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RESEARCH

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Dislocation incidence and risk factors following direct anterior primary total hip arthroplasty: a consecutive, single-surgeon cohort

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Abstract

Backgrounds Dislocation is one of the debilitating complications of total hip arthroplasty. It is a common reason for revision surgery after THA, along with other complications such as infection and instability. This study determined the incidence and risk factors of dislocation after primary total hip arthroplasty using the direct anterior approach.

Methods Retrospective Data from patients who underwent primary THA from 2013 to 2020 was analyzed. Anteversion and inclination angles were extracted from their imaging studies, and demographic data were also recorded from their medical records. Data were analyzed using SPSS version 26.

Results One thousand two hundred four cases of THA were reviewed in our study. 31 (2.57%) dislocations happened after a minimum follow-up of five years. Our study showed that DDH diagnosis as the underlying condition, using Wagner Cone and Wagner SL stem, cup size smaller than 52, head size smaller than 34, anteversion and inclination angle outside the Lewinnek safe zone can be risk factors for dislocation. Primary OA and Fitmore stem acted as protective factors for dislocation.

Conclusion In the DA approach, the underlying disease, properties of the prosthesis used such as cup and head size, stem type, and anteversion and inclination angles can be the potential risk factors for dislocation.

Level of evidence III

Keywords Total hip arthroplasty, THA, Dislocation, Complication, Direct anterior, DA

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Introduction

One of the most critical complications of total hip arthroplasty (THA) is dislocation. The prosthetic head and liner arrangement allow a range of motion (ROM) near the normal physiologic range. The incidence of dislocation is 0.2%–5.8% in primary THA [1]. Complications such as dislocation, infection, or instability diminish the quality of life and necessitate the patient to undergo a revision THA, which imposes a heavy burden on the healthcare system [2, 3].

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Various factors are involved in dislocation; Some of them are patient-related like the underlying pathology, age, neuromuscular disorders, certain lifestyles, and previous hip surgeries. Some other risk factors are related to the surgeon and the prosthesis used; this includes the surgeon's experience, the approach used, prosthesis parts arrangement, and design [3].

Various approaches are used for THA including the posterior approach, direct anterior (DA) approach, direct lateral approach, and anterolateral approach. DA is a relatively new surgical approach in THA that has gained popularity over the past few years due to its lower complication rates [4, 5]. It is also considered to be a favorable approach due to it being muscle preserving, which leads to faster recovery and lower rates of complication. After positioning the patient supine in this less invasive approach, an incision is made over and through tensor fascia lata. The hip is then flexed to allow access through the muscular and nervous components. The surgeon then makes an incision in the anterior part of the joint capsule which allows for better positioning of prosthesis and higher exposure of intracapsular structures. The acetabular and femoral parts are then prepared and after insertion and placement of the prosthetic components, reduction and closure is done [6].

The dislocation rate of the DA approach is lower compared to other methods; in a meta-analysis study by Jin et al., the dislocation rates of the DA approach compared with the posterolateral (PL) approach were significantly lower (OR: 0.26, 95% CI: 0.11 - 0.60, I2=0.0%) [5]. When compared, the DA approach had faster recovery and an earlier return to daily activities [5]. Making the incision in the anterior part also helps keep the posterior capsule intact. This can be a reason for lower dislocation rates observed in studies but is accompanied by an increased risk of lateral cutaneous nerve injury.

Preventing dislocation requires the surgeon to thoroughly examine the patients and their risk factors and plan for each patient separately. This study aimed to investigate the incidence and possible risk factors of prosthesis dislocation in a single-center single-surgeon consecutive series of patients, after primary THA, using the DA approach.

Materials and methods

Study settings and design

This is a single-center single-surgeon retrospective cohort study in accordance with the STROBE checklist for observational studies, on patients undergoing THA surgery from 2013 to 2020 at our tertiary referral center (Imam Khomeini Hospital Complex, Tehran) [7]. Participants were categorized into two groups based on their dislocation status: Dx and non-Dx. In case the patient experienced more than one events of dislocation, only the first incidence was considered and included in the study.

The inclusion criteria for our study was: patients younger than 90 with any form of hip joint pathology who underwent primary THA between 2013-2020. The exclusion criteria of our study were: 1. patients with a prior history of surgery on the affected side of the hip, including osteotomies, internal fixation, or previous arthroplasty. 2. patients undergoing revision arthroplasties 3. patients who had a clinical follow-up of less than five years 4. patients with multiple traumas, open fractures, or periprosthetic fractures involving vascular injury or peripheral nerve damage 5. Patients with severe systemic diseases or comorbidities deemed unsuitable for THA based on preoperative evaluation, including advanced cardiopulmonary disease, terminal malignancies, coagulation disorders or local or systemic infections at the time of the surgery.

