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Original Research

A Specific Capsular Repair Technique Lowered Early Dislocations in Primary Total Hip Arthroplasty Through a Posterior Approach

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ABSTRACT

Background: Dislocation is a challenging problem after total hip arthroplasty (THA). We sought to evaluate the incidence of early dislocation with 2 different posterior repair techniques after THA using a posterior approach.
Methods: From September of 2008 to August of 2019, we evaluated 841 THAs performed by a single surgeon using a posterior approach. Before November of 2015, the capsule was repaired to the greater trochanter (group 1, 605 patients). Starting November 2015, the posterior capsule was repaired in a side-to-side fashion (direct soft-tissue repair) (group 2, 236 patients). There was a mean follow-up of 31.1 months (range, 2.5-122.5 months). A multivariable logistic regression model was constructed to assess the impact of baseline patient and operative factors on the dislocation rate.
Results: There were 22 dislocations, all of which occurred in group 1. There were no dislocations in group 2. After adjusting for patient and operative factors, the direct soft-tissue repair had a large impact on the overall multivariable model as indicated by its effect likelihood ratio of 10.33 ($P = .001$); however, the odds ratio was not calculable for this factor, given that there were no dislocations in hips with direct soft-tissue repair. Increasing age was associated with an increased odds of dislocation (odds ratio, 1.04, $P = .017$), with an effect likelihood ratio of 6.25 ($P = .012$).
Conclusions: Switching from a capsular repair to the greater trochanter to a side-to-side capsular repair was associated with a decreased rate of dislocation in primary THA through a posterior approach.

Introduction

One of the dreaded complications of total hip arthroplasty (THA) is dislocation. Woo and Morrey reported on the Mayo Clinic experience with a dislocation rate of 3.2% in primary THA [1]. Others reported a dislocation rate of 0.7% to 5.9% in primary THA [2-4]. Multiple factors are associated with dislocation including the component position, surgical approach, and patient factors [5,6]. A lateral approach to THA has historically been associated with a lower rate of dislocation than a posterior approach, but with contemporary surgical techniques and implant technology, the dislocation rate associated with the posterior approach appears to have been reduced [7,8].

This reduction in dislocation with the posterior approach is likely related both to an improved surgical technique and implant design, specifically, achievement of an appropriate combined anteversion, larger femoral heads and improved offset options, and inclusion of a posterior capsular repair [4,8-10]. There are multiple variations of posterior capsule repair described, but the differences can be broken down to soft tissue—only repairs or repair of the soft tissues to the greater trochanter [4,11-18]. Therefore, the purpose of this study was to evaluate the dislocation rate of 2 posterior capsule repair techniques after primary THA: the first being a posterior capsule repair to the greater trochanter using a bone tunnel and the second being a side-to-side posterior capsular (direct soft tissue) repair. Furthermore,

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our goal was to limit variables besides the surgical technique change, so we evaluated a single surgeon who performed both techniques.

Material and methods

We evaluated all primary THAs performed by the senior author (SSW). Institutional review board approval was obtained for this study. The study was divided into 2 groups based on the type of posterior soft-tissue repair. Group 1 had posterior capsule repaired to the greater trochanter, and group 2 underwent a side-to-side posterior capsular repair. There were no other intentional technique changes between the 2 groups.

From September 2008 to August 2019, the senior author performed 1255 primary THAs. Patients were excluded if they had connective-tissue disease, were younger than 18 years at the time of surgery, had THA performed through a nonposterior approach, had undergone a significant prior open surgery in the ipsilateral hip, had undergone a metal-on-metal THA, had a dual-mobility component placed, or did not meet minimal clinical follow-up. We included patients who attended their first 12-week postoperative visit. Minimal clinical follow-up was set at 10.9 weeks to allow capture of patients who were scheduled just before 12 weeks. After exclusions, there were 841 THAs for analysis. In November of 2015, the senior author (SSW) switched from the first posterior repair type to the second repair type. This left 605 THAs in group 1 and 236 in group 2.

