

A 10-year single surgeon series of primary total hip arthroplasty performed through direct anterior approach, and literature review

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ABSTRACT

Introduction: The literature review shows improving outcomes of Total Hip Arthroplasty (THA) with Direct Anterior Approach (DA). However, the learning curve and small volume surgeons have been associated with increased complications.

Objectives: The aims were to evaluate outcomes of a single surgeon carrying out primary THA with DAA in selected cases and building up to the routine practice.

Materials & Methods: The data were collected retrospectively from 2009 to 2019 at University Hospital Crosshouse, Kilmarnock. This included demographics, Body Mass Index (BMI), blood transfusion and length of hospital stay. The Oxford Hip Score and general questionnaire were used for functional outcomes. The use of per-operative fluoroscopy during the learning curve and complications experienced were reviewed.

Results: We evaluated 146 consecutive patients who had arthroplasty using DAA from 2009 to 2019. There were 60 female and 86 male patients with a mean age of 57 years (34 to 89 years). Nineteen patient had bilateral hip arthroplasty procedures, and these were simultaneous in seven cases. The procedure was carried out initially in the series in patients with lower BMI (mean 28.4 kg/m²). The follow-up was mean 4.9 years (1.7 to 11.3 years). The mean acetabular abduction angle was 37.5° and an anteversion of 21°. The mean leg length discrepancy was 5.8 mm (-11 to 16mm). None of the patients with leg length discrepancy were symptomatic. The Oxford Hip Score improvement of mean 41 points. There were two dislocations (1.3%), one early and the second was late. There were no other major complications.

Conclusion: The current series demonstrates that the DA approach is safe for performing THA. The benefit of this approach is the ability to consistently restore the patients hip joint biomechanical parameters including abduction angle, anteversion and leg length. The complications which are recently highlighted in the literature with learning curve were avoided by using an approach based on careful patient selection, avoidance of higher BMI, use of fluoroscopy per-operatively in the first 25 cases and afterwards in the series only if any doubt on component positioning.

Keywords: Arthroplasty; Osteoarthritis; Osteoarthritis, Hip; Hip Dislocation.

The authors declared no conflict of interest. All authors contributed substantially to the planning of research, data collection, data analysis, and write-up of the article, and agreed to be accountable for all aspects of the work.

INTRODUCTION

The Direct Anterior (DA) approach to the hip has been described as early as 1881. First described by German surgeon, Carl Hueter, the approach was further promoted by Marius Nygaard Smith-Petersen in 1917 for his mould arthroplasty. The approach was reintroduced in the 1950s by Judet and O'Brien but over-shadowed by the trans-trochanteric approach and low-friction arthroplasty developed by Sir John Charnley. A modified version of the original Smith-Petersen (or Hueter) approach has more recently become popular for its muscle-sparing characteristics that allow lesser surgical trauma and thus earlier patient recovery.^{1,2} The surgical instruments, implants, and techniques have been developed to enable safe component implantation and reduce risks of surgical complications.

MATERIALS & METHODS

We performed a retrospective review of patients who underwent Total Hip Arthroplasty using a Direct Anterior (DA) approach from 2009 to 2019 at the University Hospital Crosshouse, Kilmarnock, Scotland. The senior surgeon MAK has extensive experience of primary and revision total hip arthroplasty through the Modified Hardinge approach. He went through self-directed training for the DA approach, which involved cadaver courses, observation, and then performed the procedure under supervision before starting to carry out the procedures independently. Patients were selected by the surgeon himself and this was based on Body Mass Index (BMI), general built of the patient, and extent of arthritis. This was to avoid any difficulties during the approach and to ensure patient safety in the learning curve period. Earlier in the series, only younger patients were included but later in the series this approach was also used for the active older patient group as well.