Data acquisition

Data were retrospectively gathered from our database and patient medical records using the hospital information system (HIS). We collected data from pre- and post-op visits, including demographics, past medical history, history of previous hip surgery, and the surgery record summary, indicating the prosthesis size and model used. The hospital picture archiving and communication system (PACS) was searched for patient radiographs to measure cup anteversion and inclination angles. Every patient received pre-surgery AP X-rays of their pelvis in the radiology department, following a consistent protocol; standing upright, with both legs rotated internally by 15 degrees and bearing full weight. The distance between the tube and the film was set at 1.15 m, and the beam was centered on the symphysis pubis. A metal ball with a diameter of 25 mm was used to standardize and magnify the X-rays, taped in the same position on each patient's skin. Radiological measurements were performed by an experienced PGY-3 orthopedic resident (H.R) who is highly knowledgeable about THA procedures and pre-op planning software.

Post-op radiography was used to determine the anteversion angles and pelvic obliquity (PO) based on the methods developed by Widmer et al. and Moharrami et al. [8, 9]. Cup anteversion, inclination, and S/TL ratios were then calculated, and the results were then compared to the Lewinnek safe zone (LSZ).

Definitions

Cup anteversion was calculated using the projected ellipse's short axis (S) and the total length (TL) of the projected cup. The S/TL ratio was then calculated, and the anteversion angle was determined according to their Table, as Widmer et al. 40 suggested. The resulting anteversion was compared to LSZ (15° ± 10°). Cup inclination was calculated as the angle between the longitudinal axis of the acetabular part and the inter-teardrop line in anteroposterior (AP) hip radiography in 285 non-dislocation cases and all 31 of the dislocation patients. The results were compared to the Lewinnek safe zone (40° ± 10°). Charlson comorbidity index (CCI) and American Society of Anesthesiologists (ASA) classification of physical health were used for each patient to measure their general health [10].

Intervention protocols

All patients were treated by an experienced orthopedic surgery attending using a standard DA approach. After medical clearance, the patients underwent an AP x-ray of their pelvis. Preoperative templating was done for each patient using mediCAD® 3.5 (Altdorf/Landshut, Germany) [11]. Different femoral stems and cups were chosen for each patient according to the femoral canal diameter (using the Dorr index) and the anatomy of the proximal part of the femur bone, and the availability of prosthesis; Fitmore, Wagner SL, M/L Taper, Wagner Cone (Zimmer Biomet, Indiana, USA), Accolade TMZF (Stryker, Michigan, USA), Corail (Depuy Synthesis, Indiana, USA) are the different stems used were Continuum (Zimmer Biomet, Indiana, USA), Pinnacle (Depuy Synthesis, Indiana, USA), Trident (Stryker, Michigan, USA), Trilogy (Zimmer Biomet, Indiana, USA). Patients were positioned supinely after anesthesia, and incision was made over and through the tensor fascia late. The hip joint was then flexed for better access through the nervous and muscular components. Anterior capsulectomy was performed to expose the head and neck, followed by a double neck osteotomy to remove the head. Additionally, the medial capsule was incised to expose the acetabulum better. We cut soft tissue around the greater trochanter and piriformis fossa to elevate the proximal femur and canal broaching through an incision. No tenotomy was performed, and no skeletal or skin traction was applied.

An identical post-op protocol was used for all patients. Active movements in the normal ROM and weight bearing as tolerated were allowed on the day of surgery. No hip precautions were advised. Patients were evaluated after two weeks and 2, 3, 6, and 12 months and then annually after discharge from the hospital during their routine clinical visits for ROM, inspection of surgical site for any complication, and the overall function of the joint. In cases of dislocation, the prosthesis was reduced and for more serious cases requiring further intervention, a constrained liner was used.

Ethics

The study protocol was reviewed and ethically approved by our University of Medical Sciences ethics committee (Approval ID: IR.TUMS.IKHC.REC.1400.021).

Statistical analysis

Quantitative data were reported as mean ± standard deviation (SD), and independent samples T-Test was used to compare means between the two groups. Qualitative data were reported in numbers and percentages, and Pearson's Chi-squared and Fisher's exact test were used to compare the two groups. ANOVA with Tukey's post hoc test were used to compare multiple groups. ROC analysis was used to determine the best head and cup size to prevent dislocation. IBM SPSS version 26 was used for data analysis, and $P<0.05$ was considered significant.

