accuracy of component positioning also favors the anterior approach in some studies. This review summarizes the available literature comparing the direct anterior to other approaches for total hip arthroplasty and provides a comprehensive summary of common complications.

Key words: Complications; Direct anterior approach; Surgical hip approaches; Outcomes; Total hip arthroplasty

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Core tip: Direct anterior total hip arthroplasty may provide higher rates of patients discharged to home and shorter hospital stays when compared to other approaches. Long term functional outcomes do not appear to be improved by an intramuscular approach. Complication rates may be high during the initial learning period of performing this approach; however, these rates are generally shown to not exceed that of other approaches once a surgeon has completed a modest number of cases.

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INTRODUCTION

The continued desire to perform hip reconstruction through less invasive and tissue sparing methods has markedly increased the proliferation of direct anterior total hip arthroplasty (THA) over the past 15 years^[1]. Although an abundance of recent material has been promoted, largely online, to tout the direct anterior approach (DAA) as superior to other commonly performed approaches, strong evidence to support these claims has been lacking^[2]. Several studies seem to indicate that hospital length of stay and percentage of patients discharged home are improved *via* the DAA. These results may be balanced by increased operative time and blood loss, particularly early in the surgeon's performance of this technique. Studies evaluating damage to soft tissues between approaches seem to favor the DAA, yet differences in pain and other patient-reported variables do not consistently show a significant advantage. Functional outcomes tend to be improved in the early post-operative period using the DAA; however, these differences are largely equivalent in longer-term follow-up. Complication rates in this review were consistent with other approaches and appear to be markedly reduced as a surgeon gains familiarity with the procedure.

OUTCOMES AND COMPARATIVE STUDIES

Outcomes related to modern practice of anterior hip arthroplasty have been described in a number of studies, though the vast majority has been retrospective with small or moderate sample sizes. There have been an increasing number of recent prospective studies comparing DAA with other approaches, including less-invasive or minimal-incision posterior and lateral approaches. Results of the only meta-analysis comparing anterior and posterior approaches showed the anterior approach may provide potential benefits in patient reported pain and functional outcomes, post-operative length of stay, dislocations and post-operative narcotic requirements. It further suggested that the anterior approach trended toward higher percentages of patients discharged home and percentages of cups placed within the Lewinnek safe zone^[3].

Several studies have looked at the inpatient and early post-operative outcomes comparing different THA approaches. A comparison of selected outcomes from studies included in this review is summarized in Table 1. Alecci *et al.*^[4] compared 419 patients receiving standard

lateral and minimally invasive direct anterior approaches showing similar operative time and blood loss, with less pain, shorter time to and more patients discharged home with the DAA. A retrospective review of 372 less invasive direct lateral and 258 anterior supine intramuscular anterior approaches showed greater estimated blood loss (EBL), more patients discharged home, higher Harris Hip Scores (HHS), and higher Lower Extremity Activity scores at six weeks in the anterior group. Hospital length of stay and operative time were equal between the two groups^[5]. A comparison by D'Arrigo *et al.*^[6] of three tissue sparing methods (direct anterior, direct lateral and anterolateral) with a standard lateral approach control group, found a decrease in blood loss compared to the control in all groups, better early functional scores in the direct anterior and anterolateral groups, and lower complication rate with an anterolateral approach. There was no difference in hospital stay. Of note, the study groups were comprised of only twenty patients each and were the first tissue sparing surgeries performed by the surgeon for each approach. A retrospective comparison of 100 minimal-incision DAA and 100 transgluteal lateral approaches showed decreased hospital length of stay, decreased pain on post-operative day zero and one, and decreased time to reach defined range of motion for the anterior approach. However, pain during physiotherapy was higher during some time periods for the DA hips^[7]. A retrospective comparison of 41 anterior and 47 posterior approaches found shorter hospital stay and fewer days to mobilization with the anterior approach. Incision length was shorter in the anterior approach; however, lateral femoral cutaneous nerve injury and fracture were more common with the anterior approach and operative time was 20% longer. There was a 56% rate of any complications with the anterior compared to 45% with the posterior approach^[8].

