Impact of Center of Rotation Changes on Patient-Reported Outcome Measures in Total Hip Arthroplasty

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INTRODUCTION:

Changes in hip center of rotation (COR) during acetabular cup implantation in total hip arthroplasty (THA) are common, but their magnitude and impact on patient-reported outcome measures (PROMs) is not well studied. This study evaluates whether three-dimensional COR shifts from pre- to intraoperative stages affect PROMs.

METHODS:

We retrospectively reviewed 725 patients who underwent three-dimensional computer-assisted primary THA at a single academic institution between 2018 and 2022. Intraoperative COR parameters were collected using an accelerometer-based computer-navigation system. Three directional vectors were defined with positive and negative integers in millimeters according to the plane of COR displacement. The superior(+)/inferior(-), medial(+)/lateral(-), and posterior(+)/anterior(-) planes were calculated as integers to demonstrate the changes in COR. Patient demographics, acetabular cup characteristics, and PROMs were also collected. Multivariate regression analysis was applied with coefficients reflecting the expected change in PROM per one-unit change in COR position change along the three axes (X,Y, and Z).

RESULTS:

The median COR shift was 1.0mm superiorly, 3.0mm medially, and centered in the posteroanterior plane. Although several significant associations were observed between COR displacement and changes in PROMs, all changes remained below the calculated minimal clinically important difference (MCID). Specifically, superior displacement was associated with a significant 1.6-point increase in one-year Hip Injury and Osteoarthritis Outcome Score for Joint Replacement (HOOS,JR) (p=0.033), medial displacement was significantly associated with a 0.5-point decrease in Patient-Reported Outcomes Measurements Information System (PROMIS) Pain Intensity at two weeks (p=0.032), and posterior displacement significantly correlated to 0.6 and 0.7 point greater reduction in PROMIS Pain Intensity at two weeks (p=0.018) and three months (p=0.008).

DISCUSSION AND CONCLUSION:

While COR displacements were statistically associated with improvements in certain PROMs, these changes did not reach clinically meaningful thresholds, suggesting that staying within a few millimeters of the original COR in all directions may not significantly influence kinematics or PROMs.

Figure 1. Three-dimensional scatter plot illustrating the distribution of COR position changes within a standardized anatomical coordinate system. The X-axis represents medial(+) to lateral(-) displacement, the Y-axis corresponds to superior(+) to inferior(-) positioning (vertical height), and the Z-ais reflects posterior(+) to anterior(-) placement.

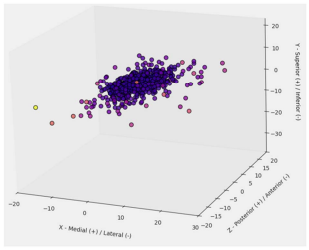

Table 1. Patient demographics and features. SD, Standard deviation; N, Number; %, Percentage; BMI, Body-mass index; ASA, American Society of Anesthesiologists; CCI, Charlson Comorbidity Index.

Parameter	Cohort (n = 728)
Mean age at surgery ± SD [range], (years)	64.3 ± 11.4 [18 – 93]
Mean BMI ± SD [range], (kg/m²)	29.7 ± 6.1 [16 – 58]
Sex, n (%)	
Female	389 (53.4)
Male	339 (46.6)
Race, n (%)	
White	490 (67.3)
Black or African American	121 (16.6)
Hispanic or Latino	15 (2.1)
Asian	15 (2.1)
Native American	2 (0.3)
Other	85 (11.7)
Smoking status, n (%)	
Never	360 (49.5)
Former	301 (41.4)
Current	67 (9.1)
ASA score, n (%)	
I	40 (5.5)
II	472 (64.8)
III	206 (28.3)
IV	10 (1.4)
Mean CCI ± SD	3.5 ± 2.6
Mean length of follow-up ± SD, (months)	23.8 ± 32.2
Mean length of stay ± SD, (hours)	45.7 ± 36.6
Mean duration of surgery ± SD, (minutes)	117.1 ± 24.7
Discharge disposition, n (%)	
Acute rehabilitation facility	11 (1.5)
Home/self-care	665 (91.3)
Skilled nursing facility	52 (7.1)

Table 2. Acetabular cup inclination, anteversion, offset and center of rotation positioning. SD, Standard deviation; COR, Center of rotation; mm, Millimeter.

