



Evaluation of Direct Anterior Approach for Revision Total Hip Arthroplasty: A Systematic Review

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The direct anterior approach (DAA) is an established approach for total hip arthroplasty (THA) but has been sparingly tried for revisions. The purpose of this study was to examine the available literature in order to consolidate information available on revision THA using the DAA. A PubMed, Embase, and Scopus search was performed using relevant keywords. Studies reporting on patients undergoing revision THA using DAA were included for analysis. In a review of the literature, nine studies matched the pre-decided inclusion criteria with 319 hip joints undergoing revision THA. Mean follow-up of all included studies was 34 months. The indications of revision after primary THA in decreasing order were aseptic loosening (53%), prosthetic joint infection (20.7%), peri-prosthetic fracture (16.9%), dislocation (7.2%), psoas impingement (1.9%), polyethylene wear (1.2%), pain (0.6%), and instability (0.3%). Of the 319 revisions evaluated, 107 underwent a stem revision, 142 underwent cup revision, 49 underwent a combined revision, and 21 underwent isolated liner/head change. A statistically significant improvement in functional score ($P < 0.05$) was observed for all studies reporting on functional outcomes. A low complication rate (51/319, 16.0%), which includes dislocation (12), infection (12), loosening of the acetabular shell (5), peri-prosthetic fractures (6), haematoma (4), and transient nerve palsy (6), was reported. Based on available level III-IV evidence, DAA appears to be a reliable alternative for revision of the failed hip arthroplasty with acceptable complication rates. Evidence of a higher quality is needed to further characterize its role in revision scenarios.

Key Words: Revision total hip arthroplasty, Direct anterior approach, Approaches to hip joint, Arthroplasty

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INTRODUCTION

Several approaches to the hip joint are used for total hip arthroplasty (THA), including the posterior (Moore or Southern), lateral (Hardinge), anterolateral (Watson Jones), and the direct anterior approach (DAA)^{1,2}. The consensus is that the DAA is an intermuscular and inter-nervous plane approach and when compared to conventional approaches, it results in less blood loss, low transfusion rates, shorter surgery times, a shorter length of hospital stay, low post-operative complication rates, and better functional recovery³. It offers the theoretical advantage of more precise component placement and more reproducible assessment of leg lengths⁴. Kennon et al.⁵ reported low complications,

including sciatic nerve injury and postoperative dislocation rate (<3%). The indication for DAA has been extended to revision hip arthroplasty, although there is a lack of consensus⁶.

When performing DAA, the general principle is to use the same incision used for primary hip arthroplasty to avoid intervening skin necrosis, but this is not a problem around the hip. The approach to the hip joint depends upon the component to be revised as anterolateral, direct lateral, or posterolateral approaches are used for acetabular component revision. In general, surgeons avoid using the anterior approach as it has been suggested that bone grafting and approaching the posterior column is difficult through this approach which forms a major step for cup revisions⁷. In addition, because it is a recent it has been sparingly described and limited experience has led to feigning disinterest among arthroplasty surgeons for revision.

Achievement of the Lewinnek safe zone for acetabular cup is difficult in revision situations⁸. Similarly femoral revision in the setting of previous bone loss, bony defects, and change in proximal femoral anatomy in revisions poses a challenge. Anterolateral or posterolateral approaches are commonly used for component revision. However, these approaches are associated with numerous complications, including sciatic nerve injury, infection, re-revision, venous thromboembolic disease, dislocation, pulmonary embolism, and death⁹. Hence, there is no perfect approach. Posterolateral has been regarded as a preferred approach by individual authors as both the posterior column of the acetabulum and the femoral shaft can be addressed through the same¹⁰.

DAA has been sparingly tried for revision, both for acetabular as well as for stem revision. Techniques of revision using DAA have been elaborated in numerous cadaveric studies; however, literature on DAA in revision is sparse and disorganised¹¹⁻¹⁴. In our review we attempt to examine the available literature in order to collect and consolidate information available on revision THA using the DAA.