A study comparing DAA and mini-posterior approach performed by two experienced surgeons found no difference in return to activities of daily living (ADLs), length of stay, complication rate, pain medication requirements, physical therapy metrics or discharge disposition. The direct anterior approach had a longer operative time, higher visual analog scale pain score in the hospital, and more patients requiring gait aids at two weeks. Direct anterior hips had higher Harris hip scores at 8 wk; however, fewer patients had returned to work and driving. There were no differences in use of gait aids or narcotics, performance of ADLs, or 0.5 mile walking at 8 wk. The DAA group had lower minor wound complications. Component placement was adequate in both groups^[9]. Spaans compared 46 DA and direct lateral (DL) hips, with operative time and EBL about double with the DA group. The DA hips in the study were the first performed by the surgeons. Hospital stays were equivalent^[10]. A comparison of 54 patient randomized to mini-posterior approach THA (MPA-THA) or DA THA showed time to ambulation without assistive device favored DA-THA (22 d vs 28 d). Three weeks SF-12 mental scores and WOMAC function and total

Table 1 Summary of select outcomes reported in the literature in comparative studies of direct anterior and other total hip approaches

Author	Study variable						
	Length of stay	Discharge to home	Post-operative pain	Short-term functional outcome	Long-term functional outcome	Blood loss	Operative time
Alecci	↓	↑	↓			↔	↔
Barrett	↓		↓	↑	↔	↑	↑
Berend	↔	↑		↑	↔	↑	↔
D'Arrigo	↔			↑	↔	↓	↑
Goebel	↓		↓				
Lamontagne				↔	↔		
Martin	↓	↔		↑	↔	↔	↑
Mayr				↑	↔		
Poehling-monaghan	↔	↔	↑	↔	↔		↑
Rathod				↔	↔		
Rodriguez	↔		↔	↑	↔		
Spaans	↔			↔	↔	↑	↑
Taunton				↑	↔		
Zawadsky	↓	↑	↓	↑			

Arrows indicate relative magnitude of the variable (*i.e.*, ↑: Increased; ↓: Decreased; ↔: Similar) for direct anterior approach compared to alternative approach for applicable study.

scores favored MPA. There were no differences at any other time point for SF-12, WOMAC or HHS scores^[11]. A study of 50 posterior, 50 DA and 50 DA approaches in a learning curve period showed decreased length of stay and more patients discharged to home in the DA groups. The DA groups also had significantly less use of assistive devices, pain scores and narcotic use at six weeks. Operative time for the learning curve group was significantly longer^[12].

Another area of interest in assessing approaches to the hip joint is functional capacity of patient post-operatively. A prospective, randomized, single surgeon study compared 43 direct anterior approaches to 44 posterior approaches, with the primary endpoint of normal ability to climb stairs and walk unlimited distances. The study showed that DAA patients performed better in the immediate post-operative period with lower Visual Analog Scale pain scores on post-operative day one, more subjects climbing stairs and walking unlimited distances at six weeks and higher HOOS Symptoms scores at three months. However, there were no significant differences at later time points^[13]. A comparison of 60 hips between anterior muscle-sparing, direct lateral approaches and a matched control group showed abnormal stair climbing kinematics were exhibited in both groups after surgery. There were fewer differences with smaller magnitudes when compared to the control population in the anterior group than the lateral group^[14]. A gait analysis study by Mayr *et al*^[15] compared sixteen direct anterior hips and seventeen anterolateral hips. At six and twelve weeks, the anterior hip group showed significant improvement in cadence, stride length and time and walking speed. The anterolateral group showed no statistically significant improvements in time-distance parameters at six or twelve weeks. Normal level of walking speed was not achieved in either group. Both groups showed

improvements in range of motion; however, neither group achieved a physiologically normal range of flexion/extension in the study period. A comparison of gait parameters in 22 patients, 11 direct anterior and 11 posterior approaches, showed improvements in flexion/extension range of motion, peak flexion, and extension moments without differences between the groups. The DAA group showed statistically significant improvements in external and internal rotation compared to the posterior group, which may be related to release and repair of external rotators in posterior group. The posterior approach group had a significant improvement in gait velocity from pre-operatively to 6 mo, becoming similar to the pre-op value for DAA^[16].

A comparison of 35 computer-navigated minimally-invasive anterior approach and 40 posterolateral approach hips found no differences in recovery of spatiotemporal parameters or angular movements of the pelvis and thorax between the groups. Both groups retained lower values for spatiotemporal parameters and frontal plane angular movements compared to healthy subjects at six months and one year^[17].