Parameter	Value
Mean cup inclination ± SD [range] (°)	40.5 ± 2.8 [28 – 49]
Mean cup anteversion ± SD [range] (°)	22.7 ± 4.1 [2 – 40]
Median (+)posterior/(-)anterior offset [range], (mm)	1.0 [-35 – 29]
Median COR [range], (mm)	
(+)Superior/(-)inferior	1.0 [-14 – 153]
(+)Medial/(-)lateral	3.0 [-185 – 26]
(+)Posterior/(-)anterior	0.0 [-34 – 37]

Table 3. Multivariate general linear model representing the impact of COR position change on PROMs. HOOS, JR, Hip Injury and Osteoarthritis Outcome Score for Joint Replacement; PROMIS, Patient-Reported Outcomes Measurements Information System; *, Statistical significance, p <0.05; MCID, Minimum clinically important difference.

Parameter		(+)Superior/(-)inferior	(+) Medial/(-)lateral	(+)Posterior/(-)anterior
	PROM	Coefficient, p-value, MCID		
HOOS, JR				
Preoperative	49.7	0.7, 0.181	0.4, 0.275	0.0, 0.960
At 2 weeks	62.1	0.5, 0.265	-0.3, 0.422	0.0, 0.902
At 3 months	68.1	1.0, 0.157	-0.4, 0.380	0.4, 0.511
At 1 year	73.3	**1.6, 0.033*, 5.1**	-0.2, 0.702	-0.2, 0.710
Δ preoperative to 2 weeks	12.4	-0.2, 0.767	-0.7, 0.159	0.1, 0.902
Δ preoperative to 3 months	18.4	0.2, 0.734	-0.8, 0.109	0.4, 0.517
Δ preoperative to 1 year	23.6	0.9, 0.238	-0.6, 0.234	-0.2, 0.735
PROMIS Pain Intensity				
Preoperative	55.5	-0.2, 0.430	-0.4, 0.049*, 3.2	0.2, 0.266
At 2 weeks	49.8	-0.2, 0.348	0.1, 0.529	-0.4, 0.062
At 3 months	44.9	-0.2, 0.462	-0.1, 0.793	-0.4, 0.062
At 1 year	44.8	-0.1, 0.612	-0.2, 0.394	0.0, 0.850
Δ preoperative to 2 weeks	-5.7	0.0, 0.954	**0.5, 0.032*, 4.3**	**-0.6, 0.018*, 4.3**
Δ preoperative to 3 months	-10.6	0.0, 0.970	0.3, 0.162	**-0.7, 0.008*, 4.4**
Δ preoperative to 1 year	-10.6	0.0, 0.862	0.2, 0.378	-0.3, 0.235
PROMIS Pain Interference				
Preoperative	65.4	0.0, 0.920	-0.2, 0.118	0.0, 0.890
At 2 weeks	62.9	-0.2, 0.394	0.1, 0.510	-0.4, 0.069
At 3 months	57.2	-0.2, 0.594	0.1, 0.538	-0.2, 0.482
At 1 year	56.9	-0.1, 0.662	-0.3, 0.241	0.0, 0.965
Δ preoperative to 2 weeks	-2.4	-0.2, 0.515	0.3, 0.122	-0.4, 0.149
Δ preoperative to 3 months	-8.2	-0.1, 0.629	0.3, 0.091	-0.2, 0.527
Δ preoperative to 1 year	-8.4	-0.1, 0.668	0.0, 0.835	0.0, 0.881