METHODOLOGY

1. Search Strategy

A PubMed, Embase, and Scopus search was performed using the keywords and boolean operators (“Direct Anterior Approach” OR “Inter-muscular approach” OR “Inter-nerve approach” OR “Bikini incision”) AND (“Revision” OR “Revised”) AND (“Total Hip Replacement” OR “Total Hip Arthroplasty” OR “THR” OR “THA”). Studies were

identified independently by three review authors. The review was submitted for PROSPERO registration (ID 201545) and data extraction was performed using extraction forms with specified outcomes with at least two review authors. A flow diagram is presented for the number of studies included in Fig. 1. This systematic review and meta-analysis incorporates the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement (<http://www.prisma-statement.org/>). A systematic literature search in electronic databases was performed for 20 years to January 2021 using combinations of the keywords mentioned above.

2. Study Selection

The findings of the research question were synthesized narratively due to the heterogeneity of study designs and data. The PICO criteria for inclusion and exclusion of studies is shown below:

- P (population): Studies reporting on patients undergoing revision THA using DAA
- I (intervention): Revision THA (either stem or cup or both) using DAA
- C (comparison): The aim of the study is to examine the available literature in order to collect and consolidate information available to date on revision THA using the DAA. Due to heterogeneity of study designs and inadequate evidence available, statistical comparisons were not performed; however, an attempt was made to compare DAA with conventional THA approaches.
- O (outcomes): Harris hip score (HHS), modified HHS, Postel-Merle d’Aubigne (PMA) function, and Western Ontario and McMaster Universities Arthritis Index (WOMAC) scores expressed as mean \pm standard deviation, complication rates and postoperative radiological orientation (inclination and ante-version).

Only studies reporting on patients undergoing revision THA using the DAA were included for evaluation and analysis. Studies not in the English language, reporting surgical technique, cadaveric technique descriptions, and using additional approaches for part of the procedure were excluded.

RESULTS

In a review of the literature, of 118 articles found after removing duplicates, 15 were studied in detail and nine studies matched the pre-decided inclusion criteria. Of the excluded articles, three described surgical technique, two

were cadaveric study, and one was in German (Fig. 1). Although we searched literature for the last 20 years, the included articles were published after 2017, showing a recent increase in interest for performing revision THA using the DAA.

1. Demographic Analysis

The nine studies included 319 hip joints undergoing revision THA in 317 patients. Two studies, Baba et al.¹⁵ and Tamaki et al.¹⁶, discussed height and weight of patients, with a mean height of 149.7 cm (148.7 cm and 150.5 cm, respectively), and mean weight of approximately 53.3 kg (52.2 kg and 55.4 kg, respectively). Body mass index (BMI) is well recognized as an important factor associated with success of DAA by facilitating adequate exposure. Four studies, Hasler et al.⁶, Baba et al.¹⁵, Horsthemke et al.¹⁷, and

Tamaki et al.¹⁶, discussed BMI of patients; mean BMI was 27.45 kg/m² (range, 23.5-29.7 kg/m²). Of three studies, Baba et al.¹⁵, Bouveau et al.¹⁸, and Tamaki et al.¹⁶, have taken yet another characteristic, time between primary and revision arthroplasty; mean time to revision surgery was 12.17 months (range, 4.4-17 months). Mean follow-up of all included studies was 34 months (range, 18-80.4 months). The demographic details of all studies available in literature are discussed in Table 1. Most evidence available for DAA in revision arthroplasty is level IV. Baba et al.¹⁵ retrospectively compared patients who underwent acetabular revisions using DAA and a posterior approach providing level III evidence.

2. Indications for Revision

The indications for revision after primary THA in decreasing order were aseptic loosening (53%), peri-prosthetic

