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Early Hip Dislocation Rate in a Consecutive Series of 1093 Primary Total Hip Arthroplasties Using Imageless Navigation

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Purpose: Postoperative hip dislocation remains a major complication in total hip arthroplasty. Various studies have demonstrated that several factors influence dislocation. While computer-assisted navigation has been proposed to enhance component alignment, its impact on dislocation rates remains unclear. This study aimed to investigate the early dislocation incidence and associated risk factors in primary total hip arthroplasty (THA) using imageless navigation.
Methods: A retrospective review of patients undergoing imageless-navigated THA between February 2013 and December 2022 was conducted. Inclusion criteria comprised primary THA with a minimum 6-month follow-up. Statistical analysis included univariate regression to identify dislocation risk factors.
Results: A total of 1093 THAs were analyzed. Dislocation occurred in 16 cases (1.5%), six in elective procedures (0.76%), and 10 in femoral neck fracture (FNF) (3.28%). The univariate regression analysis revealed that FNF emerged as a significant risk factor (OR = 4.418, P = 0.004), while age, gender, femoral head size, and save zone cup placement of Lewinnek did not significantly affect dislocation rates.
Conclusions: Navigation use showed a reduced rate of early dislocation. FNF is a factor associated with postoperative hip dislocation in primary THA.

Keywords: Primary, Total hip arthroplasty, Dislocation, Imageless computer navigation

Dislocation after total hip arthroplasty (THA) is a major cause of revisions in the United States [1], presenting as one of the most challenging complications in orthopedic surgery. This issue holds significant implications for both patient outcomes and healthcare costs [2,3]. The incidence of dislocation is 1%–4% in primary THA [4,5] and mostly occurs within the first 3-6 months after surgery. Approximately 75% of dislocations occur within the first year, with recurrent dislocations affecting 16%–59% of patients [6-8].

The causes of THA dislocation are multifactorial [9-11], and one major factor is acetabular cup malalignment. According to Wera et al [12], the most common causes of unstable THA are acetabular cup malposition (33%) and abduction deficiency (36%).

Many previous studies demonstrated that navigation use is associated with reduced outliers of abduction and anteversion angles [13-20]. In our prior investigation, Suksathien et al. [21] demon-

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strated the precision of acetabular cup placement using imageless computer navigation, with 100% of cases being within Lewinnek's safe zone in both abduction and anteversion angles. However, few studies have addressed the clinical benefits derived from using computer navigation, especially in decreasing dislocation [22].

This study aimed to analyze the incidence and identify the risk factors of early THA dislocation using imageless navigation.

MATERIALS AND METHODS

This study retrospectively reviewed patients who underwent primary THA from February 2013 to December 2022. The inclusion criteria were patients who underwent THA using imageless computer navigation and had a minimum follow-up of 6 months. The exclusion criteria included dislocation due to a high-energy mechanism, revision cases, and the absence of radiographic data. It was approved by our Institutional Review Board (No. 045/2024). Of these, 659 were men (60.3%) and 434 were women (39.7%). The mean age of the patients was 53.5 years (range, 15-101 years). A total of 1,093 patients were enrolled: 598 cases (54.7%) were diagnosed with osteonecrosis of the femoral head (ONFH), 305 cases (27.9%) had a femoral neck fracture, 130 cases (11.9%) had primary osteoarthritis of the hip (1° OA), and 60 cases (5.5%) had developmental dysplasia of the hip (DDH) (Table 1).

Surgical Technique

Imageless navigation was utilized in all hips using THA cup-only software of the OrthoPilot (Aesculap AG) by three experienced surgeons (SY, SJ, and TT.) through a modified Hardinge approach. Two small pins were inserted into the ipsilateral iliac crest, one centimeter above the anterior superior iliac spine (ASIS), and connected with a two-pin transmitter fixation. A navigation passive transmitter was attached to the two-pin transmitter fixation and the bony landmarks which are both ASIS and pubic symphysis were registered by using a straight pointer. The OrthoPilot software uses registered data to generate a digitized anterior pelvic plane (APP), which is used as a reference plane for determining the abduction and anteversion angles of the acetabular cup.