Results

Demographics and baseline characteristics

One thousand two hundred four cases of hip arthroplasties were retrieved from our registry, of which 31(2.57%) were known to have suffered from dislocation in the follow-up. 51% of patients were males in our cohort. Their ages ranged from 15 to 90 years (45.1 ± 15.0). Body mass index (BMI) had a mean and SD of 24.6 ± 4.4. 626 (51.9%) of cases were right hip arthroplasty, and 578 (48.9%) were left side THA; 936 (83.9%) of operations were unilateral THA, and 268 (22.1%) were bilateral THA. 263 (21.8%) had a history of any previous hip surgery unless THA since patients with a history of THA were excluded as our study targeted primary THA patients. The underlying disease which indicated the patient for surgery is as follows; 325 (26.9%) primary OA, 310 (25.7%) DDH, 276 (22.9%) AVN, 194 (16.1%) fracture, 22 (1.8%) Perthes', 17 (1.4%) hemophilia, septic Arthritis 14 (1.1%), rheumatoid Arthritis 13 (1.0%), 11 (1.4%) juvenile rheumatoid arthritis, Arthrodesis 11 (1.4%), acetabular protrusion 9 (0.8%), exostosis 2 (0.2%).

Description of the dislocated cohort

In the dislocated cohort, 17 (54.8%) hips were treated by closed reduction, six (19.4) were treated by open reduction, and 8 cases (25.8%) underwent revision surgery; In two (25%) of these cases, only the cup was replaced, and in one (12.5%), only the liner was replaced with a constrained liner. Five cases of dislocations happened before the patient was discharged from the hospital (Inpatient dislocation, 16.1%), and 26 (83.9%) occurred

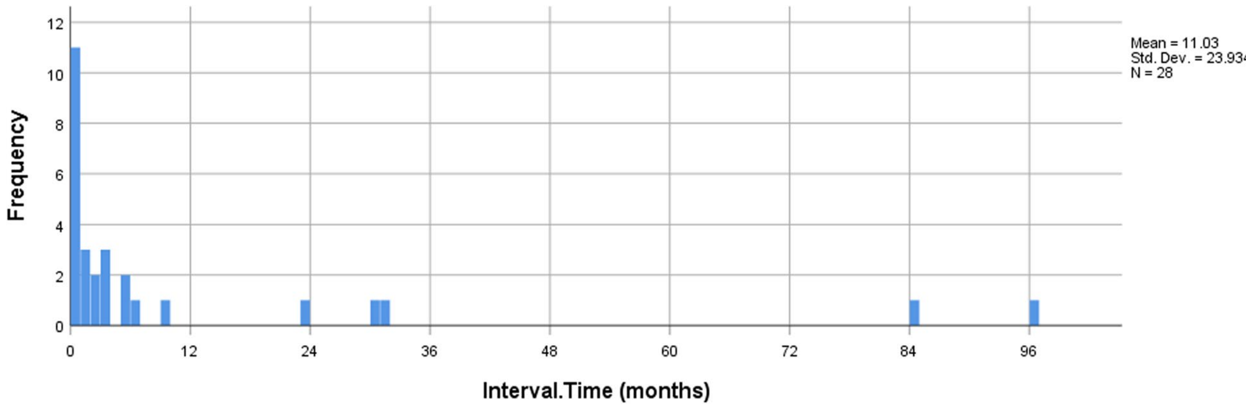

Fig. 1 Time to event distribution in patients suffering from dislocation (n = 31)

after discharge. Time to event interval for dislocation ranged from 0 to 96 months (mean ± SD: 10.8 ± 23.1) (Fig. 1). The indication for THA in 18 (58.1%) cases of dislocation was DDH; it was hip fracture in 5 (16.1%) cases. 3 (9.7%) were AVNs, 2 (6.5%) were arthrodesis, 2 (6.5%) were hemophilia, and 1 (3.2%) was primary OA.

Inclination and anteversion angles ranged from 22.3 to 65.3 (mean ± SD: 43.1 ± 10.7) and 4 to 39.8 (mean ± SD: 17.1 ± 8.2) degrees, respectively. Compared to the LSZ, 19(61.3%) patients were in the safe zone for inclination, 24(77.4%) were in the safe zone for anteversion, and 15(48.4%) were in the safe zone for both.

Comparison between the dislocation and non-dislocation groups

There was no significant difference between the dislocation and non-dislocation group in age, sex, BMI, CCI score, ASA classification, surgery side (right or left), bilateral or unilateral THA, previous hip surgery, or joint disease in the opposite hip (P>0.05) (Table 1).

Indications for THA differed significantly between the Dx and non-Dx groups (P<0.001). Analysis using ANOVA showed a significant difference in dislocation rates between the DDH groups with primary OA (P<0.001) and AVN (P<0.003). Other diagnoses did not vary significantly between the two groups (P>0.05).

Stem type, cup size, and head size varied significantly between the two groups. Wagner Cone (38.7% vs. 6.7%, P<0.001) and Wagner SL revision stem (12.9% vs. 2.7%, P=0.001) were used more frequently in the dislocation group. On the contrary, Fitmore stem was used less frequently in the dislocation group (9.7% vs 45.7%, P<0.001). Neck size and type of cup used type did not vary significantly between the two groups (P>0.05). The cup size in the Dx group (47.4 ± 4.2) was significantly smaller than the non-Dx group (52.5, 4.5, P<0.001). Head size was also significantly smaller in the Dx group (30.5 ± 4.4 vs. 34.7 ± 3.4, P<0.001). A summary of the two groups' comparison can be seen in Tables 1, 2 and 3.