A prospective non-randomized trial comparing 60 DAA and 60 posterior hips showed early functional differences favoring the DAA group, including improved timed up and go (TUG) parameters immediately post-operatively, faster time to walk 150 feet and stairs and transfers. Beyond two weeks, there were no differences in HHS, University of California at Los Angeles (UCLA), functional independence measure (M-FIM), and TUG scores, as well as need for gait aids, time to walk 0.5 miles or resumption of activities of daily living^[18]. An analysis of 20 DAA and 20 direct lateral hips compared to 20 controls showed negligible difference between the two approach groups with both groups showing gait anomalies. Neither group achieved kinetics and kinematics similar to the control group^[19]. A small study

comparing DAA and anterolateral THAs with a control group showed no difference in return of hip strength and mobility between the two groups compared to control groups. Patients in the DAA hip group showed greater gait velocity and stride length, abductor strength and sagittal plane range of motion at six weeks compared to pre-operatively, but was not significantly different in improvement from the anterolateral group. Strength and mobility between DAA and anterolateral groups were similar at 16 wk post-surgery^[20].

A limited number of studies have also evaluated the patients' perceived outcomes related to the surgical approach. A survey of 1273 patients in approximately equal distribution of lateral, anterior and posterolateral approach groups showed that adjusted HOOS scores for pain, other symptoms, activities of daily living, sport/recreation, and quality of life (QOL) were significantly worse for the lateral approach than for the anterior approach and the posterolateral approach. These results were largely related to more patient-reported limping with the lateral approach than with the anterior and posterolateral^[21]. A prospective, randomized comparison of 100 patients enrolled in either a modified direct anterior or small-incision anterolateral approach of equivalent incision lengths showed better improvement in SF-36 scores for role limitation, bodily pain and general mental health for patients in the anterior group^[22]. A comparison of 85 DAA hips and 86 transgluteal lateral hips found no difference in HHS, SF-36 mental and physical component scores and daily activity by daily activity questionnaire. There was a significant difference in the UCLA activity score, with the lateral group scoring higher^[23]. A prospective randomized trial between 50 DAA and 50 DL hips showed improvements at follow-up up to one year that were statistically significantly better for DAA in physical functioning, role limitations, bodily pain, social functioning, general mental health, vitality energy or fatigue and post-op physical and mental health dimensions of the SF-36, WOMAC and QOL component of Linear Analogy Scale Assessment. There were no differences remaining at 2 years^[24].

One of the main arguments for superiority of the DAA is the minimal soft tissue and muscle damage resulting from utilizing an intramuscular plane. Twenty-nine patients treated with minimally invasive THA through a DAA and twenty-eight patients treated with the same procedure through a posterior approach were prospectively analyzed. The levels of the markers of inflammation were slightly decreased in the direct-anterior-approach group as compared with those in the posterior-approach group. The rise in the CK level in the posterior-approach group was 5.5 times higher than that in the anterior-approach group in the post-anesthesia-care unit and nearly twice as high cumulatively^[25]. A study comparing 25 DAA and transgluteal approaches found detachment of abductor insertion, partial tears and tendinosis of the glut medius and minimus, presence of peri-trochanteric bursal fluid and gluteus medius and minimus fatty atrophy were significantly less in DAA

approach when compared using magnetic resonance imaging one year post-operatively^[26]. A comparison of visually inspected muscle damage to cadaveric specimens undergoing anterior or posterior approaches showed less damage to the gluteus medius and minimus with the anterior approach. Thirty-one percent of the anterior hips showed evidence of tensor fascia lata (TFL) damage and 12% had damage to the direct head of the rectus femoris. The greatest difference was in damage to the gluteus minimus. All external rotators were released as part of the posterior approach, whereas 50% of anterior hip procedures required release for mobilization^[27]. A study of 421 DAA hips estimated that increasing TFL damage was related to the male sex and increasing body mass index (BMI)^[28]. The incidence of heterotopic ossification (HO), possibly related to retraction damage to the TFL or rectus femoris, has also been evaluated in anterior hips. An analysis of 236 hips in 214 patients at two hospitals undergoing DAA showed an overall incidence of HO of 41.5% between two hospitals. There was a significant reduction in patients on aspirin compared to Coumadin or Lovenox for deep venous thrombosis prophylaxis, and a higher rate in male patients. Hospital One had an incidence of 33% compared to 48.8% at Hospital Two. The rate of HO was similar to reported rates of 28%-61% with other approaches. It was hypothesized that use of the OSI Hana table and mechanical lift at Hospital One may have reduced soft tissue trauma and also contributed to lower HO rates^[29].

In summary, several studies seem to indicate that hospital length of stay and percentage of patients discharged to home are improved *via* the DAA. These results may be balanced by increased operative time and blood loss, particularly early in the surgeon's performance of this technique. Some functional outcomes may be improved in the early post-operative period using the DAA; however, these results are largely negligible in long-term follow-up.