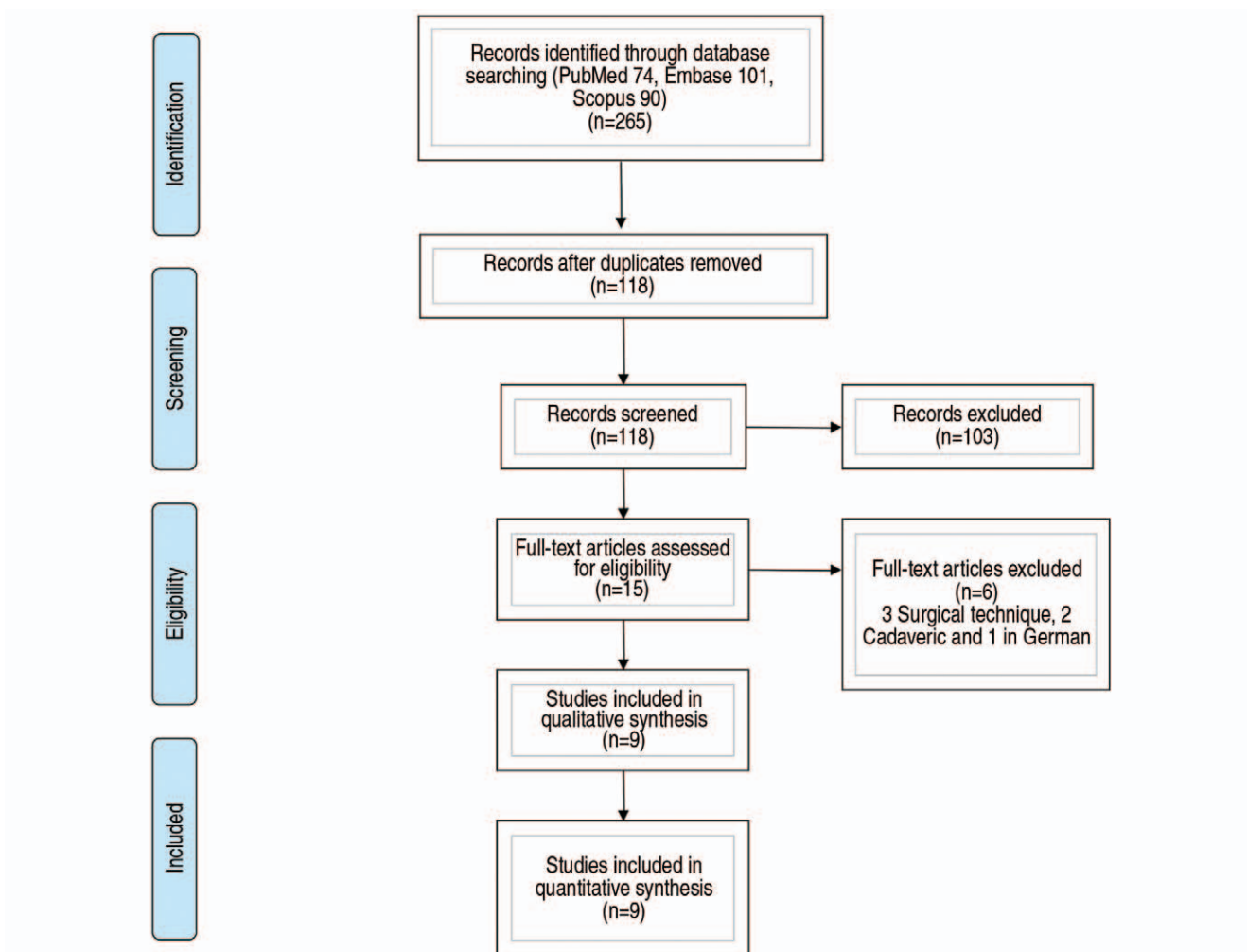


Fig. 1. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement flow chart used in the current study.

Table 1. Showing Various Demographic Parameters of Studies Reporting Revision Total Hip Arthroplasty Using Direct Anterior Approach

No.	Study	Year	Level of evidence	No. of patients included	No. of hip joints operated	No. of males	Mean age (yr)	Mean BMI (kg/m ²)	Time to revision surgery (mo)	Follow-up (mo)
1	Hasler et al. ⁶⁾	2020	IV	63	63	27	73	29.7	NS	18 (22 ML/14 AC/15.6 FC/14 Both)
2	Baba et al. ¹⁵⁾	2020	III	NS	22	2	71.7	23.5	17	45.6
3	Bouveau et al. ¹⁸⁾	2018	IV	15	17	7	45	NS	4.4	80.4
4	Horsthemke et al. ¹⁷⁾	2019	IV	48	48	14	70	27	NS	65
5	Tamaki et al. ¹⁶⁾	2018	IV	11	11	0	71.8	24.5	14.5	19.8
6	Thaler et al. ²⁰⁾	2020	IV	49	49	28	73.1	NS	NS	29.9
7	Thaler et al. ²¹⁾	2019	IV	40	40	22	74.3	NS	NS	50.4
8	Ghijsselings et al. ¹¹⁾	2017	IV	5	5	3	65	NS	NS	NS
9	Thaler et al. ¹⁹⁾	2020	IV	64	64	27	72.3	NS	NS	27.6

BMI: body mass index, NS: not specified, ML: mobile liner, AC: acetabular component, FC: femoral component.

joint infection (20.7%), peri-prosthetic fracture (16.9%), dislocation (7.2%), psoas impingement (1.9%), polyethylene wear (1.2%), pain (0.6%), and instability (0.3%) (Table 2).

