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HIP ARTHROPLASTY

The minimalinvasive direct anterior approach in aseptic cup revision hip arthroplasty: a mid-term follow-up

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Abstract

Introduction The minimally invasive direct anterior approach (DAA) is an established approach for primary total hip arthroplasty (THA). The complication rates in hip revision arthroplasty are much higher in comparison with primary THA. A right positioning of the implants and a soft tissue, especially the abductors spearing approach, is important to get good functional results and low complication rates. The aim of this study was to show the clinical and radiological outcome of isolated revision hip arthroplasty of the cup by using the DAA.

Materials and methods Aseptic cup revisions were carried out in 48 patients using the DAA. A decision to exchange the stem was made intraoperatively in seven cases. Complications, radiological and functional outcome were assessed. All of the data were collected retrospectively. The mean follow-up period was 65 months.

Results In most of the cases the standard DAA was used. A proximal extension was nescessary in 15 patients (31%). The mean cup inclination angle after revision was 44° (min. 25°, max. 62°). Six implants (12.5%) were located outside of the Lewinnek safe zone. The centers of rotation of the revision implants were a mean of 0.6 cm superior (min. 0, max. 2.2 cm) and 0.5 cm lateral (min. 0.2 cm, max 1.2 cm) in comparison with the center of rotation in the healthy hip on the contralateral side. Harris Hip Score improved significantly from 50 to 91 ($P=0.03$). Complications noted consisted of two periprosthetic infections (4.2%), one aseptic cup loosening (2.1%), two hematomas requiring revision (4.2%), and one case each of femoral nerve injury, lower-leg venous thrombosis, and pneumonia. No dislocations were observed and there were no cases of heterotopic ossification based on the Brooker classification. No persistent damage of the nervus cutaneus femoris lateralis was found at the follow-up examinations.

Conclusions The DAA represents a feasible option in hip revision arthroplasty. Anatomic reconstruction of the cup is reproducibly possible. Good medium-term results can also be achieved. Particularly in relation to dislocation, the complication rates are low. Due to the learning curve, the DAA should only be used in hip revision arthroplasty by those with sufficient experience in primary THA. Adequate data regarding stem revisions through the DAA are not available at the moment.

Keywords Direct anterior approach · Revision hip arthroplasty · Minimal invasive arthroplasty · Total hip replacement

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Introduction

The minimally invasive direct anterior approach (DAA) is an established approach for primary total hip arthroplasty (THA). Good results and advantages in comparison with other approaches have been reported in the literature—particularly during the first 12 weeks, but also during the longer-term follow-up—in relation to dislocation rates and heterotopic ossification [1–8].

The complication rates in hip revision arthroplasty are much higher in comparison with primary THA [9]. The reasons for the increased complication rates with revision procedures are multifactorial. The bony defect situation, positioning, and choice of implant all play a role. However, increasing damage to the soft tissues, especially to the abductor muscles, also explains higher infection rates, dislocation rates, and poorer functional scores in comparison with primary THA [10, 11].

To our knowledge, this is one of the few studies, which presents mid-term results following aseptic cup revision using the DAA. The following questions were addressed: Is anatomic reconstruction possible in revision cases using the DAA? What are the results and complication rates in comparison with the literature for conventional approaches?

Materials and methods

Aseptic cup revisions were carried out in 48 patients with a mean age of 70 (min. 44, max. 82; 14 men, 35 women) in the period from 2009 to 2012. All of the revision arthroplasties were performed by a single surgeon (senior author). The right side was involved in 23 cases and the left in 25. The patients' mean body mass index (BMI) was 27 kg/m^2 (min. 23.5, max. 29).

The number of previous cup revisions was 1 in 33 patients, 2 in 9 patients, 3 in 5 patients, and 6 in 1 patients.

Inclusion criteria were all patients with an indication for aseptic revision of the cup without obvious loosening or malpositioning of the stem. Exclusion criteria were Primary THA for tumor desease or metastasis and periprosthetic infections using preoperative joint aspiration and biopsy if needed [12].