The data were collected from the theatre records. This consisted of patient demographics including age, gender, BMI, diagnosis, length of hospital stays (LOS), and complications. The use of a preoperative one dose of Tranexamic acid at induction was recorded. Blood loss was assessed from the difference between preoperative and

postoperative haemoglobin levels during the admission period. The functional outcomes at final follow-up were measured using Oxford Hip Score and a General questionnaire. The general questionnaire included: 1) Time taken to go back to work? 2) Was the operation worth it? 3) Will recommend the operation to other patients? 4) Forgotten hip? 5) Patient satisfaction?

The use of per-operative fluoroscopy during the procedure was recorded and postoperative radiographs were measured for acetabular abduction angle and anteversion of acetabular component on horizontal beam lateral radiograph. The femoral component was assessed for implant position and the Leg length discrepancy was measured by referencing the ischium and lesser trochanter bilaterally.

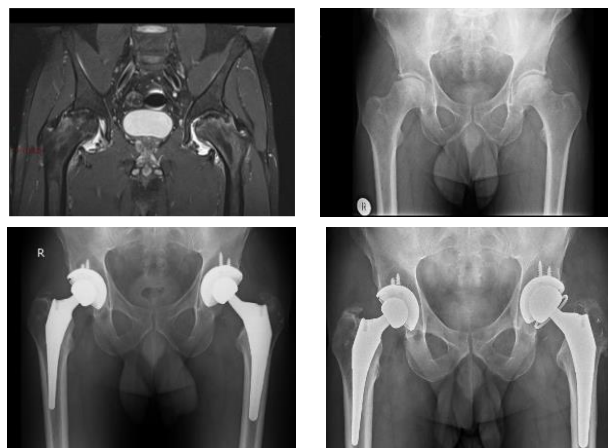
The implants used during our study were Exceed ABT acetabular shell and Taperloc femoral (Biomet UK, Ltd, Waterton Industrial estate, Bridgend, South Wales, CF31 3XA). There were issues with implant sourcing. This was changed in 2015 to R3 acetabular shell and Anthology femoral stem, Primary Hip System (Smith & Nephew Inc, 1450 Brooks Road, Memphis, TN 38116, USA). Corail and Pinnacle Hip system by Depuy-Synthes used in the last two years (Depuy International Ltd, Cornford Road, Blackpool, FY14 4QQ, Lancashire, England). Hybrid arthroplasties were carried out in two cases due to the very narrow and bowed femurs. This was with a combination of uncemented Trident acetabular system with a PSL cup and tapered polished cemented Exeter stem (Stryker, 325 Corporate Drive Mahwah, NJ 07430). Stryker Constrained liners were used for revision cases. All the above implants are 10A-star or more on Orthopaedic Data Evaluation Panel (ODEP), UK.

RESULTS

Of 146 procedures, 19 patients had bilateral arthroplasties (seven patients had simultaneous procedures). There were 86 males and 60 female patients with age mean of 57 years (range 34 to 89 years). The mean BMI 28.4 kg/m² (range 19.7 to 38.5). The mean follow-up was 4.9 years (1.7 to 11.3 years). One patient was lost from long-term follow up who died of an unrelated cause. The commonest diagnosis was primary osteoarthritis of the hip. The other cases of arthritis were secondary to avascular necrosis (n=8), Slipped Upper Femoral Epiphysis (n=2), Perthes (n=1), and Developmental Dysplasia (n=1). Tranexamic acid was routinely administered at induction in all cases after 2011. The mean haemoglobin level drop during hospital stay was 28 g/L (range 2 to 70 g/L). The higher ranges of blood loss were noted in patients with simultaneous bilateral cases. Nine patients (6%) in the series required blood transfusion, out of which five had bilateral procedures, one patient had gastrointestinal bleeding postoperatively, and three patients had haemoglobin level less than 130g/dl preoperatively. The mean length of hospital stay was 3.5 days (range 1 to 16 days). The common causes noted for delays in discharge were bilateral procedures, warfarin dosage, post-operative unexplained pyrexia postoperatively (n=3), cellulitis (n=1), and social issues.