Quantitively compared, there was no significant difference between the values of the two groups for inclination (43.1 ± 10.7 vs. 40.7 ± 7.9, P=0.29) and anteversion (*17.1* ± 8.2 vs. 16.3 ± 6.4. P=0.93,). Regarding LSZ, patients in the non-Dx group were significantly more in the safe zone for both inclination and anteversion than the dislocation group (70.5% vs. 48.4%, P=0.02, OR for dislocation: 2.54, 95% CI: 1.19 - 5.42). Considering only the inclination, a similar result was yielded (80.4% vs. 61.3%, P=0.01, OR for dislocation: 2.57, 95% CI: 1.17–5.67). When anteversion was only considered, the two groups had no significant difference (77.4% vs. 87.0%, P=0.16, OR for dislocation: 1.93, 95% CI: 0.77–4.85). Pelvic obliquity (PO) did not have any significant difference between the two groups (P>0.05). The distribution of dislocated and non-dislocated joints categorized based on their inclination and anteversion angles can be seen in Fig. 2.

Subgroup analysis

Also, since the etiology for joint instability is different in DDH patients, a subgroup analysis was also conducted for DDH patients. The incidence rate of dislocation in DDH patients (7.0%, 95%CI: 3.8% - 10.2%) were significantly higher the other groups of our cohort (1.6%, 95% CI: 0.7% - 2.5%) (P < 0.001).

The odds of dislocation were significantly higher in DDH patients who were not within the LSZ for both anteversion and inclination (OR: 3.95, 95% CI: 1.27–12.3). Conversely, the odds of dislocation were not significantly higher in DDH patients who were not within the LSZ for anteversion (OR: 2.57, 95% CI: 0.6–10.9) or inclination (OR: 2.89, 95% CI: 0.88–9.53), when considered separately.