The indications for revision were dislocation due to malpositioning ($n=5$), aseptic loosening ($n=42$), and psoas impingement ($n=1$). A decision to exchange the stem was made intraoperatively in seven cases, because of insufficient exposure of the acetabulum $n=1$, aseptic loosening $n=4$, retrotorsion $n=2$.

In all patients the direct anterior approach between the muscle tensor fasciae latae and the rectus femoris was used like that described from Rachbauer et al. [13, 14]. In cases of isolated revision of the cup, the femoral head is removed. The hip will then be put in about 30° of flexion. By rotating the femur the stem can be put in a pocket created posterior superior to the acetabulum. To get better access release of the capsule posterolateral of the femur is nescessary in most cases. Then a minimal invasive hook is placed at the posterior rim of the acetabulum to push the stem posteriorly.

A proximal extension was nescessary in 15 patients (31%) (Table 1). Proximal approach extensions were most often carried out for type 3 defects (53%). In these cases an extension of 2–3 cm in direction of the anterior iliac crest with release of the tendon of the tensor fascie latae was sufficient [15].

Patient-specific data, data on the operation carried out, and the follow-up results including complications, were drawn from the patient files. Signs of loosening, the inclination angle, and superior and lateral changes to the center of rotation in comparison with the original healthy joint of the contralateral side were assessed using a.p. radiographs [16] The Trendelenburg sign and Harris hip score (HHS) were assessed preoperatively and at the last follow-up examination. All of the data were collected retrospectively.

The mean follow-up period was 65 months (min. 44, max. 121). Three patients were lost to follow-up. Two patients died after 50 and 60 months, respectively, independently of the operation carried out.

Statistical analysis was carried out using IBM SPSS Statistics for Windows, version 20.0 (Armonk, New York: IBM Corporation). The study was approved by the local institution's Ethics Committee (reference no. 2017-601-f-S) and was conducted in accordance with the Helsinki Declaration.

Results

Table 1 lists the type of acetabulum defects, numbers of extensions, and numbers of stem exchanges.

Table 1 Paprosky classification of types of acetabular defect, numbers of proximal extension and stem exchanges

Type of defect	$N=48$	Proximal extension $N=15$	Stem exchange $n=7$
Type 1	2	1	1
Type 2a	14	1	1
Type 2b	14	4	1
Type 2c	1	0	0
Type 3a	14	6	2
Type 3b	3	3	2

Table 2 Cups used in previous and revision arthroplasties

Type of cup	Previous arthroplasty (*n*)	Revision arthroplasty (*n*)
Hemispherical press fit	18	23[a]
Threaded cups	14	0
Cemented polyethylene	10	0
Cage with cemented polyethylene	4	0
Cage with cemented dual mobility cup	0	13[b,c]
Cemented dual mobility with metal augment/wedge (off-label)	0	5[b,a]
Dual mobility cemented	0	7[3]

[a]Trabecular Metal™ (Zimmer Biomet, Warsaw, Indiana, USA), $n=5$; Tritanium® (Stryker, Kalamazoo, Michigan, USA), $n=18$

[b]Burch Schneider cage (Zimmer Biomet, Warsaw, Indiana, USA)

[c]Avantage® cup (Zimmer Biomet, Warsaw, Indiana, USA)

The type of cups implanted before and afterrevision are listed in Table 2.

Table 3 lists the head sizes used before and after revision arthroplasties.

Allografts or bone substitutes (Vitoss; Stryker, Kalamazoo, Michigan, USA) were used in 11 patients and seven patients, respectively.

The mean operating time was 125 min (min. 65, max. 235).

In 37 patients no transfusion of packed red cells was nescessary, in one patient 1 transfusion was nescessary, 7 patients got 2 transfusions, in 3 cases 4 packed red cells were transfused and in 1 patient 6 packed red cells were transfused.

The mean cup inclination angle at the follow-up was 44° (min. 25°, max. 62°). Six implants (12.5%) were located outside of the Lewinnek safe zone independent from the type of defect [10].