In group 1, 312 (51.6%) hips were of women, with a mean age of 57.7 years (range, 21.0-91.8), a mean body mass index (BMI) of 29.7 kg/m^2 (range, 16.0-54.1), and a mean follow-up of 37.8 months (range, 2.6-122.5 months). Indications for the THAs were for osteoarthritis in 322 (53.2%), osteonecrosis of the femoral head in 204 (33.7%), failed free fibular graft for osteonecrosis in 27 (4.5%), displaced femoral neck fracture in 21 (3.5%), dysplasia in 14 (2.3%), rheumatoid arthritis in 8 (1.3%), post-Perthes disease in 3 (0.5%), failed percutaneous screw or pin fixation for femoral neck fracture in 3 (0.5%), post-traumatic hip fracture treated nonoperatively in 1 (0.2%), benign pathologic condition in 1 (0.2%), and pigmented villonodular synovitis in 1 (0.2%). Thirty-two (5.3%) hips had size 28-mm femoral heads, 184 (30.4%) hips had 32-mm femoral heads, 387 (64.0%) hips had 36-mm femoral heads, and 2 (0.3%) hips had a 40-mm femoral head. Two hundred forty hips had ceramic femoral heads, and 365 hips had cobalt-chrome femoral heads. Two hundred thirty (38%) hips had computer tomography–based hip navigation used to aid in acetabular component positioning.

In group 2, 125 (53.0%) hips were of women, with a mean age of 60.5 years (range, 18.5-91.2), a mean BMI of 29.7 kg/m^2 (range, 16.5-50.6), and a mean follow-up of 13.7 months (range, 2.5-45.3 months). Indications for the THAs included osteoarthritis in 159 (67.4%), osteonecrosis of the femoral head in 49 (20.8%), failed free fibular graft for osteonecrosis in 15 (6.4%), rheumatoid arthritis in 4 (1.7%), displaced femoral neck fracture in 3 (1.3%), dysplasia in 3 (1.3%), post-Perthes disease in 2 (0.8%), and failed percutaneous screw or pin fixation for femoral neck fracture in 1 (0.4%). Fifty-four (22.9%) hips had 32-mm femoral heads, 181 (76.7%) hips had 36-mm femoral heads, and 1 (0.4%) hip had a 40-mm femoral head. Two hundred twenty-three hips had ceramic femoral heads, and 13 hips had cobalt-chrome femoral heads. One hundred seven (45.3%) hips had computer tomography–based hip navigation used to aid in acetabular component positioning.

Statistical analysis

Descriptive statistics including means (standard deviation or range) and proportions (percentages) were calculated for the baseline patient and operative factors as appropriate. Student's *t*-tests and Pearson's chi-squared analysis were used to determine differences between the bone tunnel and direct soft-tissue repair groups. Differences between dislocation rates in the 2 repair groups were assessed using Student's t-tests and Pearson's chi-squared analysis as appropriate. A multivariable, main-effects, logistic regression model was constructed to assess the impact of baseline patient and operative factors on the dislocation rate. Statistical significance was set at $P < .05$. All statistical analyses were performed in JMP Pro, version 14 (Statistical Analysis Software, Cary, NC).

Surgical technique

The senior author (SSW) performed all cases using a standard posterior approach in which the short external rotators and posterior capsule were taken down as separate layers and the gluteus minimus was elevated off the superior capsule.

For group 1 (605 cases), a repair to the greater trochanter was performed. In short, after a standard posterior approach, the short external rotators were detached from their insertion. Next, the capsule was tagged and a trapezoidal posterior capsulotomy with a small superior capsulectomy was performed. The superior border of this capsulotomy was made anterior to the piriformis tendon. At the completion of the case, the hip was placed into a neutral or slight external rotation and one drill hole was made through the posterior aspect of the greater trochanter. The posterior capsule was repaired by passing heavy suture through this hole (superficial to deep), then through the free edge of the capsule with multiple throws, then back, deep to superficial, through the very base of the abductor tendon. The short external rotators were repaired back to the abductor tendon insertion using a heavy mattress suture.

