TITLE: A Prospective Randomized Controlled Trial Comparing Computerised Tomography-based Planning With Conventional Total Hip Arthroplasty Versus Robotic-arm Assisted Total Hip Arthroplasty.

AUTHORS AND CO-AUTHORS:
Andreas Fontalis[1,2]*, Babar Kayani[1]*, Ricci Plastow[1], Dia Eldean Giebaly[1], Jenni Tahmassebi[1], Isabella Catrina Haddad[1], Alastair Chambers[1], Fabio Mancino[1], Sujith Konan[1], Fares S Haddad[1,2]
*Shared co-first authorship
INSTITUTION(S):
1. Department of Trauma and Orthopaedic Surgery, University College Hospital, London, UK. 2. Division of Surgery and Interventional Science, University College London, Gower Street, London, WC1E 6BT, UK
AUTHOR DISCLOSURES
Fares Haddad: Editor-in-Chief, Bone & Joint journal, Consulting Fees and Research Support (Stryker)

ABSTRACT
INTRODUCTION: Achieving accurate implant positioning and restoring native hip biomechanics are key surgeon-controlled, technical objectives in Total Hip Arthroplasty (THA). The primary objective of this study was to compare the reproducibility of the planned preoperative centre of hip rotation (COR) in patients undergoing robotic-arm assisted THA versus conventional THA.
METHODS: This prospective randomized controlled trial included 60 patients with symptomatic hip osteoarthritis undergoing conventional THA versus robotic-arm assisted THA. Patients in both arms underwent pre- and post-operative CT scans and a patient-specific plan utilising the robotic software was created. The COR, combined offset, acetabular orientation and leg length discrepancy were measured on the pre- and post-operative CT scanogram at six weeks following surgery. Patient Reported Outcome Measures (PROMs) were collected at baseline and 1-year's follow up.
RESULTS: There were no significant differences for any of the baseline characteristics including spinopelvic mobility. The mean absolute error for achieving the planned horizontal COR, vertical COR and combined offset in the RO THA group was 1.4mm(0.87, 3.42), 0.91mm(SD, 0.73), 2mm(0.97, 5.45) versus 4.6mm(SD 2.6, p=0.033), 2.3mm(1.2, p< 0.001) and 3.9mm(2, 7.9), p=0.019) in CO THA. Improved accuracy was observed with RO THA in achieving the desired acetabular cup positioning (Root Mean Square Error for anteversion and inclination were 2.6 and 1.3 versus 8.9 and 5.3) and leg length (mean 0.6mm vs 1.4mm, p< 0.001). PROMs were comparable between the 2 groups at baseline and 1-year. Participants in the RO THA group necessitated less physiotherapy sessions post-operatively 6(4.5, 8) versus 8(6, 11,p=0.005).
DISCUSSION: This RCT suggested that robotic-arm assistance in THA was associated with improved accuracy in restoring the native COR, better preservation of the combined offset, leg length correction and superior accuracy in achieving the desired acetabular cup positioning. Further evaluation through long-term and registry data is necessary to assess whether these findings translate into improved implant survival and functional outcomes.
SIGNIFICANCE/CLINICAL RELEVANCE: This randomized controlled trial highlights the advantages of robotic-arm assisted Total Hip Arthroplasty in achieving more precise surgical outcomes, specifically in restoring the native center of rotation, offset, leg length and ensuring accurate placement of the acetabular cup. This study adds valuable insights to the ongoing discourse regarding the integration of advanced technology in orthopaedic surgery and arthroplasty.

Table 1. Radiological outcomes between the study arms.

Variables	Robotic-arm assisted group (N=30)	Conventional group (N=30)	p-value
Horizontal Centre of Rotation (mm)			
Pre-operative (diseased)	90.6 (5.6)	88.6 (5.8)	
Planned (CT-based, using the robotic software)	89 (5.7)	87.6 (5)	
Post-operatively	87.7 (5.4)	84.5 (5.4)	**<0.001$**
Absolute error in achieving the planned horizontal COR	1.4 (0.87, 3.42) &	4.7 (2.6)*	
Vertical Centre of Rotation (mm)			
Pre-operative (diseased)	14.2 (2.8)	14.2 (2.9)	
Planned (CT-based, using the robotic software)	14.3 (2.7)	14.1 (2.5)	
Post-operatively	14.6 (1.6)	13.9 (1.9)	
Absolute error in achieving the planned vertical COR	0.91 (0.73) *	2.3 (1.3)*	**<0.001§**
Inclination (degrees)			
Planned (CT-based, using the robotic software)	40 (0.9)	40 (0)	
Post-operatively	40.2 (1.6)	40.2 (5.5)	
Absolute error in achieving the planned inclination	0.7 (1.2) *	4.1 (3.6)*	**<0.001§**
Anteversion (degrees)			
Planned (CT-based, using the robotic software)	20.8 (3)	22.2 (2.4)	
Post-operatively	21.4 (3.8)	28.1 (6.7)	
Absolute error in achieving the planned anteversion	1.5 (2.2) *	6.7 (6)*	**<0.001§**
Combined offset (mm)			
Pre-operative (diseased)	68.5 (8.2)	70.9 (6.9)	
Planned (CT-based, using the robotic software)	67 (8.4)	68.1 (6.6)	
Post-operatively	68.7 (7.7)	70.2 (5.8)	
Absolute error in achieving the planned combined offset	2 (0.97, 5.45) &	3.9 (2, 7.9) &	**0.019$**
Mean absolute leg length discrepancy vs opposite (mm)	0.6 (0.8) *	1.4 (1.1)*	**<0.001§**

RMSE: root mean square error, COR : Centre of Rotation, SD : Standard Deviation, CT : Computerized Tomography § Independent-samples t-test, $Mann-Whitney U test. Mean (standard deviation)* Median (quartile 1, quartile 3)&

Figure 1. Flow of patients through the phases of the randomized controlled trial.