The mean acetabular abduction angle was 37.4 degrees (SD 3.5) with a range from 22 to 56 degrees. There were 12 cases (8%) where the abduction angle was above 45 degrees. The mean acetabular anteversion was 21 degrees (SD 8.4) with a range from 5 to 41 degrees. The acetabular abduction angle in 92% and anteversion angle in 81% was within the Lewinnek safe zone. Further, 13% (n=19) cases showed anteversion between 26 to 30 degrees. Per-operative fluoroscopy was used in 34% cases. This was used as a single shot before final insertion of implants. This was regularly used in first 25 cases and subsequently used only if clinically required. When fluoroscopy was used the mean acetabular abduction angle was 36.5 and mean anteversion was 22 degrees. Whereas the mean acetabular abduction angle was 37 degrees and mean anteversion was 21 degrees without fluoroscopy. Thus, no major difference in the radiological parameters were noted with or without the use of fluoroscopy. The mean leg length discrepancy was 5.8 mm with a range from 1 to 16 mm and none of the patients were symptomatic with the discrepancy. Measurements of femoral component showed varus alignment in 58% but the mean was only 3.1 degrees, valgus in 10% with a mean of 2.6 degree and neutral alignment in 32%. There was no loosening or subsidence of the implants noted on final follow-up.

The functional outcomes were available in 120 patients (83%) and Oxford Hip Scores showed an improvement of 41 points (range 23 to 60). The general questions showed 97% patients were satisfied with the procedure and felt it was worth it and will recommend it to other patients. In addition, 77% claimed to have forgotten the hip replacement. The mean return to work time, or felt like back to normal in mean 2.4 months (0.75 to 5 months). Walking aids were used by nine patients with a mean age of 62 years.



Case-1: Radiograph and MRI of a patient with bilateral hip avascular necrosis. Bilateral hip arthroplasty through DA approach was done. Patient had recurrent dislocation of the left THR which only required revision to a constrained liner.

The complication experienced during this study were superficial infection 1.3% (n=2), persistent LFCN paraesthesia 1.3% (n=2), unexplained dermatitis 0.6% (n=1) and dislocation 1.3% (n=2). One patient who had early dislocation at 9 weeks was working under the car to fix exhaust and the second one was a late dislocation at 18 months from sudden bending over to reach a bin in a 6-feet tall lady. Both the patients had recurrent

dislocations and underwent revision procedures. The component positions were found to be optimum during revision and unable to dislocate even when under anaesthesia. The acetabular liners were only revised to a constrained liner. There were no further issues following the revision.

Table 1: Summary of Results

Variables	Mean (Range)
Age	57 years (34-89)
Male	86 (58%)
Female	60 (42%)
BMI	28.4 Kg/ m ² (19.7-38.5)
Primary Osteoarthritis	134 (91%)
Secondary Osteoarthritis	12 (9%)
Blood loss	28g/L (2- 70g/L)
Blood Transfusion	9 (6%)
Length of hospital Stay	3.5 days (1 – 16)
Follow-up	4.9 years (1.7 to 11.3)
Acetabular abduction angle	37.4 degrees (22-56)
Acetabular anteversion angle	21 degrees (5 – 41)
Leg length Discrepancy	5.8 mm (-11 to 16)
Per-operative fluoroscopy	34%
Oxford Hip Score	56.8 (22 – 60)
Oxford Hip score improvement	34 points
Patient Satisfaction	97%
Forgotten Hip	81%
Complications	
Superficial Infection	2 (1.3%)
Persistent Paraesthesia	2 (1.3%)
Dislocation	2 (1.3%)

DISCUSSION

The hip arthroplasty procedure significantly improves the quality of life in patients with hip arthritis. A review of a prospective cohort of 850 patients for both direct lateral and posterior approaches by Ankawe in 2011 showed dissatisfaction of rate of 7%, and further 17% rated as satisfied only.³ The abductors in the lateral approach and external rotators in the posterior approach are affected which may result in complications. The patients may develop Trendelenburg gait and trochanter pain.