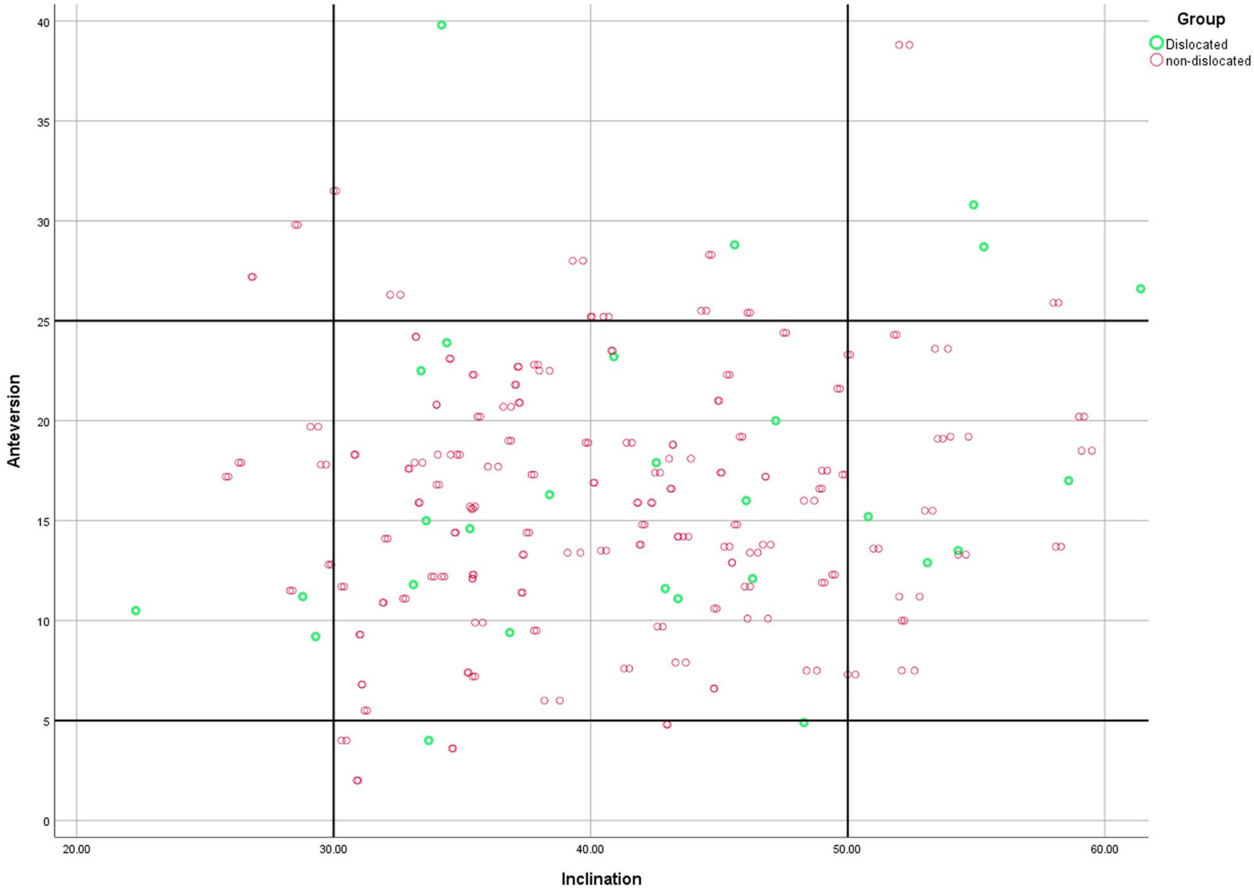

Fig 2 Distribution of cup inclination and anteversion variables for dislocation (green) and non-dislocation (red) groups compared to LSZ (black rectangle)

ROC analysis

ROC analysis showed a significant correlation between dislocation and head and cup sizes (P<0.001, P<0.001, respectively). Maximum sensitivity and specificity were obtained at a head size of 34 (sensitivity: 77.4%, specificity: 70.0%). The area under the curve (AUC) was estimated to be 0.77 (95% CI = 0.68–0.86). Maximum sensitivity and specificity for cup size were obtained at size 52 (sensitivity: 77.4%, specificity: 65.6%). AUC was estimated at 0.79 (95% CI = 0.71–0.87). This suggests that cup sizes <52 (RR: 6.54 and 95% CI =2.78-15.3) and head sizes <34 (RR: 7.81 and 95% CI =3.30-18.34) were associated with higher risks of dislocation. ROC curve analysis for neck size did not yield any significant results (Fig. 3).

Discussion

The results of our study showed that the incidence of dislocation after primary THA surgery DA approach is 2.6% during a follow-up of at least five years, and most of these dislocations (84%) occur during the first nine months after surgery. The dislocation rates of other studies investigating the DA approach in THA can be seen in Table 4 [4, 12–23]. Possible risk factors for dislocation are DDH diagnosis prior to surgery, Using Wagner Cone and Wagner SL stem, cup size smaller than 52, head size smaller than 34, anteversion and inclination angle outside the LSZ. Primary DJD and Fitmore stem could be regarded as protective factors against dislocation. Dislocation is a disastrous complication for the patients and the healthcare system. It is estimated that each revision THA surgery can cost around 51259$ (ranging from 24,697$ to 77,821$) aside from the discomfort caused to the patients and the decline in their quality of life [24]. There are various methods used for treatment of dislocations, which in include closed reduction, open reduction, and revision surgery using dual mobility or constrained liners.

Impingement is the leading cause of dislocation. Osteophytes on the bony, capsular, or scar tissue can dislocate the prosthesis head to the anterior or posterior [3]. Unlike our study, which showed no significant relationship, Fessy et al. claimed that high ASA scores had a higher risk of dislocation (OR: 1.93, 95% CI: 1.4–2.6) [25]. Mispositioning of prostheses and other technical mistakes are common causes of dislocation [3, 26, 27].

Table 1 Comparison of demographic and operative variables between two groups. Data are reported as Mean ± SD

Variable	Dislocation 31 (2.6%)	Non-Dislocation 1173 (97.4%)	*P*-Value
Sex			0.13
Female	20 (64.5%)	594 (50.6%)	
Male	11 (35.5%)	579 (49.4%)	
Age (years)	46.1 ± 13.8	45.1 ± 15.1	0.72
BMI, kg/m^2	25.2 ± 5.0	24.6 ± 4.4	0.51
Side of Surgery			0.44
Right	14 (45.2%)	612 (52.2%)	
Left	17 (54.8%)	561 (47.8%)	
Unilateral vs. Bilateral			0.41
Unilateral	26 (83.9%)	910 (77.6%)	
Bilateral	5 (16.1%)	263 (22.4%)	
Previous Hip Surgery	7 (22.6%)	256 (21.8%)	0.92
ASA Classification			0.43
1	23 (74.2%)	938 (80.0%)	
2	8 (25.8%)	235 (20.0%)	
Indication for Surgery			<0.001
AVN	3 (9.7%)	273 (23.3%)	0.07
DDH	18 (58.1%)	292 (24.9%)	<0.001
Primary DJD	1 (3.2%)	324 (27.6%)	0.003
Fracture	5 (16.1%)	189 (16.1%)	1
Other	4 (13%)	95 (8.1%)	0.34
	Arthrodesis 2 (6.5%)	Arthrodesis 9 (0.8%)	
	Hemophilia 2 (6.5%)	Hemophilia 15 (1.3%)	
		Exostosis 2 (0.2%)	
		JRA 11 (0.9%)	
		Perthes' 22 (1.9%)	
		Acetabulum Protrusion 9 (0.8%)	
		RA 13 (1.1%)	
		SA 14 (1.1%)	