COMPLICATIONS

One of the common arguments against the DAA is the high rate of complications. Table 2 summarizes reported complications from multiple studies and available complications from comparative approaches. Several studies note markedly higher rates of complications in the "learning curve" period, or the initial series of surgeries performed by a surgeon adapting the approach. Moskal *et al*^[30] proposed that the surgeons level of experience with DA approach directly correlated with complication rates, with a plateau between the first 40-100 cases. A study reporting outcomes of the first 43 cases performed by a single surgeon showed significant reductions in operative time and EBL between the first and last ten cases performed, with a decline in total complications^[31]. Seng *et al*^[32] tracked conversion of surgeries from lateral to DAA, and found that after 6 mo and 37 cases, more than half of joint replacements were being performed

Table 2 Summary of select complications reported in the literature in comparative studies of direct anterior and other total hip approaches n (%)

Author	Approach	No. patients	Complications													
			Dislocation	Femur fracture	Great trochanter fracture	Hematoma	Ankle injury	Nerve injury	Reoperation due to infection	Reoperation - other than infection	Bursitis	Superficial infection/wound complication	Acetabulum (or pelvis) fracture			
Alexandrov	A	43	1 (2.3)	1 (2.3)	5 (11.6)	1 (2.3)	0	2 (4.7)								
Amile	A	421	13 (3.1)					25 (5.9)	5 (1.2)	8 (1.9)						
	L	431	16 (3.7)					27 (6.3)	8 (1.9)	21 (4.9)						
	P	421	10 (2.4)					14 (3.3)	5 (1.2)	7 (1.7)						
Bal	A	100		1 (1.0)				4 (4.0)								
Barrett	A	43	0 (0.0)	0 (0.0)		1 (2.3)								1 (2.3)		
	P	44	1 (2.3)	1 (2.3)		0 (0.0)								0 (0.0)		
Berend	A	258		4 (1.6)												
	L	375				2 (0.5)		2 (0.8)	1 (0.3)	2 (0.8)				1 (0.3)		1 (0.3)
Bhandari	A	1277	8 (0.6)	22 (1.7)	13 (1.0)	5 (0.4)		13 (1.0)	3 (0.2)	32 (2.5)				22 (1.7)		8 (0.6)
Christensen	A	505							3 (0.6)	2 (0.4)				2 (0.4)		
	P	1288							1 (0.1)	1 (0.1)						
De Geest	A	300	2 (0.7)	12 (4.0)	3 (1.0)			16 (5.3)	6 (2.0)	14 (4.7)				6 (2.0)		
Hallert	A	200	4 (2.0)	3 (2.0)				3 (2.0)	1 (1.0)							
Hoell	A	113	0 (0.0)	1 (0.9)					1 (0.9)	3 (2.7)						
Keggi	A	687	17 (2.5)	15 (2.2)	5 (0.7)			5 (0.7)	1 (0.1)							
Jewett	A	800	7 (0.9)	24 (3.0)		13 (1.9)		1 (0.1)	7 (0.9)	19 (2.4)						1 (0.1)
Kennon	A	2222	28 (1.3)	63 (2.8)	24 (1.1)	31 (1.4)		9 (0.4)	7 (0.3)					3 (7.3)		3 (0.1)
Martin	A	41	1 (2.4)	1 (2.4)				7 (17.1)	1 (0.2)					4 (8.5)		
	P	47	3 (6.4)	0 (0.0)				0 (0.0)	1 (0.4)							
Matta	A	494	3 (0.6)	6 (1.2)	3 (0.6)	3 (0.6)		1 (0.2)	1 (0.2)	3 (0.6)						
Mirza	A	258	4 (1.5)	9 (3.5)												
Reichert	A	85	0 (0.0)	1 (1.2)				6 (7.1)								
	L	86	0 (0.0)	1 (1.2)					1 (1.2)	1 (1.2)						
Sariali	A	1764	27 (1.5)	28 (1.6)	1 (0.1)											
Spaans	A	46	1 (2.2)													
	P	46	1 (2.2)													
Wayne	A	100	2 (2.0)	8 (8.0)				6 (6.0)	0 (0.0)	5 (5.0)				0 (0.0)		1 (2.2)
	L	100	1 (1.0)	2 (2.0)				0 (0.0)	3 (3.0)	3 (3.0)				4 (4.0)		3 (3.0)
Yi	A	61	1 (1.6)	2 (3.3)	3 (4.9)	1 (1.6)		1 (1.6)	1 (1.6)	2 (3.3)						1 (1.0)
Zawadsky	A	100	0 (0.0)						2 (2.0)	3 (3.0)						
	P	50	1 (2.0)					3 (6.0)	3 (6.0)	0 (0.0)						