For group 2 (236 cases), an all-soft-tissue, side-to-side posterior capsular repair technique was performed. After an initial posterior approach, and detachment of the short external rotators from the femur, the capsule was incised in line with where the piriformis tendon had previously been (Fig. 1) and then turned distally along the intertrochanteric line, leaving the capsule both superior and inferior to repair together at the completion of the case (Fig. 2). At the completion of the case, the gluteus minimus was again elevated and the hip was placed into slight internal rotation to gain exposure to the capsulotomy (Fig. 3). The superior and inferior aspects of the capsulotomy were repaired in an interrupted fashion with 3 figure-of-eight sutures, using heavy nonabsorbable suture (Fig. 4a and b).

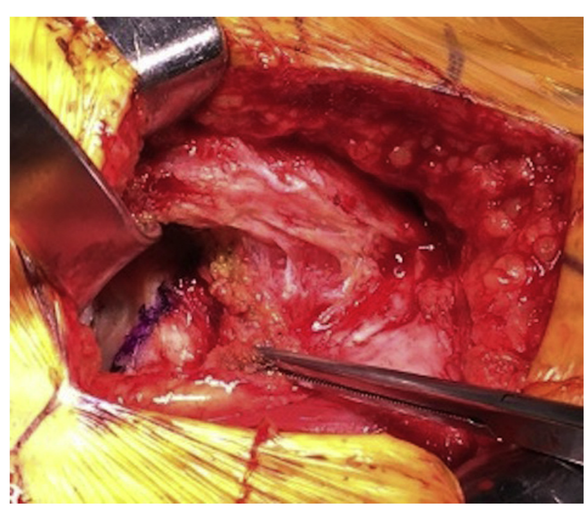

Figure 1. Right hip (the patient's head to the left of the image) with short external rotators retracted with the forceps. The capsule is marked to show the capsulotomy trajectory.

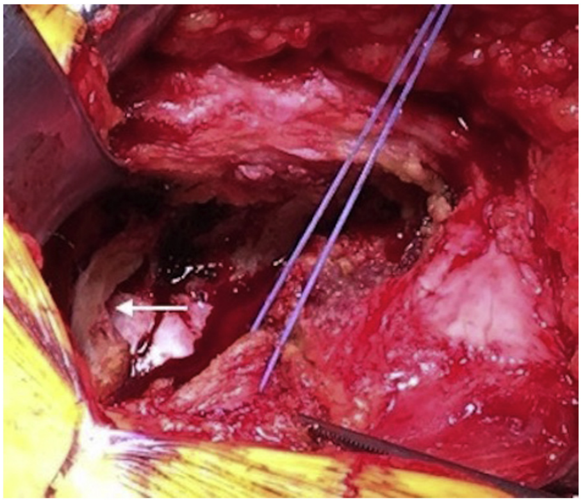

Figure 2. Right hip (the patient's head to the left of the image) with capsulotomy performed and the inferior capsular flap tagged with suture. The arrow is pointing to the superior capsule flap.

If desired, the hip could be gently brought into flexion and internal rotation to attempt to dislocate the hip and evaluate the sling effect of the posterior capsular repair. Next, the hip was brought into neutral rotation (Fig. 4c), and the short external rotators were repaired with a single heavy mattress suture back to the abductor tendon insertion on the greater trochanter (Fig. 5a and b). This was the same short external rotator repair as in group 1.

Results

As shown in Table 1, sex and BMI distribution were similar between groups undergoing bone tunnel repair and direct soft-tissue repair. However, hips undergoing direct soft-tissue repair were more often older, had osteoarthritis (OA) as the primary indication for surgery, and had a head size $\geq$36 mm. Duration of follow-up was increased in hips undergoing bone tunnel repair.

