The Influence of Digital Radiography Navigation on Improving Component Placement during Total Hip Arthroplasty

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INTRODUCTION:

Optimal implant positioning and sizing during total hip arthroplasty (THA) is associated with improved patient outcomes and implant survival. Intraoperative digital radiography has been shown to improve the accuracy of component placement for patients undergoing posterior approach THA in the lateral decubitus position. Despite being based on a technology that is familiar, reliable, and cost-effective, the use of digital radiography for THA has had slow adoption. There is limited data on the type and frequency of intraoperative changes made as a result of digital radiography, especially among experienced, high-volume surgeons. The purpose of this study was to quantify the value of intraoperative digital radiography to experienced arthroplasty surgeons performing posterior approach THAs at a single institution.

METHODS: From March 2020 through September 2020, 100 consecutive hips undergoing primary THA by four experienced fellowship trained arthroplasty surgeons were included in the study. Following placement of the acetabular implant and trial femoral components, the surgeon was asked to estimate the adequacy of several parameters: limb length, femoral offset, cup abduction and anteversion angles, and the size and position of the acetabular cup and femoral stem. An intraoperative digital radiograph was then taken, and image analysis software (Radlink™, Inc.) was utilized to measure the parameters of interest [Fig 1]. The accuracy of surgeon prediction and frequency of changes made after intraoperative x-ray were recorded and analyzed using McNemar's test with SPSS software.

RESULTS: Surgeons accurately predicted cup abduction within ±3 degrees only 45% of the time and cup anteversion within ±3 degrees only 46% of the time [Fig 2]. Surgeons were less accurate in predicting appropriate limb length (48%, p=0.014), appropriate femoral stem size (66%, p=0.047), and femoral offset (66%, p=0.089), but had higher accuracy in predicting femoral stem position (varus/valgus) (78%, p=0.27), appropriate acetabular cup size (99%, p=0.999) and cup positioning (medial/lateral positioning) (87%, p=0.123) [Table 1]. After an intraoperative x-ray was taken, changes to implants were made in 91% of cases [Table 2]. The most common changes made were to limb length (68%), followed by stem size change (51%), cup abduction angle (30%) and cup anteversion angle (19%). Figures 3 and 4 provide examples of intraoperative changes. Final cup position was more likely to be in appropriate abduction/anteversion with fewer outliers after using intraoperative radiograph to guide intraoperative changes [Fig 5].

DISCUSSION AND CONCLUSION:

Among experienced, high-volume surgeons, the use of digital radiography led to intraoperative changes in 91% of cases. Surgeons' estimates of limb length, femoral stem size, and acetabular cup orientation were significantly different than digital radiography measurements and were the parameters most frequently changed intraoperatively. The ability for digital radiography to assess the femoral stem is a distinct advantage of this technique, and this study emphasized its importance finding a high rate of intraoperative changes made to femoral stem size. In conclusion, digital radiography is a valuable and influential navigation tool to ensure reliable implant positioning and restoration of limb length and offset in THA.

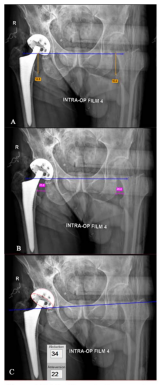
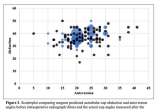
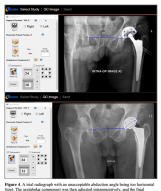


Figure 1. Trial radiographs demonstrating how image analysis software measures limb length (A), femoral offset (B), and cup abduction and anteversion angles (C) using digital radiography.





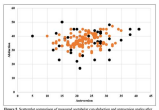


Table 1. Accuracy of surgeon estimates compared with assessment by intraoperative radiography

		AFTER TRIAL		
LIMB LENGTH 48% accuracy (P=0.014)		Appropriate	Short	Long
BEFORE TRIAL	Appropriate	48%	21%	7%
	Short	6%	14%	3%
	Long	7%	8%	10%
STEM POSITION 78% accuracy (P=0.176)		AFTER TRIAL		
		Neutral	Varus	Valgus
BEFORE TRIAL	Neutral	69%	3%	0%
	Varus	10%	8%	3%
	Valgus	2%	4%	4%
STEM SIZE 66% accuracy (P=0.047)		AFTER TRIAL		
		Appropriate	Small	Large
BEFORE TRIAL	Appropriate	47%	16%	6%
	Small	11%	14%	4%
	Large	3%	1%	0%
CUP POSITION 87% accuracy (P=0.123)		AFTER TRIAL		
		Appropriate	Medial	Lateral
BEFORE TRIAL	Appropriate	59%	21%	7%
	Medial	0%	0%	0%
	Lateral	7%	0%	10%
FEMORAL OFFSET 66% accuracy (P=0.098)		AFTER TRIAL		
		Appropriate	Too Little	Too Much
BEFORE TRIAL	Appropriate	59%	21%	7%
	Too Little	0%	0%	0%
	Too Much	7%	0%	10%

Table 2. Description of the frequency and type of changes made after intraoperative radiography

Type of Change	Frequency
Limb Length	68%
Cup Abduction Angle	30%
Cup Anteversion Angle	19%
Stem Size	51%
Neck Type	12%
Femoral Head	19%
Cup Size	8%
Any Change	91%