Aseptic loosening was reported as an indication for revision in seven studies, with a total of 167 such revisions^{6,11,15-19)}. The defect was acetabular in the majority of cases (158 cases), which were classified according to Paprosky classification by Horsthemke et al.¹⁷⁾, Tamaki et al.¹⁶⁾, and Baba et al.¹⁵⁾ In a detailed analysis, Paprosky type 1 defect was reported in two cases, type 2a in 22 cases, type 2b in 29 cases, type 2c in 14 cases, type 3a in 39 cases, and type 3b in 38 cases, and type 4 in one case. Two studies reported femoral defects in seven cases while Hasler et al.⁶⁾ and Ghijsselings et al.¹¹⁾ reported a case each with combined acetabular and femoral loosening.

In two studies, 66 hips with peri-prosthetic infection were revised, where Hasler et al.⁶⁾ reported 17 hips with infection of which 16 underwent mobile liner and head exchange and one patient underwent isolated femoral component revision, while in another study by Thaler et al.²⁰⁾, which included 49 hips, both components were revised in two stages. Fifty four periprosthetic fractures were reported as indications in four studies. Of these, 53 were femoral periprosthetic fracture and one involved the acetabulum,

50 were classified according to Vancouver classification Type A – 2, Type B2 – 38, and Type B3 – 4^{11,21)}. Bouveau et al.¹⁸⁾ reported three femoral neck fractures as indications for revision of the femoral component.

Two studies had 23 dislocations as an indication of revision^{6,17)}. Of the 18 cases reported by Hasler et al.⁶⁾, five had isolated liner change, nine underwent acetabular revision, and two each had femoral and combined revision. In contrast, Horsthemke et al.¹⁷⁾ used dual mobility cups for revisions of recurrent dislocation of THA prosthesis.

3. Per-operative Characteristics

In six studies the mean operative time was 134.3 minutes (range, 97.9-203.2 minutes) and in three studies mean intra-operative blood loss was 486.8 mL (range, 436-1,472 mL). In 2020 Thaler et al.²⁰⁾, who performed revision in two stages, mentioned operative time of the first stage only, which was 140 minutes; duration of surgery for the second stage has not been specified (Table 3).

Table 2. Depicting Various Indications of Revision Using Direct Anterior Approach

No.	Study	Instability	Periprosthetic joint infection	Aseptic loosening	Paprosky classification	Vancouver classification	Dislocation	Psoas impingement	Periprosthetic fracture	Polyethylene wear
1	Hasler et al. ⁶¹	-	17 (16 ML /1 FC)	12 (7 AC /4 FC /1 Both)	NS	NS	18 (5 ML/ 9 AC/2 FC /2 Both)	5 (5 AC)	7 (1 AC /6 FC)	4 (4 AC)
2	Baba et al. ¹⁵¹	-	-	22 AC	Type 2a 6, type 2b 4, type 2c 7, type 3a 4, type 3b 1	NA	-	-	-	-
3	Bouveau et al. ¹⁸¹	1	-	8 FC, 3 AC	NA	NA	-	-	3	-
4	Horsthemke et al. ¹⁷¹	-	-	46 AC	Type 1 2, type 2a 14, type 2b 14, type 2c 1, type 3a 14, type 3b 3	NA	5	1	-	-
5	Tamaki et al. ¹⁶¹	-	-	11 AC	Type 2a 2, type 2c 1, type 3a 3, type 3b 5	NA	-	-	-	-
6	Thaler et al. ²⁰¹	-	49		NS	NA	-	-	-	-
7	Thaler et al. ²¹¹	-	-			B2 – 36, type B3 – 4	-	-	-	-
8	Ghijsselings et al. ¹¹¹	-	-	1 Both	NS	Type A – 2, type B2 – 2	-	-	40	-
9	Thaler et al. ¹⁹¹	-	-	64	Type 2b 11, type 2c 5, type 3a 18, type 3b 29, type 4 1	NA	0	-	-	-

ML: mobile liner, FC: femoral component, AC: acetabular component, NS: not specified, NA: not applicable.