As shown in Table 2, hips without dislocation had a significantly higher rate of direct soft-tissue repair. There were no hips that underwent a direct soft-tissue repair, which subsequently sustained a dislocation.

As shown in Table 3, direct soft-tissue repair had a large impact on the overall multivariable model as indicated by its effect likelihood ratio. However, the odds ratio was not calculable for this factor, given that there were no dislocations in hips with direct soft-tissue repair. Increasing age was also a significant risk factor for dislocation.

Twenty-two of 841 (2.6%) hips that underwent THA in this study sustained a dislocation. All 22 of the dislocations occurred in hips that had their capsule repaired to the greater trochanter. No hips in the side-to-side capsule repair group sustained a dislocation. All dislocations were posterior. Fourteen (64%) hips sustained their first dislocation within 12 weeks of index THA. Fourteen (64%) hips had multiple dislocations. The mean number of dislocations was 2.7. Fourteen (64%) hips were treated by closed reduction alone, and 8 (36%) hips required revision THA. Average time from index THA to revision was 2.4 years (range, 12 days to 8.6 years). None of the 8 hips requiring revision had instability after their revision or needed a second revision.

Of the 8 hips requiring revision, 3 (38%) had a cup revision, 4 (50%) were revised to a constrained liner, and one (13%) had a stem revision. In the 3 hips with acetabular cup revision alone, a dual-mobility construct was used, and none of these hips had further instability or revision surgery. In the 4 hips with revision to a constrained liner, no hips had further instability or revision surgery. In the one hip with an isolated stem revision, the hip was revised to increase length and offset and had no further instability or revision surgery.

Figure 3. The leg is placed into internal rotation to assist in capsular closure.

Discussion

Posterior capsule repair appears to be one of the factors that have led to decreasing rates of instability after posterior approach THA. In this crossover study, after controlling for patient and surgical factors, we found that a side-to-side posterior capsular repair was associated with a lower rate of dislocation than a repair of capsule to the greater trochanter. This promising technique is easily reproducible and may help lower the risk of dislocation in patients undergoing primary THA through a posterior approach.

There have been many techniques described for repair of the posterior soft tissues in primary THA. The theory behind repair of the capsule to the greater trochanter is that the capsule acts as a checkrein to internal rotation, thereby preventing dislocation. Pellicci et al. [15] found that with repair of the short external rotators and capsule through drill holes, one in 519 (0.2%) hips had a dislocation. White et al. [4] evaluated a posterior capsular repair through drill holes after posterior approach to THA and found 3 in 437 (0.7%) hips had dislocation. They did note 4 (0.9%) hips with an avulsion fracture of the greater trochanter as a complication of the repair. In the present study, repair of capsule to the greater trochanter was associated with a higher rate of dislocation. When performing repair of the capsule and short external rotators to the greater trochanter, the hip is typically placed in an external rotation to allow the capsule to reach the greater trochanter, but when the patient's hip is no longer externally rotated, the repair is stressed, potentially compromising the integrity of the repair [19].

The all-soft-tissue repair does not provide a checkrein to the hip internal rotation but does provide a posterior soft-tissue sling that may be closer to the articulation than with the greater trochanter repair technique. Tsai et al. [17] evaluated 62 hips with a U-shaped capsular repair after posterior approach to THA; they reported that none of the hips with this repair dislocated. Browne and Pagnano [11] reported on a soft-tissue-only repair of the capsule and short external rotators. They found that one in 178 (0.6%) hips had a dislocation. The technique described in the present study allows the hip capsule to be repaired in the internal rotation position, decreasing tension on the repair. After this type of repair, one can flex and internally rotate the hip without damaging the repair, allowing the surgeon to range the hip and confirm stability and repair integrity. Increasing age was also a significant predictor of dislocation. Other studies have found increased age to be a risk factor for dislocation after THA [20,21]. This study can also be used to educate patients about the increased risk of dislocation with increasing age.