Table 2 Comparison of post-op radiologic assessments of prosthesis placement between two groups. CCI and opposing hip disease were also assessed in 285 and therefore reported along with radiologic variables. Data are reported as Mean ± SD

Variable	Dislocation (*n*=31)	Non-Dislocation (*n*=285)	*P* value
Inclination cup	43.1 ± 10.7	40.7 ± 7.9	0.29
Anteversion cup	17.1 ± 8.2	16.3 ± 6.4	0.93
Lewinnek safe zone (both)	15 (48.4%)	201 (70.5%)	0.02
Lewinnek safe zone (Inclination)	19 (61.3%)	229 (80.4%)	0.01
Lewinnek safe zone (Anteversion)	24 (77.4%)	248 (87.0%)	0.16
Pelvic obliquity (PO.)	5.0 ± 5.5	4.2 ± 3.8	0.55
Opposing Hip Disease	10 (32.3%)	100 (35.1%)	0.51
Charlson Comorbidity Index (CCI)			0.29
0	21 (67.7%)	190 (66.7%)	
1	6 (19.4%)	69 (24.2%)	
2	4 (12.9%)	16 (5.6%)	
3	0	10 (3.5%)	

Table 3 Comparison of prosthesis parts' size and type in two groups

Variable	Dislocation 31 (2.6%)	Non-Dislocation 1173 (97.4%)	*P*-Value
Stem Type			<0.001
Fitmore®	3 (9.7%)	536 (45.7%)	<0.001
M/L taper®	3 (9.7%)	63 (5.4%)	0.31
Wagner Cone®	12 (38.7%)	79 (6.7%)	<0.001
Accolade®	1 (3.2%)	75 (6.4%)	0.48
CORAIL®	7 (22.6%)	361 (30.8%)	0.33
Wagner SL revision®	4 (12.9%)	32 (2.7%)	0.001
Other	1 (3.2%)	27 (2.3%)	0.75
	ME Muller cemented	Link 6 (0.5%)	
		ME Muller cemented 3 (0.3%)	
		Ominifit 11 (0.9%)	
		SA EcoFit® 2 (0.2%)	
		Tilastan 5 (0.4%)	
Cup Type			0.11
ontinuum®	16 (51.6%)	369 (31.4%)	
PINNACLE®	9 (29.0%)	346 (29.5%)	
Trident®	1 (3.2%)	82 (7.0%)	
Trilogy®	4 (12.9%)	355 (30.3%)	
Other	1 (3.2%)	21 (1.8%)	
	Marathone cemented 1 (3.2%)	Combicup 4 (0.3%)	
		Crossfire 3 (0.3%)	
		Link 5 (0.4%)	
		Marathone cemented 2 (0.2%)	
		Restoration 1 (0.1%)	
		SA EcoFit® 3 (0.2%)	
		ZCA all poly 3 (0.2%)	
Cup Size (range, median)	(40–56, 46)	(36–72, 52)	<0.001
≤38	0	6 (0.5%)	
40	1 (3.2%)	6 (0.5%)	
42	2 (6.5%)	5 (0.4%)	
44	10 (32.3%)	56 (4.8%)	
46	3 (9.7%)	59 (5.0%)	
48	3 (9.7%)	94 (8.0%)	
50	5 (16.1%)	180 (15.4%)	
52	3 (9.7%)	236 (20.2%)	
54	3 (9.7%)	194 (16.6%)	
56	1 (.2%)	166 (14.2%)	
58	0	86 (7.3%)	
60≤	0	85 (7.2%)	
Head size (range, median)	(22–40, 28)	(22–48, 36)	<0.001
≤26	3 (9.7%)	12 (1.0%)	
28	12 (38.7%)	121 (10.3%)	
30	0	4 (0.3%)	
32	32 (29.0%)	221 (18.8%)	
36	6 (19.4%)	676 (57.6%)	
38	0	1 (0.1%)	
40	1 (3.2%)	136 (11.6%)	
44	0	1 (0.1%)	
48	0	1 (0.1%)	

Table 3 (continued)

Variable	Dislocation 31 (2.6%)	Non-Dislocation 1173 (97.4%)	*P*-Value
Neck Size (range, median)	0 (−3.5 - 10.5, 0)	(−5 - 12, 0)	0.93
5-	0	38 (3.2%)	
4-	0	14 (1.2%)	
3.5-	6 (19.4%)	176 (15.0%)	
2.0-	2 (6.5%)	101 (8.6%)	
0	13 (41.9%)	321 (27.4%)	
1	1 (3.2%)	64 (5.5%)	
1.5	0	89 (7.6%)	
3.5	5 (16.1%)	196 (16.7%)	
4	0	8 (0.7%)	
5	1 (3.2%)	103 (8.7%)	
7	1 (3.2%)	35 (3.0%)	
8.5	1 (8.5%)	14 (1.2%)	
9	0	2 (0.2%)	
10.5	1 (3.2%)	7 (0.6%)	
12	0	5 (0.4%)	