Table 3. Depicting Per-operative Characteristics for All Included Studies

No.	Study	Operative time (min)	Intra-operative blood loss (mL)
1	Hasler et al. ⁶¹	97.9	436
2	Baba et al. ¹⁵¹	203.2	504
3	Bouveau et al. ¹⁸¹	NS	NS
4	Horsthemke et al. ¹⁷¹	125	NS
5	Tamaki et al. ¹⁶¹	148	743
6	Thaler et al. ²⁰¹	First stage – 140 min, time between 1st & 2nd stage – 65.7 days	NS
7	Thaler et al. ²¹¹	154.2	NS
8	Ghijsselings et al. ¹¹¹	NS	NS
9	Thaler et al. ¹⁹¹	NS	1,472

NS: not specified.

4. Procedure Performed

The revision was either a head/liner change, stem revision, cup revision, or a combined revision. Of the 319 hips reported in the literature to date, 107 patients underwent a stem revision, 142 patients underwent cup revision, and 49 patients underwent a combined revision. Only head/liner change was performed in 21 patients. Isolated head liner change was reported by Hasler et al.⁶ in all these patients (Table 4).

Twenty two cup revisions performed by Baba et al.¹⁵ had Kerboull-type plate and allogenic femoral head graft to provide acetabular support. Horsthenke et al.¹⁷ used a Hemispherical press fit cup in 23 patients, cage with cemented dual mobility cup in 13 patients, cemented dual mobility cup with metal, augment/wedge (off-label) in five patients and a dual mobility cemented cup in seven hip revisions. Thus a 28 mm head was used in one patient, seven patients had a 32 mm head, 15 patients had a 36 mm head and most commonly a dual mobility system was used in 25 hip revisions. Tamaki et al.¹⁶ used a Kerboull-type plate, allogenic femoral head bone grafts, with cemented cup of 44 mm in two hips, an isolated cemented cup of 48 mm in eight hips, and a cemented cup of 52 mm in one hip in revisions for aseptic cup loosening using the DAA. In this study head size was 28 mm in five hips and 32 mm in six hips. The study by Hasler et al.⁶ did not report type of implant for acetabular cup revisions. Thaler et al.¹⁹, in reporting midterm results of acetabular reconstruction using DAA, described graft augmentation prosthesis (GAP)-II with a reconstruction cage.

Modular cemented and un-cemented stem and long cemented and un-cemented stem were used in six studies where femoral stem revisions were performed. A study by Ghijssels et al.¹¹ reported on revision of the femoral stem plus cerclage wires (two cerclage wires at the lesser trochanter (LT) for Vancouver's type A, five cerclage wires around the LT and isthmus, and three cerclage wires for loosening along with ETO [extended trochanteric osteotomy]). Thaler et al.²¹ reported on the use of modular un-cemented stem in 21 hips, modular cemented stem in four hips, long cemented stem in 12 hips, and long un-cemented stem in three hips for peri-prosthetic femoral fractures.

5. Functional Outcome

Functional outcome was scored by different authors at inconsistent time points and using heterogeneous scor-

ing systems such as HHS, modified HHS, PMA function, and WOMAC score. In the evaluation performed by Hasler et al.⁶ mean HHS at final follow up was 91 at one year post-operatively, which falls in the good to excellent category. In a subgroup analysis the follow-up score was 93 after liner revision, 89 after acetabular component revision, 94 after femoral revision, and 91 after combined revision. Horsthenke et al.¹⁷ found that the mean HHS improved from 50 (range, 20-76) preoperatively to 91 (range, 57-96) postoperatively ($P=0.03$). Baba et al.¹⁵ used modified HHS for functional evaluation, which improved from 52.8 ± 9.1 preoperatively to 86.7 ± 10.3 postoperatively at the time of final evaluation ($P<0.001$) and 5-year implant survival rate was 100%. In a comparison of the DAA group to the posterior approach group the authors found that even though the functional outcomes were not significantly different, the intraoperative blood loss ($P<0.05$), complication rate ($P<0.05$) and the time to independent mobilization favoured DAA ($P<0.03$).