This study had several strengths. A detailed surgical technique is outlined, which we believe is reproducible by other surgeons

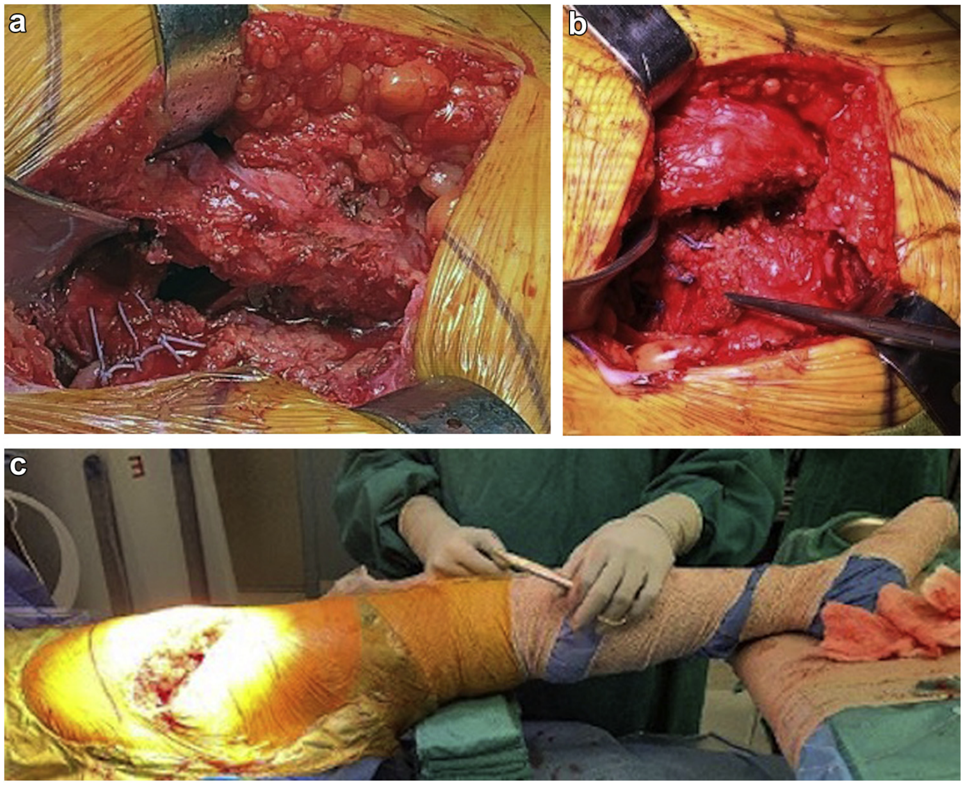

Figure 4. a. The capsulotomy is repaired with 3 interrupted sutures (the patient's head to the left of the image). b. The capsulotomy is repaired with 3 interrupted sutures in a right hip (the patient's head to the left of the image). c. The hip is brought into neutral rotation.

performing a posterior approach. In addition to simply outlining the surgical technique, we found that a modification in capsular repair was associated with a change in the dislocation rate. Having a single surgeon is also a strength of this study. The senior author had no other major changes in the technique over the course of the study, and this limits variability and increases the odds that the association with dislocation was truly from the change in the repair technique.