In DDH patients, the anatomy of the hip can be faulty and prevent the prosthesis from ever being correctly implanted. Regarding this, the anatomical position of the greater trochanter, Gluteus Medius muscle weakness, and shortening of the iliopsoas tendon have been said to be involved in the higher dislocation rates of DDH patients which was also observed in our study (6.9% compared to 0.2% in other groups in the cohort) [3]. In cases of scar tissue formation, supporting muscle weakness and palsy, bone defects, and cases requiring the surgeon to resect the proximal femur, using larger head sizes can help reduce the risk of dislocation [3, 24, 27–33]. Smaller head

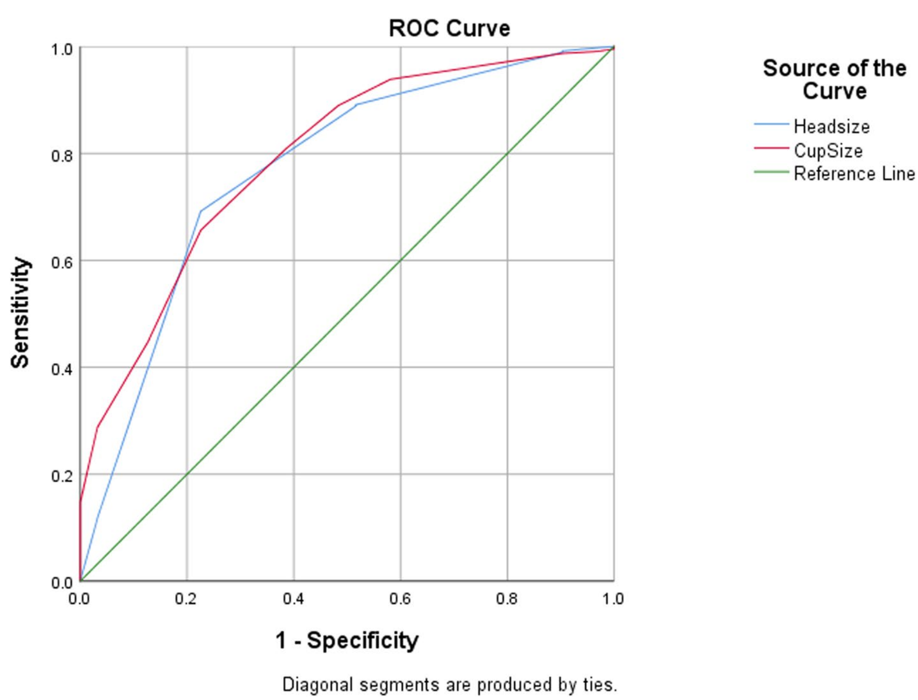

Fig. 3 ROC curve for head size (blue) and cup size (red)

Table 4 Dislocation rates of studies investigating the DA approach for THA

Study	Dislocation rate	Sample Size
Christensen 2023 [12, 36]	0.70%	4936
Jin 2023 [5, 42]	0.00%	183
Dimitriou 2023 [14]	0.01%	1176
Rivera 2022 [45]	0.20%	412
Cao 2020 [44]	0.00%	65
Barrett 2019 [46]	4.65%	43
Bon 2019 [22]	20.00%	50
Moerenhout 2019 [23]	3.57%	28
Taunton 2018 [47]	1.92%	52
Brismar 2018 [18]	4.00%	50
Reichert 2018 [17]	0.00%	77
Cheng 2017 [15]	2.86%	35
Zhao 2017 [43]	1.67%	60
Christensen 2015 [19]	1.39%	505
Taunton 2014 [16]	7.41%	27

sizes have the advantage of better wear rates, but they are more likely to dislocate. In revision THAs, the surgeon might use head sizes of 36-40 mm to reduce to risk of dislocation [33]. In a meta-analysis study conducted by Guo et al., they found out that age (SMD: −0.222, 95% CI: −0.413 - −0.031), femoral heads smaller than 28 mm (OR: 1.451, 95%CI: 1.056–1.994), history of instability (OR: 2.739, 95%CI: 1.888–3.974) can be significantly effective in the incidence of post-op dislocations [30].

In a study conducted on the Swedish Hip Arthroplasty Registry data, Hailer et al. found out that patients with a femoral fracture or AVN or more susceptible to dislocation compared to OA(RR = 3.7, CI: 2.5–5.5) [33]. Gausden et al. reported inflammatory arthritis and AVN as significant risk factors for dislocation (OR 1.56, 95% CI 1.25–1.97, p<0.0001; OR 1.67, 95% CI 1.45–1.93, P<0.0001 respectively) [29]. However, in a meta-analysis study, it was found that there is no significant difference between OA patients and DDH patients in dislocation rates (OR: 1.78, 95%CI: 0.58–5.51, p: 0.200) [34].