A: Anterior; L: Lateral; P: Posterior.

with the anterior approach, indicating increased comfort with the procedure. This time mark also coincided with a plateau in operative time and EBL. They had two femoral perforations during this learning curve period and observed no dislocations. Surgeons who performed less than 100 cases had a twofold increase in complications in one review of 1277 DAA THAs^[33]. Wayne *et al.*^[34] compared the first 100 patients in a DAA compared to the previous 100 patients receiving a direct lateral approach and showed increased blood loss (change in hemoglobin pre- vs post-operatively), longer operative time, increased rate of nerve damage, femur fracture, blood transfusion, acetabular malposition, with shorter hospital stays and fewer operative site infections.

Femur fractures have been particularly found to be of high incidence in initial adaptation of the approach. A study of 800 DA hips showed a significantly higher rate

of femur fracture early in the series, with none in the second half. A second-generation fracture table with electronic hook elevation system, allowing for more gradual and gentle femoral elevation, was attributed to reduce the rate of fracture, along with better understanding of tension applied to the femur and necessary superior capsule and occasional piriformis tendon release during exposure. Femoral perforations also occurred early in the series in patients with severe flexion contracture which was mitigated through better understanding of the using a more horizontal insertion angle of starting broach to follow the angle of the femur in the contracted position^[35]. Yi *et al.*^[36] reported an 8.2% rate of intraoperative femoral fracture during the first 61 cases of anterior supine intermuscular THA performed, all occurring during the first 32 of 61 cases. De Geest *et al.*^[37] compared early outcomes and complications of 300 hips and showed 5 proximal femur fractures with Medacta Quadra and anterior minimally invasive surgery stems but none in the group using Taperloc stems. They did not find a difference in infection rates between early and later cases, but had a high rate of post-operative overall complication rate (14%), and 6.7% of patients required a surgical re-intervention. The authors concluded that there may be a significant learning curve with a complication rate that may be too high for some surgeons to change their surgical technique.

Dislocation rates have been shown to be low with the DAA in several studies. It is postulated that inherent stability exists, as muscles are not detached posteriorly or anteriorly^[38]. Siguier showed a dislocation rate of 0.96% (10 of 1037 patients) with MIS DAA THA^[39]. An analysis of 22237 hips performed through posterior, anterolateral, direct lateral, and anterior approaches found that anterolateral and anterior hips had lower dislocation rates compared to posterior. Among 42438 hips analyzed for need for revision, there was no difference between approaches. The dislocation rate for DA hips was 0.8%^[40]. A prospective study by Sariali *et al.*^[41] of 1764 DA hips found an overall dislocation rate of 1.5%. Significant risk factors for dislocation were male sex, higher BMI, osteonecrosis, head diameter (22 > 28 mm, 2% vs 0.5%), higher EBL and low post-operative range of motion.

Wound complications have also been a source of concern, particularly in obese patients with poorer proximal skin where the DAA incision may lie in the overhanging fat apron or over fold itself. Use of an abdominal binder for patients with pendulous abdomens to keep the pannus from resting on the incision until healed has been suggested, as well as maintaining a sterile bandage^[30]. A comparison of 1288 posterior approach and 505 DAA hips showed a higher rate of re-operation for wound-related complications (0.2% to 1.4%, respectively)^[42]. Some authors have endorsed use of tissue protectors intra-operatively to reduce skin damage; however, use of a ring retractor did not improve wound cosmesis in a small study on the subject^[31,43,44].

CONCLUSION

All standard approaches to the hip have been shown to be safe and efficacious, with particular advantages and disadvantages to each approach. The DAA to the hip has gained significant popularity recently, and can be a valuable technique for hip replacement in most patients. Although it has been associated with a steep learning curve, overall complication rates in the available literature do not appear to exceed those of other approaches to the hip. The growing desire for less invasive arthroplasty with improvement in functional results makes this approach an attractive choice. The surgeon must carefully consider the possible benefits and disadvantages of the approach, especially in an early phase of adopting the procedure. Long-term studies of larger numbers of patients are still required to demonstrate a cost benefit or quality of care advantage to other hip approaches. As patient driven health care and hospital associated costs became a larger factor in the practice of arthroplasty, the trends in outcomes related to direct anterior total hip arthroplasty should be more closely examined.

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