This study had limitations. We set minimum follow-up at 10.9 weeks. It is certainly possible that longer minimum follow-up would have led to more dislocations being detected. That said, the majority of THA dislocations seem to occur in the early postoperative period [22]. Follow-up time did not seem to have an impact on the rate of dislocation in the unadjusted analysis. To evaluate the effect of follow-up time in more detail, we included this as a factor in our multivariable, main-effects, logistic regression model. After this analysis, follow-up time still did not appear to have a significant effect on the rate of dislocation. Next, with any crossover study design, changes such as patient complexity or implant design between the groups may also affect the outcome of dislocation. Specifically, group 1 hips, when compared to group 2 hips, were more likely to have an indication other than osteoarthritis and more likely to have a femoral head size less than 36 mm. After controlling for these and other factors in our multivariable,

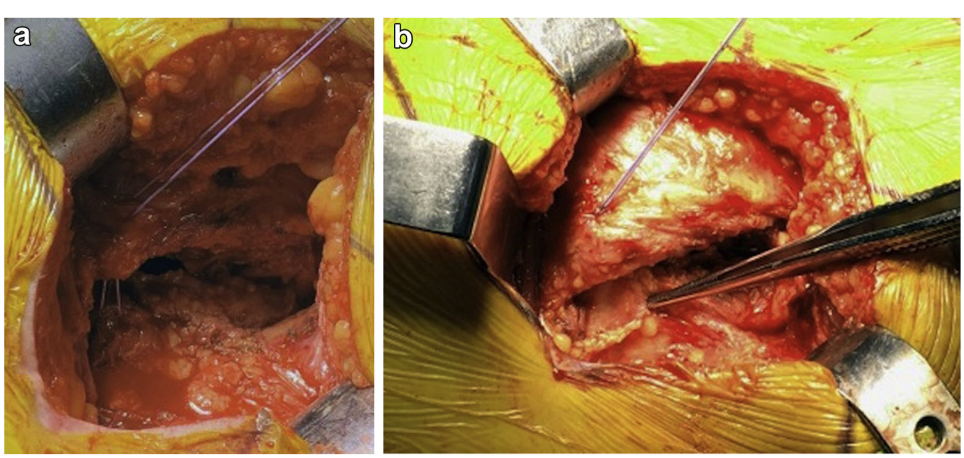

Figure 5. a. The short external rotators are sutured back to the gluteus medius insertion on the greater trochanter (the patient's head to the left of the image). b. The short external rotators are sutured back to the gluteus medius insertion on the greater trochanter in a right hip (the patient's head to the left of the image).

Table 1
Baseline patient and operative factors.

Patient and operative factors	Bone tunnel repair (n = 605)	Direct soft-tissue repair (n = 236)	*P*-value
Age (years)	57.7 (15.7)	60.5 (16)	.02[a]
Female	312/605 (51.6%)	125/236 (53%)	.72
BMI (kg/m²)	29.7 (6.3)	29.7 (6.3)	.98
OA indication	322/605 (53.2%)	159/236 (67.4%)	<.001[a]
Head size ≥36 mm	389/605 (64.3%)	182/236 (77.1%)	<.001[a]
CT-based hip navigation	230/605 (38%)	107/236 (45.3%)	.052
Follow-up (years)	3.2 (2.4)	1.1 (0.7)	<.001[a]
Direct soft-tissue repair	0/605 (0%)	236/236 (100%)	n/a

CT, computed tomography.
[a] Denotes statistical significance.

main-effects, logistic regression model, we found that the repair type was associated with the dislocation risk. The study was of moderate size, and it is possible with a larger population that the actual incidence of dislocation may have differed. We performed post hoc power calculations. To calculate post hoc power using Fisher's exact test, it was necessary to assume that one patient in group 2 (direct soft-tissue repair) sustained a dislocation. This would artificially decrease our estimate of achieved power. Nonetheless, even with this disadvantage, assuming proportions of 22 of 605 (3.64%) in group 1 compared with one of 236 (0.42%) in group 2, post hoc power obtained through Fisher's exact test demonstrated 82.3% achieved power. Therefore, this study was adequately powered to detect the statistically significant result that was displayed in the results. This study evaluated the results of a single, skilled, fellowship-trained arthroplasty surgeon. The results may have differed if there were multiple surgeons, but we believe this technique is simple and reproducible by other surgeons. Furthermore, having a single surgeon limits other variables that may affect the rate of dislocation. It is also possible that the senior surgeon may have gone through a learning curve, but the change in the capsular technique was the only intentional technical change over the course of the study. We did not include a radiographic evaluation, and malpositioned cups may have been a risk factor for dislocation. However, a plain radiographic review can be unreliable, and the cup position can change relative to pelvic orientation, making measurements less informative [23,24]. Over the course of the study, our institutional protocol for hip radiographs has changed from supine to standing, changing the orientation of the pelvis. For this reason, radiographic comparison would be challenging to compare between the groups.