The approach used in surgery has been investigated in some studies. In a meta-analysis conducted by Awad et al., which compared the DA approach with the posterior approach, DAA was discovered to have a higher risk of overall intraoperative and postoperative complications (OR 1.64; p=0.003) (OR 4.12; p=0.005), nerve injury (OR 22.0; p<0.00001) (OR 0.28; p<0.00001), revision surgery(OR 1.54; p=0.01) (OR 7.37; p=0.006), surgical wound complications(OR 1.67; p=0.002). The posterior approach showed a non-significant higher risk of dislocation (OR 0.63, p=0.65) [24]. Various other studies have compared the rate of dislocation between various approaches [35–37]. In a retrospective review of 13,335 cases of primary THA, a significant difference was found between posterior approach (PA), DAA, and lateral approach (1.1%, 0.7%, and 0.5%, respectively, P= 0.026) [36]. Another recent meta-analysis study has found the PA approach to have the highest and DAA approach to have the lowest dislocation rates between the compared approaches (posterolateral, posterior, direct superior, direct anterior, and direct lateral approaches). However, the differences in subgroup analyses were all insignificant [35].

In the study conducted by Fessy et al., having an inclination angel outside LSZ is associated with a higher risk of dislocation (OR: 2.4, 95% CI: 1.4–4.0) [25]. Newer studies have found that the functional safe zone (FSZ) is superior to LSZ for preventing dislocation [38]. FSZ is calculated based on the hip joint positions during normal daily activities such as sitting and standing. Therefore, changes in the cup position in these routine daily activities are considered the functional safe zone and are measured using sagittal X-rays when sitting and standing [39]. In that study, 90% of late dislocation cases were associated with spinopelvic imbalance [39].

Our study did have some limitations; a significant shortcoming of our study is that we could not fit a proper multivariate logistic regression model to our data due to insufficient patients in the dislocation group which could limit the generalizability of our results due to the confounding bias. The method used for measurement of anteversion using x-ray images in our study does not yield a very accurate result. Another limitation of our study is that we could not conduct a subgroup analysis based on the prosthesis components due to the low number of dislocated patients and high variety of prostheses used. Another limitation of our study is that we did not have access to the data regarding THAs to compare the dislocation incidence between DA approach and other approaches. Spinopelvic parameters are known to have a considerable effect in predicting the risk of dislocation, which was not included as a parameter in our study.

Conclusion

In conclusion, our study showed that the incidence of dislocation after primary THA surgery DA approach is 2.57% during a follow-up of at least five years, and most of these dislocations (84%) occur during the first nine months after surgery. While no significant differences were observed between dislocation and non-dislocation groups in demographic or baseline surgical variables (e.g., age, BMI, surgical side), multiple factors were found to influence the risk of dislocation, including the underlying hip pathology, component sizes (cup and head), and positioning parameters such as anteversion and inclination angles. Patients with developmental dysplasia of the hip (DDH) had a significantly higher dislocation rate compared to other indications for THA, especially when component positioning fell outside the Lewinnek Safe Zone (LSZ). ROC analysis identified optimal threshold values for component sizes associated with higher risk, with head sizes <34 mm and cup sizes <52 mm significantly increasing the likelihood of postoperative dislocation. Subgroup analysis further emphasized the elevated risk in DDH patients, particularly when implants were positioned outside the LSZ for both inclination and anteversion. These findings suggest that component selection and precise positioning are critical in minimizing dislocation, especially in patients with a challenging anatomy such as those with DDH.

In summary, careful attention to surgical planning, component sizing, and precise alignment within established safe zones can substantially reduce the risk of dislocation in primary THA, especially when using the DA approach.

Clinical trial number
Not applicable.

Authors' contributions
P. Mirghaderi analyzed data and revised the final manuscript. MT.PF. wrote the initial draft and edited the final manuscript and prepared the tables and figures. Alireza Moharrami and Hesan Rezaee and Hadi Ravanbod contributed to the study concept and edited the final manuscript. SMJ. Mortazavi and MH. Pourgharib, introduced the concept, supervised and designed the study, and edited the final manuscript. All authors read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available from the authors but restrictions apply to the availability of these data.Data are, however, available from the authors upon reasonable request.

Declarations

Ethics approval and consent to participate
All procedures performed in studies involving human participants were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. (Research Ethics Committees of Imam Khomeini Hospital Complex- Tehran University of Medical Sciences, IRB approval ID: IR.TUMS.IKHC.REC.1400.021).
An informed consent signed by all the study participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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