Changes in the center of rotation following the cup revision via DAA, in comparison with the healthy hip joint on the contralateral side, were noted in 19 patients. The centers of rotation of the revision implants were a mean of 0.6 cm superior (min. 0, max. 2.2 cm) and 0.5 cm lateral (min. 0.2 cm, max 1.2 cm) in comparison with the center of rotation in the healthy hip on the contralateral side.

No radio lucent lines were found in 31 patients. 7 patients had radio lucent lines in zone 1, in 8 patients radio lucent lines were found in zone 1 and 2, one patient each showed radio lucent lines in zone 1,2,3 and zone 2,3.

Table 4 lists the Trendelenburg signs before and after revision, dependent of approaches before revision.

The mean HHS was 50 preoperatively (max. 76, min. 20) and 91 at the follow-up examination (max. 96, min. 57) ($P=0.03$).

Complications noted consisted of two periprosthetic infections (4.2%), with two-stage exchanges after 14 and 27 months, and one aseptic cup loosening after 25 months (2.1%) in a type 3a defect. Two hematomas required revision (4.2%), and there was one case each of femoral nerve injury, lower-leg venous thrombosis, and pneumonia. No dislocations were observed and there were no cases of heterotopic ossification based on the Brooker classification [17]. No cases of injury to the lateral cutaneous nerve of the thigh were found at the follow-up examinations.

The 7 patients with a stem exchange showed no differences in HHS preoperativly and at follow-up to the group of single cup revision. No modular revision system was used. All stems were cemented. In 3 patients proximal extension of the approach with release of the tendon of the tensor fasciae latae was nescessary for better visualization of the femur. In one patient postoperativly an incomplete lesion of the femoral nerve was diagnosed.

Discussion

The DAA for THA is an established approach that is associated with good results [6, 18–21]. Soderquist et al. recently showed that the DAA is also a safe and reliable approach in relation to anatomic reconstruction and positioning of the cup components in particular [22]. Eighty-five percent of the cup implants were placed within the Lewinnek safe

Table 3 Head sizes used in the previous and revision arthroplasties

Head sizes	Previous arthroplasty (*n*)	Revision arthroplasty (*n*)
28 mm	28	1
32 mm	16	7
36 mm	2	15
46 mm (metal on metal)	1	0
54 mm (metal on metal)	1	0
Dual mobility	0	25

Table 4 Trendelenburg signs before and after revision, relative to the approaches used before revision

Approaches before revision ($n=42$)	Trendelenburg sign before revision	Trendelenburg sign after revision
Lateral ($n=25$)	$n=15$ (60%)	$n=8$ (32%)
Posterior ($n=12$)	$n=7$ (58%)	$n=3$ (25%)
Direct anterior ($n=3$)	$n=0$	$n=0$
Watson Jones (anterolateral) ($n=2$)	$n=1$ (50%)	$n=1$ (50%)
Total	$n=25$ (60%)	$n=12$ (29%)

zone using a freehand technique. Kawarai et al. investigated implant alignment in primary hip arthroplasties and compared the DAA and the anterolateral approach. No significant differences between them were found with regard to the accuracy of cup positioning (85% versus 97%) [23]. When positioning the revision implant not only the right inclination and anteversion are important but also restoring the center of rotation are important to get a stable joint with good function and no early lossening. In the present group of patients, implantation in the safe zone was also achieved in 87.5% using the DAA, even in revision cases.

As is known from the literature, cranialization and lateralization of the center of rotation leads to an increased rate of loosening and to weakening of the abductors [24, 25]. Asayama et al. concluded that a slightly inferomedial cup position can lead to an improvement in abductor function [26].

Restoring the center of rotation in the hip joint is much more difficult in revision cases, due to the presence of bony defects.

In our series cup implants could be fixed in the safe zone in 87.5%, which is comparable with the data in primary hip arthroplasties using the DAA. The center of rotation was only minimally changed to a superior (mean 0.6 cm) and lateral (mean 0.5 cm) position, which represents a good anatomical reconstruction even in cases with Paprosky typ III decects. As the present data show, an anatomic reconstruction can be achieved in most cases even in revision procedures using appropriate implants such as wedges. The DAA does not present any limitations here. The approach can also be extended proximally to fill defects with metal wedges, or to fix cages with screws, in cases of larger superiorcranial defects [27].