In conclusion, we were able to find that switching to a soft-tissue side-to-side capsular repair was associated with a decreased rate of dislocation in primary THA through a posterior approach. This technique is a reproducible option for surgeons performing primary THA through the posterior approach.

Table 2
Unadjusted dislocation outcome with baseline patient and operative factors.

Patient and operative factors	No dislocation (n = 819)	Dislocation (n = 22)	*P*-value
Age (years)	58.3 (15.8)	63.2 (15.9)	.157
Female	424/819 (51.8%)	13/22 (59.1%)	.5
BMI (kg/m²)	29.8 (6.3)	27.5 (5.2)	.097
OA indication	472/819 (57.6%)	9/22 (40.9%)	.118
Head size ≥36 mm	560/819 (68.4%)	11/22 (50%)	.069
CT-based hip navigation	329/819 (40.2%)	8/22 (36.4%)	.72
Follow-up (years)	2.5 (2.2)	3.2 (2.8)	.21
Direct soft-tissue repair	236/819 (28.8%)	0/22 (0%)	.003[a]

CT, computed tomography.
[a] Denotes statistical significance.

Table 3
Adjusted model of the impact of patient and operative factors on dislocation.

Patient and operative factors	Odds ratio (95% CI, *P*-value)	Effect likelihood ratio (*P*-value)
Age (per year)	1.04 (1.01, 1.08; *P* = .017[a])	6.25; *P* = .012[a]
Female	0.83 (0.3, 2.33; *P* = .73)	0.12; *P* = .73
BMI (per kg/m²)	0.96 (0.88, 1.03; *P* = .25)	1.44; *P* = .23
OA indication	0.4 (0.15, 1.11; *P* = .079)	3.08; *P* = .079
Head size ≥36 mm	0.5 (0.18, 1.39; *P* = .186)	1.78; *P* = .183
CT-based hip navigation	1.32 (0.51, 3.41; *P* = .56)	0.33; *P* = .57
Follow-up (per year)	1.07 (0.88, 1.29; *P* = .46)	0.54; *P* = .46
Direct soft-tissue repair	n/c	10.33; *P* = .001[a]

CT, computed tomography; CI, confidence interval.
Effect likelihood ratio testing results are included because there were no dislocation events in the direct soft-tissue repair group. "n/c" = not calculable in the setting of no dislocations in the direct soft-tissue repair group.
[a] Denotes statistical significance.

Conflict of interests

M. Bolognesi receives royalties from Zimmer Biomet and TJO, is a paid consultant for Total Joint Orthopedics and Zimmer Biomet, holds stock ownership in TJO and Amedica, receives research support from DePuy Synthes, Exactech, and PCORI, receives other financial or material support from Zimmer Biomet, DePuy, Stryker, TJO, Smith & Nephew, DJO, and Exactech, is a member of the editorial/governing board of *Arthroplasty Today*, and is a board member of the EOA, AAHKS, AAOS, JOA, and JSOA; S.S. Wellman receives royalties from and is a paid consultant for Total Joint Orthopedics, receives research support from DePuy, Zimmer Biomet, and Stryker, is a member of the editorial/governing board of the *Journal of Arthroplasty*, and is a member of the AAHKS Publications committee; all other authors declare no potential conflicts of interest.

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