The cementless acetabular cup (Plasmafit, B.Braun Aesculap, Tuttlingen, Germany) with a polyethylene liner (Vitelene, Vit E Stabilized Highly Crosslinked Polyethylene, B.Braun Aesculap, Tuttlingen, Germany) was used in all hips, with target angles for acetabular cup abduction and anteversion of 40° and 15°, respectively. The number of fixation screws used depended on the bone quality and implant stability. A metal head was used in all hips. The 28 mm diameter was used in 43 cases (3.9%), 32 mm in 470 cases (43%), and 36 mm in 580 cases (53.1%) (Table 1)

Regarding the femoral cementless stem, both short (Metha, B.Braun Aesculap, Tuttlingen, Germany) and conventional stems (Excia, B.Braun Aesculap, Tuttlingen, Germany) were utilized. The Metha stem, designed for metaphyseal fitting without diaphyseal anchorage, was chosen for young patients with good bone quality and who were diagnosed with DDH, ONFH, and OA. For elderly patients with good bone quality, the Excia stem was used. In cases of poor bone quality and advanced age, a cemented stem (cemented Excia) was preferred to prevent intraoperative periprosthetic fractures and subsidence.

Table 1 Demographic data.

Parameter	Values
No of Hip	1093
Mean age (yr) (range, SD)	53.5 (15-101, 15.3)
Gender (male/female)	659/434
Diagnosis, n (%)	
Elective case	788 (72.1%)
ONFH	598
OA	130
DDH	60
Femoral neck fracture (non-elective)	305 (27.9%)
Femoral head size, n (%)	
28 mm	43 (3.9%)
32 mm	470 (43%)
36 mm	580 (53.1%)
Mean cup abduction angle (degree) (range, SD)	41.6 (34-50, 2.5)
Mean cup anteversion (degree) (range, SD)	10.3 (6-16, 2.1)

Post-Operative Protocol

Patients were allowed to stand and progress to full weight-bearing using crutches or walkers on the second postoperative day. A standard protocol for anteroposterior (AP) digital radiographs of both hips with both legs at 15° internal rotation and lateral cross-table were conducted on the first postoperative day and at each follow-up period. Patients were routinely contacted every 3 months during the first postoperative year and then every 6 months thereafter.

Postoperative AP digital radiographs were calibrated using a known femoral head size to minimize magnification errors. The cup abduction angle was assessed by forming an angle with the acetabular cup in an AP view, referencing the inter-teardrop line. Anteversion was calculated using Liaw's method (23-24).

Statistical Analysis

A univariate regression analysis was conducted to determine the factors associated with early dislocation, including age (≥ 60 years), gender, diagnosis, abduction angle, anteversion angle, and femoral head size. Statistical analyses were performed using SPSS version 25.0 (SPSS Inc., Chicago, IL), with significance set at $p < 0.05$.

RESULTS

In the entire cohort, dislocation occurred in 16 cases (1.5%), with the mean time to dislocation of 3.2 weeks (range, 2-8) after the index surgery. Among the cases of dislocation, the mean age was 61.7 (range, 48-88) years, affecting 10 men and 6 women. This included 6 cases of elective procedures (0.76%) (2 cases of ONFH, 2 cases of OA, and 2 cases of DDH) and 10 cases of FNF (3.28%) (Table 2).

The univariate regression analysis revealed that factors such as age, gender, femoral head size, and cup alignment within Lewinnek's safe zone did not significantly influence early dislocation. However, the diagnosis of FNF emerged as a significant influencing factor [odds ratio (OR) = 4.418; 95% confidence interval (CI) = 1.592 – 12.264; $p = 0.004$] (Table 3).

The mean abduction angle of the acetabular cup was 40.8° (range, 34–50°), and the mean anteversion was 8.8° (range, 6–15°) (Table 2). Thirteen cases were successfully managed with close reduction under fluoroscopy, one underwent open reduction, and two underwent revision to enhance stability by increasing the head length. (Table 4)

Table 2 Details of patients with dislocation.