Bouveau et al.¹⁸ used PMA functional score, which improved from 9 ± 2.4 (range, 4-14) preoperatively to 16 ± 1.6 (range, 12-18) postoperatively ($P<0.001$) in which five hips were classified as "very good" or "excellent", eight hips were classified as "good", and two hips were classified as "poor". In their study on prosthetic infection Thaler et al.²⁰ used WOMAC score for evaluation, which improved significantly from 61.8 ± 19 preoperatively to 21.9 ± 15.6 postoperatively ($P<0.01$). Similarly, in their series of aseptic loosening of the acetabular cup Thaler et al.¹⁹ reported that WOMAC improved from 59 to 34.4 ($P<0.05$) (Table 5).

6. Radiological Evaluation

Only two studies have described the radiological evaluation of acetabular and femoral component^{6,17}; acetabular component orientation was evaluated by a mean cup inclination angle of 43.4° (42° and 44°), which is within the Lewinnek safe zone⁸. Similarly, acetabular anteversion was measured postoperatively by Hasler et al.⁶ and had a mean of 21. Horizontal and vertical centre of rotation (COR; horizontal or COR medialization 4 mm, and vertical or COR cranialization 5 mm) was assessed by Hasler et al.⁶. The femoral component position was evaluated according to vertical inter-teardrop distance, which was 21.5 mm, vertical leg lengthening 17 mm, and leg length discrepancy which improved from 14.9 to 2.2 mm in the series published by Tamaki et al.¹⁶ (Table 5).

Table 4. Discussing the Revision Procedure Performed for Revision Using Direct Anterior Approach in Included Studies

No.	Study	Head/liner change	Stem revision	Cup revision	Combined revision	Liner and head exchanges	Acetabular cup revisions	Femoral stem revisions
1	Hasler et al. ⁶⁾	21	13	26	3	21	26	13
2	Baba et al. ¹⁵⁾	0	0	22	0	-	Kerboull-type plate+allogeneic bone of the femoral head	-
3	Bouveau et al. ¹⁸⁾	0	1	0	16	16 Hips (13 CoC, 2 MoP, 1 MoM), 1 isolated femoral revision	-	-
4	Horsthemke et al. ¹⁷⁾	0	0	41	7	28 mm 1, 32 mm 7, 36 mm 15, dual mobility 25	Hemispherical press fit 23, cage with cemented dual mobility cup 13, cemented dual mobility with metal, augment/wedge (off-label) 5, dual mobility cemented 7	Total=7
5	Tamaki et al. ¹⁶⁾	0	0	11	0	28 mm 5, 32 mm 6	Kerboull-type plate, allogenic femoral head bone grafts, cemented cup 44 mm – 2, cemented cup 48 mm – 8, cemented cup 52 mm – 1	5 and 7 (Eng’s grade 2-3)
6	Thaler et al. ²⁰⁾	0	49	0	0	Custom-made spacer B/W 2 staged procedure	-	-
7	Thaler et al. ²¹⁾	0	40	0	0	-	-	Modular uncemented 21, modular cemented 4, long cemented 12, long uncemented 3
8	Ghijsselings et al. ¹¹⁾	0	4	0	1	-	-	-
9	Thaler et al. ¹⁹⁾	0	0	42	22	-	Graft augmentation prosthesis (GAP)-II, reconstruction cage	NS
Total		21	107	100	27	-	-	-

CoC: ceramic on ceramic, MoP: metal on polyethylene, MoM: metal on metal, B/W: between, NS: not specified.

Table 5. Clinico-radiological Evaluation of Hip Joints Undergoing Revision Total Hip Arthroplasty Using Direct Anterior Approach

No.	Study	Cup inclination angle (°)	Acetabular anteversion (°)	Leg length discrepancy (mm)	Functional evaluation
1	Hasler et al. ⁶¹	42	21	NS	HHS 91 (93 ML/89 AC/94 FC/91 Both)
2	Baba et al. ¹⁵¹	NS	NS	NS	Modified HHS 52.8→86.7
3	Bouveau et al. ¹⁸¹	NS	NS	NS	PMA functional score 9→16
4	Horsthemke et al. ¹⁷¹	44	NS	NS	HHS 50→91
5	Tamaki et al. ¹⁶¹	NS	NS	14.9→2.2	
6	Thaler et al. ²⁰¹	NS	NS	NS	WOMAC score 61.8→21.9
7	Thaler et al. ²¹¹	NS	NS	NS	
8	Ghijsselings et al. ¹¹¹	NS	NS	NS	
9	Thaler et al. ¹⁹¹	NS	NS	NS	WOMAC score 59→34.4

NS: not specified, HHS: Harris hip score, ML: mobile liner, AC: acetabular component, FC: femoral component, PMA: Postel-Merle d'Aubigne, WOMAC: Western Ontario and McMaster Universities Arthritis Index.