The DA approach avoids violation of the muscle and has shown promising results due to a true inter-nervous and inter-muscular approach. There is minimal soft tissue injury when compared with traditional posterior and lateral approaches. The improvement in functional scores, with reduced postoperative pain is reported due to the avoidance of muscle and soft tissue damage. Blood tests in the early postoperative period were shown to be significantly lower levels of CRP, IL-6, and ESR in the DA approach compare to the posterior approach.^{4,7} Ponzio et al showed DA group demonstrated reduced procedure time, lower blood transfusion rate and shorter length of stay.⁸ Patients in the DA group were more likely to report no pain, no limp and also the outcomes which are not covered by routine Patient-Reported Outcome Measures (PROMs) such as walk to unlimited distances and climb stairs without the use of the railing at 3 and 6-month follow-up ($p < 0.001$).^{9,10} RCT by

Parvizi et al in 2016 comparing lateral and DA approach showed a significant improvement of functional outcomes at 6 weeks and at 6 months.¹⁰ A detailed function analysis revealed an early return to driving, work, gait speed, and Time to get up and go test. Parvizi et al also identified that more than two-thirds of the patients in the DA group did not require physiotherapy.¹⁰ A systematic review comparing DA and posterior approaches by Higgins et al with the pooled results showed a significant difference in favour of the DA approach for the length of hospital stay and dislocations.¹¹ Similarly, Wang et al revealed DA group had early functional recovery and lower pain scores.¹² A meta-analysis by Putananon et al showed that the DA approach in comparison to both lateral and posterior approaches had the better postoperative VAS score and Harris hip score.¹³

The learning curve is one of the major issues with the DA approach which has been highlighted in the recent literature. There are concerns with increased operative time, blood loss, femoral fracture, and early femoral component loosening and revision.¹⁴⁻¹⁶ The complications were relatively higher in smaller case series. Whereas large case series showed lower complication rates in the DA group. In comparison studies, the complications were significantly higher for the posterior group (10.9% posterior vs 6.2% DA, $p < 0.05$). Revision rate was significantly higher for the posterior group (2.7% posterior vs 0.7% DAA, $p < 0.032$) due to higher incidence of dislocation, 1.5% for the posterior approach vs 0.4% for the DAA.¹⁷ The study by Stone et al showed gradual improvement in procedure-time compared to the default posterior approach. The overall complications were 3.6%, these were higher in the first 50 cases and later spread across the study times. The dislocation rate was only 0.1% compare to dislocation of around 1.7 to 3.9% for the PA and DA approach of 0.6 to 1.2%.¹⁴ On the other hand, there are also studies that have not shown any difference in the dislocation between the two approaches.¹⁸ Mjaaland et al study looking at the implant survival using MIS anterior, MIS anterolateral, Direct Lateral and Posterior approach did not show increased risks of revision with any of these approaches in the Norwegian Joint registry.¹⁹

In terms of operative accuracy, the supine position provides advantages including on table precise leg length measurement, range of movement to test stability during the procedure and use of per-operative fluoroscopy, if required. On the contrary, the lateral approach and posterior approach may result in implant malposition and complication such as Trendelenburg gait and trochanter pain. Both these complications are difficult to manage. Several studies have shown accurate and improved positioning of components with fluoroscopy with the DA approach.^{2,20-22} Hamilton et al² reported a significant reduction in variations of cup abduction angle with the DA, and Lin et al²² showed a more consistent abduction angle with DA approach compared with the posterior approach. The optimum component position and reliably reproducing the results are of major importance in the outcomes of hip arthroplasty. The “safe zone” proposed by Lewinnek et al²³ first described optimal positioning of the acetabular component to prevent dislocation. This zone was defined as 40 degrees \pm 10 degrees of acetabular abduction