Parameter	Values
Number (n) (%)	16/1093 (1.5%)
Mean time from index surgery	3.2 weeks
Mean age (yr) (range, SD)	61.7 (48-88, 15.31)
Gender (men/women)	10/6
Diagnosis, n (%)	
Elective case (788/1093)	6 (0.76%)
ONFH	2
OA	2
DDH	2
Femoral neck fracture (non-elective) (305/1093)	10 (3.28%)
Femoral head size, n (%)	
28 mm	1 (6.25%)
32 mm	9 (56.25%)
36 mm	6 (37.5%)
Mean cup abduction angle (degree) (range, SD)	40.88 (34-50, 2.4)
Mean cup anteversion (degree) (range, SD)	8.87 (6-15, 2.17)

Table 3 Result of univariate regression analysis of 16 cases with dislocation.

Variables	OR	95%CI	*P*-value
Age (≥60)	1.427	0.527 – 3.861	0.484
Gender			
Male	1.099	0.397 – 3.046	0.856
Diagnosis			
Elective case (ONFH, DDH, OA)	Ref		
Femoral neck fracture	4.418	1.592 – 12.264	0.004
Femoral head diameter			
36 mm	Ref		
32 mm	2.274	0.268 – 19.327	0.452
28 mm	1.860	0.657 – 5.265	0.657

Table 4 Details of dislocation cases.

No	Age	Gender	Diagnosis	Femoral head size	Abduction angle	Anteversion Angle	Time to dislocation	Treatment
1	59	M	ONFH	32	38	8	2 weeks	Revision
2	50	F	NOF	28	35	9	2 weeks	Closed reduction
3	52	F	NOF	32	43	7	2 months	Closed reduction
4	74	F	NOF	32	46	12	1 week	Revision
5	53	F	NOF	32	39	9	1 month	Closed reduction
6	48	M	DDH	32	39	8	1 week	Closed reduction
7	73	M	OA	36	47	7	3 weeks	Closed reduction
8	56	M	NOF	36	41	8	3 weeks	Closed reduction
9	88	M	NOF	32	34	6	1 month	Closed reduction
10	52	M	DDH	32	50	12	1 month	Closed reduction
11	50	F	NOF	36	37	7	1 week	Closed reduction
12	58	M	ON	36	44	15	2 months	Closed reduction
13	73	M	OA	36	42	7	3 weeks	Closed reduction
14	63	M	NOF	32	39	10	1 week	Closed reduction
15	64	F	NOF	32	42	7	3 weeks	Closed reduction
16	74	M	NOF	36	38	10	1 month	Open reduction

DISCUSSION

Our retrospective study found that image-less computer navigation THA may decrease the dislocation rate compared to manual techniques, with (FNFs emerging as significant influencing factors. We observed dislocation in 16 of 1,093 cases (1.5%), all of which occurred spontaneously and non-traumatically. When comparing the dislocation rate in this study with manual techniques reported in previous studies, it is evident that the dislocation rate in our study was lower (Table 5).

Consistent with Bohl et al. [25], they demonstrated that using computer-assisted navigation was associated with a dislocation reduction (hazard ratio [HR] = 0.69; 95% CI = 0.58 to 0.82; p < 0.001), with a reported dislocation rate of 1.00% from 14,540 cases, compared to 1.7% from non-navigated 803,732 cases. A study by Agarwal et al. [22] supports this finding; they indicated that using navigation can lower the rate of revision for dislocation (HR = 0.46; 95% CI = 0.29 – 0.74; p = 0.002).

In our study, six dislocations occurred in elective procedures and exhibited a dislocation rate of 0.76%, which is notably lower than the rates reported by Gausden et al. (26), where all cases were elective with a dislocation rate of 1.4% with the manual technique.

Numerous studies have demonstrated varying dislocation rates of THA in FNF when using manual techniques, ranging from 1.9%–30% (Table 6). A large sample of more than 60,000 FNF studies by Pangaud et al. (27) showed a dislocation rate of 5.69%. In our study where imageless navigation was utilized for THA in FNF, we observed 10 cases of dislocation of 305 cases (3.28%), which was lower than the dislocation rate in manual techniques (Table 6).

Table 5 Dislocation rate in manual THA.

Study or Subgroup	Dislocated cases	Total cases	Dislocation rate
Bargar 1998 (32)	4	62	6.5 %
Honl 2003 (33)	3	30	3.8 %
Kamara 2017 (34)	1	198	0.5 %
Nakamura 2009 (35)	2	78	2.6 %
Nakamura 2010 (36)	1	71	1.4 %
Siebel 2005 (37)	1	35	2.9 %
Total	12	524	
Average			2.3 %
Our study	16	1093	1.5 %

Table 6 Dislocation rate of THA in FNF (38).