On the functional side we could show a significant improvement in the HHS with a mean of 91 points after a follow-up of 65 months.

After a mean follow-up period of 65 months, the HHS significantly improved from 50 to 91 points ($p=0.03$) Other studies have also confirmed a significant improvement in the HHS after hip revision arthroplasty, from 44 to 81 [28]. To achieve this functional improvement, no further damage to the abductors is essential. In our series the Trendelnburg sign could be reduced from 60% preoperativly to 29% after revision.

In another study following primary hip arthroplasty via the lateral approach, 20% of the patients had a positive Trendelenburg sign, indicating abductor muscle weakness; after hip revision arthroplasty with the same approach, the figure was as high as 63.3% of the patients [29]. These data are consistent with the results of the present study. To achieve this functional improvement, no further damage to the abductors is essential. In a study of patients who underwent total hip arthroplasty via the DAA in developmental dysplasia of the hip, slight impairment of the gluteus minimus was noted 1 year postoperatively. No damage to the gluteus medius was present. The fatty atrophy demonstrated on magnetic resonance imaging did not have any effects on the HHS postoperatively [30].

Of course the large number of positive Trendelenburg signs in the present group is not due to previously damaged gluteal muscles alone. Loosened implants and malpositioning of the components also lead to a positive Trendelenburg sign. So the present clinical results cannot be attributed to the approach used alone, since qualitative examinations of the musculature before and after the procedure were not carried out in the study. A stable fixation of the implants with restoring the center of rotation is also essential for good functional results [24–26].

In a study of patients who underwent total hip arthroplasty via the DAA in developmental dysplasia of the hip, slight impairment of the gluteus minimus was noted 1 year postoperatively. No damage to the gluteus medius was present. The fatty atrophy demonstrated on magnetic resonance imaging did not have any effects on the HHS postoperatively [30]. But also a stable fixation of the implants with restoring the center of rotation is essential for good functional results [24–26].

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In a study including 3555 revision procedures following total hip arthroplasty, the most frequent complications observed were infection, at 17.3%; repeat revisions were needed in 15.8% of cases; and dislocations occurred in 5.43%. In the present group as well, the revision rates were higher than after primary procedures, although the percentage was lower than in the study by Badarudeen et al. [9]. It was notable that no dislocations occurred. Cogan et al. reported a 6.6% dislocation rate and Mast et al. reported 0% after isolated cup revision using the DAA [15, 31]. These studies do not give any details of the head sizes selected, which influence the dislocation rates. In the present group of patients, head sizes of 36 mm or dual-mobility cups were often used, and these also reduce dislocation rates [6]. In the literature only one more study describes the results of the DAA in revision hip arthroplasty. In 15 patients MoM arthroplasties were revised through the DAA. After 6.7 years no rerevision was required. One fracture of the greater trochanter and four dysethesia of the lateral femnoral cutaneous nerve were reported [32].

In a cadaver study from 2006 it could be shown that an uncompromised quality of the cement mantle of the femoral stem can be achieved by using the DAA [33]. In our small group of stem revisions all stems were cemented with no further revision in our follow-up. Because of our inclusion criteria and the small number of stem exchanges no conclusion can be drawn. At the current time no clinical results with a larger gruop of stem revisons exist. There are only studies describing the distal extension to the femur for this approach [34–36].

There are several limitations

The present study involved retrospective data collection without a control group. Despite the inclusion and exclusion criteria established, there is still some heterogeneity in the group that makes comparison with the results of other studies difficult. The number of patients involved is pretty small. Descriptive statistics were mostly used, due to the small number of cases.

Conclusions

The DAA represents a feasible option in hip revision arthroplasty. Anatomic reconstruction of the cup is reproducibly possible. Good medium-term results can also be achieved. Particularly in relation to dislocation, the complication rates are low. Due to the learning curve, the DAA should only be used in hip revision arthroplasty by those with sufficient experience in primary THA. Adequate data regarding stem revisions through the DAA are not available at the moment.

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Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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