7. Complications

In this review we found a low complication rate (51/319), which included 12 dislocations, 12 infections, five cases of loosening of the acetabular shell, six peri-prosthetic fractures, four hematoma requiring after evacuation, five cases of femoral nerve injury, one case of peroneal nerve injury, two cases of psoas impingement, one case of deep vein thrombosis, and one case of pneumonia. Sixteen of these hips required revision in view of complications. Two deaths were reported in one study, which were not related to approach but due to co-morbidities²¹¹ (Table 6).

DISCUSSION

The DAA for THA has grown in popularity owing to its usage of inter-muscular and inter-nervous plane and the preservation of both the external rotators and the hip abductors^{7,221}. Literature shows strong results and advantages, in relation to the dislocation rate and heterotopic ossification, compared with other approaches in both mid to long term²³⁻²⁸¹. The use of DAA, however, has been limited to use in primary hip arthroplasty. Enthusiasm for the DAA has arisen in recent years, whether in nuanced revisions or complex primary procedures; thus only recently have authors concentrated on the extension of this approach, either proximally or distally, as well as on the morphology of the surrounding anatomical structures in the DAA^{14,29,301}.

Revision hip arthroplasty is marred by a difficult technique and much higher complication rates compared with primary surgery³¹¹. There are multifactorial explanations for increased complication rates with revision procedures; damage to soft tissues is considered one of the main causes con-

tributing to the same. Soft tissue damage, especially the abductor muscular, explains higher rates of infection, dislocation and poorer functional values than primary THA³²¹. Moreover, to ensure good function with adequate stability and prevent failure, correct inclination and anteversion are critical for placing the revision implant, and so is restoration of the COR. Early component loosening has been attributed to cranialisation and lateralisation of the hip centre which also causes weakness of the abductors^{33,341}. In a revision scenario, considering the existence of bony defects, it is much more difficult to restore the COR of the hip joint. This in effect means that the ideal approach for revision arthroplasty should not only provide abductor preservation but also provide a stable and accurate fixation of the implants along with restoring the COR.

Across the literature, it is believed and proven that the DAA in THA is associated with less soft-tissue damage as compared to other approaches for hip arthroplasty because it follows an inter-muscular plane and has the potential to increase the dynamic hip stability and lower the risk of hip dislocation following surgery³⁵¹. In addition, this approach preserves the hip abductors and simultaneously provides optimum acetabular exposure, that enables perfect cup placement and in effect decreases bearing surface wear³⁶¹. This has been further and more recently proved by Soderquist et al.³⁷¹ who have demonstrated that the DAA is an effective and safe approach to the anatomical reconstruction of the acetabulum as well as positioning of the cup. This has also been stated by Nogler et al.³⁸¹ who indicate that the strength of DAA is a reasonable approach for acetabular reconstruction. However, they feel that revision of the femoral procedure remains often troublesome. Except in the case of severe acetabular defects, the recovery of old acetabular compo-

Table 6. Complications Described in Patients Undergoing Revision Total Hip Arthroplasty Using Direct Anterior Approach

Study	Compli-cations	Infection	Dislo-cation	Loose-ning of acetabular shell	Psoas impinge-ment	Peripros-thetic fractures	Hemato-ma needing evacuation	Reope-ration	Femoral nerve injury	DVT	Pneu-monia	Death
Hasler et al. ⁶⁾	9	3	2	1	2	0	1	8	0	0	0	0
Baba et al. ¹⁵⁾	1	0	1	0	0	0	0	0	0	0	0	0
Bouveau et al. ¹⁸⁾	0	0	0	0	0	0	0	0	0	0	0	0
Horsthemke et al. ¹⁷⁾	8	2	0	1	0	0	2	0	1	1	1	0
Tamaki et al. ⁶⁾	1	0	0	1	0	0	0	0	0	0	0	0
Thaler et al. ²⁰⁾	17	5	6	0	0	5	0	8	1	0	0	0
Thaler et al. ²¹⁾	5	0	0	0	0	1	1	0	1	0	0	2
Ghijssels et al. ¹¹⁾	1	0	0	0	0	0	0	0	1	0	0	0
Thaler et al. ¹⁹⁾	9	2	3 (1 closed reduction, 2 revision surgery)	2 (1 at plate cup junction in type 3b, 1 cage migration >6 mm)	0	0	0	0	2 (1 peroneal nerve, 1 femoral nerve)	0	0	0
Total	51	12 (3.8)	12 (5.3)	5 (2.8)	2 (0.6)	6 (1.9)	4 (1.25)	16	6 (1.9)	1 (0.3)	1 (0.3)	2 (0.6)

DVT: deep vein thrombosis.

nent, introduction of structural or morselized allogenic bone grafting and the positioning of the implant can be done less invasively by a single anterior incision¹⁶⁾.