Study or Subgroup	Dislocated cases	Total cases	Dislocation rate
Baker 2006	3	40	7.5 %
Cadossi 2013	2	42	4.8 %
Dorr 1986	7	39	17.9 %
Keating 2006	3	69	4.3 %
Macaulay 2008	1	17	5.9 %
Mouzopoulos 2008	2	16	12.5 %
Narayan 2006	3	10	30 %
Ravikumar 2000	18	89	20.2 %
Schleicher 2003	1	54	1.9 %
Van de Bekerom 2010	8	115	6.9 %
Chammout 2016	4	69	5.8 %
Zhoukai 2024	7	51	13.7 %
Bhandari 2019	34	718	4.7 %
Total	93	1329	
Average			6.9 %
Our Study	10	305	3.3 %

Understanding the significant factors linked to predicting dislocation rates after THA is crucial for pre-operative planning and post-operative protocols. In this study, we identified FNF as the primary significant risk factor among patients. Our regression analyses highlighted the statistical importance of this correlation (OR = 4.4; 95% CI = 1.592–12.264; p = 0.004).

After analyzing the data, we found no significant difference in dislocation rates between the elderly and younger groups. This may be because, while soft tissue tension is typically worse in older patients compared to younger patients, the activity of the patient also decreases, potentially contributing to the lack of difference in dislocation rates. One reason for this may be that in our study group, the mean age is 53.5 years and 61.7 years in the overall and dislocated groups, respectively, which is not excessively high. Perhaps if we use another age group cutoff, the results may differ significantly.

Despite the differences in muscle mass, laxity, and activity between men and women, patient gender is not a risk factor for dislocation according to many studies [39-42], ranging from single institution to registry studies. Additionally, the rate of revision did not differ. Our study also shows no difference between men and women in the rate of dislocation.

The alteration in femoral head diameter significantly affects the head-neck ratio and jump distance, resulting in a diminished dislocation rate. Kelley et al. [28] highlighted that the use of a 22 mm diameter head escalated the dislocation rate in comparison to a 28 mm head (35% vs. 0%; p = 0.012). Similarly, Singh et al. [29] observed a substantially reduced dislocation rate with a 36 mm diameter head relative to a 28 mm head in primary THA (0.6% vs. 6.4%; p = 0.0107). However, our study suggests that femoral head size does not emerge as a significant factor; there exists no substantial difference in the dislocation rate among 28 mm, 32 mm, and 36 mm heads. Our findings are in line with those of Hedlundh et al. [30], who reported no significant disparity in the dislocation rate between the 22 mm and 32 mm femoral head.

One of the renowned studies guiding the alignment of acetabular cup placement is Lewinnek's safe zone [20], which prescribes 40 +/- 10° for the abduction angle and 15 +/- 10° for anteversion. They reported a dislocation rate of 1.5% within the safe zone, while alignment outside this range resulted in a dislocation rate of 6.1%. In this study, we also employed imageless computer navigation in all cases, resulting in none outside Lewinnek's safe zone. However, despite 16 dislocation cases meeting the safe zone criteria for abduction and anteversion angles, they still experienced dislocation. This observation resonates with Abdel et al.[31], who examined 206 dislocated cases of 9784 primary THAs and found that 58% of dislocated cases (120/206) maintained alignment within the Lewinnek safe zone. Therefore, while Lewinnek's recommended values for acetabular cup abduction and anteversion may offer guidance, they do not ensure stability, given the multifactorial nature of dislocation.

Limitations of the research include its retrospective design, which introduced inherent biases and limitations. Additionally, the study's single center may restrict the generalizability of the results. Variations in patient demographics, surgical practices, and institutional protocols at this single-center might not accurately represent the diversity seen in other hospitals or regions, raising concerns about the external validity of the study. Despite analyzing 1093 cases, the relatively small sample size may compromise the statistical power needed to detect significant associations between variables, particularly when identifying less common risk factors or conducting effective subgroup analyses.

CONCLUSIONS

Imageless computer-assisted THA shows a low hip dislocation rate. FNF has emerged as a significant influencing factor.

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