angle and 15 degrees \pm 10 degrees of anteversion. The risk of hip dislocation within the safe zone was only 1.5% versus 6% for those outside the zone.²³ Sadhu et al²⁴ reviewed dislocations in primary and revision THR with a matched cohort for a posterior approach with posterior soft tissue repair and showed that patients with dislocations had less frequently components within the safe zone in comparison to the control cohort. Both abduction angle and anteversion in the dislocation group were in the safe zone 24% compared to 50% in controls ($p < 0.001$). The dislocations were noted with increasing abduction angle and decreased anteversion.²⁴ Another comparative study showed that in 92.2% of the cases in the DA group, the cup abduction angle was within the safe zone as compared to 83% in the lateral approach. The anteversion angle was within the safe zone in 96.9% of the cases in the DA, as compared to 85.1% in the lateral approach ($p = 0.016$). The Leg Length Discrepancy (LLD) in the study was 11mm for the lateral approach compares to 6mm in the DA group.²⁵ In our study, 92% of the cases cup abduction angle was within safe zone and the mean LLD was 5.8mm. On the contrary, the study by Abdel el²⁶ failed to show the difference in groups with and without dislocation even when components were in the Lewinnek zone. In addition to a safe zone, surgical approach, soft tissue tension, restoration of the centre of rotation, implants and patient factors have also been identified as causes of dislocation. Even in the Lewinnek study one of the surgeons who carried out about two-thirds of the procedure was found to have most cups out of the safe zone, actually had a dislocation rate of 0.5%. He suggested particular attention to soft tissue tension and stability checks at the time of the procedure as the major factors.²³

Furthermore, acetabular component alignment impacts not only hip stability but also wear. Tian et al²⁷ showed higher linear and volumetric wear in patients with cup abduction angles of more than 50 degrees. This may ultimately affect the longevity of the implants. Elkins et al²⁸ in a finite element model analysis have shown that cup alignment improves stability and minimizes wear; according to him increased cup inclination, reduced cup and stem anteversion may lead to superiorly distributed high shear stresses thus potentially accelerating wear. The implant malposition can affect as much as 10 to 33% of wear, in particular cup medialization and abduction angle.²⁸⁻²⁹

A meta-analysis by Wang et al¹² compared four complications (intraoperative fracture, postoperative dislocation, heterotrophic ossification, and groin pain) between DA and posterior approach, and the results showed no significant difference

($p > 0.05$). Thus, the DA approach is equally safe and reproducible when compared to standard approaches. Schwartz et al¹⁵ demonstrated that high-volume experienced surgeons can safely transition to the DA approach without increasing complications or readmissions. The only major complication experienced in our series was dislocation (1.3%) which is in line with the literature.

We think that the posterior and lateral approaches are well established with surgical training, instrumentation, and implants. Nonetheless, a recent renewed interest in the DA approach has quickly caught up with the posterior approach. The advantages which are persistently shown to improve with the DA approach are in the areas of early rehabilitation, and functional scores. This has a major bearing on patients' perspective who will prefer early recovery and return to work and quality of life. Parvizi et al¹⁰ in 2016 recommended DA approach should be performed after training as it is challenging in the initial learning phase. He further went on to suggest that during the learning curve one should take a stepwise approach, one should attend the cadaveric course, followed by performing procedures under supervision.¹⁰ Proceed with a strict selection criterion excluding high BMI and abnormal anatomy. This process was followed by the senior surgeon MAK in this series.

The limitation of our study was the retrospective nature of the study. We were unable to consistently capture the data on blood loss, length of stay and functional outcomes. This was secondary to an upgrade in 2010 in software used in the operation theatre. We lost some of the procedures carried out in 2009 and 2010.

CONCLUSION

The current series demonstrates that the DA approach is safe for performing Total Hip Arthroplasty. The benefit of this approach is the ability to consistently restore the patients' hip joint biomechanical parameters including abduction angle, anteversion and leg length. This approach avoids risk of Trendelenburg gait, trochanteric pain, and lower risk of dislocation. The complications which are recently highlighted in the literature with learning experience were avoided using an approach based on careful patient selection, avoidance of higher BMI, use of per-operative fluoroscopy during learning phase and if any doubt on component positioning.

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