Femoral revisions for periprosthetic femoral fractures were performed more recently by Thaler et al.²⁰⁾ with good results in 49 cases. The authors routinely extend the original approach used for DAA distally while maintaining the same dissection interval for all periprosthetic femoral fracture cases requiring revision of the femoral component. This technique described by Ghijssels et al.³⁹⁾ in their cadaveric technique description is an alternative way to gain additional exposure of the femur during the DAA and is based on precise knowledge of the periarticular neurovascular structures^{26,27)}. Femoral revisions using a posterior hip joint method, along with the release of external rotators, traditionally show a dislocation rate of up to 30% in literature^{40,41)}. The same group of authors (Thaler et al.²⁰⁾ have also studied DAA for two stage revision arthroplasty following peri-prosthetic joint infection. They reported a very low dislocation rate of 12.2% after first stage and no dislocations until follow-up after second stage. In both their studies of periprosthetic fracture as well as for periprosthetic infection the authors reported femoral nerve palsies which were transient in nature. They also reported a periprosthetic calcar fracture in 10.5% of their first stage revisions which was managed by cerclage wiring²⁰⁾.

Distal extension for DAA is associated with a theoretical risk of injury to the lateral femoral cutaneous nerve which was not commonly identified by Thaler et al.²¹⁾ in their series. In contrast the incidence of sciatic nerve palsy after primary hip arthroplasty was recently reported as 0.17% using the conventional posterior approach⁴²⁾. In the revision setting, sciatic nerve palsy has been reported to occur from 0% to as high as 7.6% using traditional approaches^{43,44)}.

Nevertheless, data on DAA revision arthroplasty is limited in available literature. A few studies have supported use of the DAA in revision arthroplasty; our literature search shows that revision arthroplasty using the DAA has been studied in 248 hip arthroplasty revisions. Posterior and lateral approaches are commonly used for revision of hip arthroplasty due to better visualization and have been conventionally favored¹⁵⁻⁴⁷⁾. Research by Mast and Laude¹²⁾ assessing hip arthroplasty using DAA for revision identified a small rate of complications. In their series, no dislocations were recorded with near ideal functional performance at a follow-up of 55

months. DAA appears to be a reliable technical solution for management of failed hip replacements. Of the 319 revision hips reported using DAA to date, 107 patients underwent a stem revision, 142 patients underwent cup revision, 49 patients underwent combined revision, and 21 patients underwent dry revision (head/liner change). Theoretically, dry revisions are the most favorable indication of DAA revision THA but this is not supported with evidence. Tensor fascia lata, Obturator internus, and Gluteus minimus damage, fatty atrophy and loss of cross sectional muscle mass in complex primary hip arthroplasty cases (DDH [developmental dysplasia of hip]) have been reported⁴⁸). However, this has not lead to a decrease in HHS, and no damage to the gluteus medius, which is the primary abductor, was observed in the mentioned study. Our findings from review of the literature suggest that hip arthroplasty revision can be successfully performed using the DAA. The current study is limited by non availability of level 1 evidence and comparative studies to further prove superiority of DAA over conventional approaches for revision THA.

CONCLUSION

Based on available evidence, DAA appears to be a reliable and practical alternative for revision of the failed hip arthroplasty, although the quality of evidence is insufficient to draw concrete conclusions. Complication rates with DAA are nearly comparable if not less as compared to posterior and lateral approach to the hip joint for revisions. The learning curve for this technique is undoubtedly steep and surgeons wishing to perform this approach need to have performed a significant number of primary hip arthroplasties using this approach⁴⁹). The most recent clinical and cadaver studies also indicate increased use of DAA for acetabular and femoral revisions³⁹). Comparative studies with a more robust design are needed to prove superiority or equivalence of DAA over conventional approaches for revision arthroplasty.

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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