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Use of a Fluoroscopy-Based Robotic-Assisted Total Hip Arthroplasty System Produced Greater Improvements in Patient-Reported Outcomes at One Year Compared to Manual, Fluoroscopic-Assisted Technique

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Abstract

Introduction: The adoption of new technology should be supported by improvements in patient-reported outcomes (PROMs). The purpose of this study was to assess the one-year PROMs of patients who underwent total hip arthroplasty (THA) using a novel, fluoroscopy-based, robotic-assisted (RA-THA) system when compared to a manual, fluoroscopic-assisted technique (mTHA).

Materials and Methods: A review of 91 consecutive mTHA and 85 consecutive RA-THA via a direct anterior approach was conducted. All cases were performed by the same surgeon at the same institution, for a pre-operative diagnosis of osteoarthritis, avascular necrosis, or rheumatoid arthritis. Outcomes included one-year Veterans RAND-12 (VR-12) Physical/Mental, Hip Disability and Osteoarthritis Outcome (HOOS) Pain/Physical

Function/Joint Replacement, and University of California Los Angeles (UCLA) Activity scores, as well as the difference between pre-operative and one-year post-operative PROMs.

Results: Patients in the RA-THA cohort had lower pre-operative HOOS-JR scores compared to patients in the mTHA cohort (37.0 vs. 43.1; p=0.031). Cohorts experienced similar one-year post-operative VR-12, HOOS, and UCLA Activity scores. Patients in the RA-THA cohort experienced greater improvements across all pre- and post-operative HOOS scores compared to patients in the mTHA cohort: Pain (+54.7 vs. +42.1; p=0.009), Physical Function (-41.6 vs. -28.7; p=0.007), and Joint Replacement (+46.6 vs. +33.0; p=0.002). These differences exceeded minimum clinically important difference (MCID).

Conclusions: Both manual and robotic cohorts experienced benefit from THA at one-year post-operative. Importantly, the use of a novel, fluoroscopy-based robotic assistance system for primary THA resulted in greater improvements in PROMs at one-year relative to manual technique.

1 Introduction:

Total hip arthroplasty (THA) is the standard treatment for end-stage osteoarthritis of the hip, however, up to 27% of THA patients report having unfulfilled expectations regarding their surgery [1-3]. Some studies have suggested that the use of robotic-assistance for total hip arthroplasty (RA-THA) improves post-operative patient-reported outcome measures (PROMs) relative to manual, unassisted technique (mTHA) [4,5], though conflicting evidence exist in the literature [6,7]. In 2021, a novel, fluoroscopy-based RA-THA platform received approval from the United States (U.S.) Food and Drug Administration (FDA) for use in primary THA. The purpose of the present investigation was to compare PROMs of patients who underwent primary THA using the novel RA-THA system, to those who underwent mTHA at one-year post-operative.

2 Methods:

Institutional Review Board approval was obtained prior to the initiation of this study. We performed a retrospective analysis on a consecutive series of patients who received fluoroscopy-assisted mTHA and fluoroscopy-based RA-THA at our institution from the primary study surgeon between 2021 and 2022. Patient PROM scores were collected during pre-operative and one-year post-operative follow-up office visits as a part of standard institutional practice, and were extracted from the electronic health record [8]. The PROM instruments used in this study include the Veterans RAND 12 (VR-12) Physical (PCS) and Mental (MCS) Component scores [9], the Hip Dysfunction and Osteoarthritis Outcome Score (HOOS) (Pain, Physical Function (PS), and Joint replacement (JR) scores) [10] and the University of California, Los Angeles (UCLA) Activity Scale score [11].

Inclusion criteria for this study were patients ≥ 18 years of age who underwent primary unilateral direct anterior approach (DAA) THA by the primary surgeon. Exclusion criteria for this study included patients who underwent THA for a femoral neck fracture, revision THA, bilateral THA, and patients < 18 years of age. Based on the previously reported Minimum Clinically Important Difference (MCID) for HOOS JR, we sought to include approximately 60 patients per treatment arm to detect an 18-point difference in HOOS JR scores, with 80% statistical power [12].

3 Results:

A total of 176 patients, including 91 mTHA and 85 RA-THA, were identified in the study period who met selection criteria and completed baseline PROM surveys. Comparison of baseline treatment and demographics variables demonstrated no significant differences between treatment groups for distributions of patient age, sex, body mass index (BMI), race, procedure laterality, pre-operative diagnosis, and American Society of Anesthesiologists (ASA) classification.

The only significant difference in pre-operative PROMs was in HOOS JR scores, with the RA-THA cohort having lower average reported scores than the mTHA cohort (37.0 vs. 43.1). All other baseline PROM scores were similar between treatment groups (**Table 1**). Approximately 72% of patients, 66 mTHA and 61 RA-THA, completed one-year follow-up PROM surveys. No difference was seen in post-operative VR-12, HOOS, and UCLA Activity scores when the average post-operative PROM scores were compared between cohorts (**Table 1**).

When the average changes in post-operative PROM scores from baseline were compared, patients in the RA-THA cohort experienced greater improvements between pre- and post-operative HOOS scores compared to patients in the mTHA cohort. These key HOOS outcomes included Pain (+54.7 vs. +42.1), Physical Function (-41.6 vs. -28.7), and Joint Replacement (+46.6 vs. +33.0). No differences were seen in changes for VR-12 or UCLA activity scores (**Table 2**).

4 Discussion:

Patient satisfaction is an increasingly important metric for assessing the outcomes of THA. The results of our investigation demonstrated that the use of a novel, fluoroscopy-based robotic assistance system for DAA THA resulted in a greater improvement in all HOOS scores, relative to mTHA, from baseline to one-year post-operative.

The first significant finding of this study was that there were no differences in average post-operative PROMs between the mTHA and RA-THA cohorts. While these findings are in agreement with those of Fontalis and Karunaratne et al. [7,13], other authors have reported that the use of RA-THA produced improved post-operative Harris Hip, Forgotten Joint, Short Form 12, VR-12, and UCLA activity scores relative to mTHA [4-6,14]. Interestingly, the studies that reported no differences between PROMs were over a shorter follow-up period (2-3 years) [7,13], relative to studies that showed improvement (2-5 years) [4-6,14].

The second significant finding of this study was that the RA-THA cohort experienced a benefit of 12.6, 12.9, and 13.6 additional points with regards to score improvement for HOOS Pain, HOOS-PS, and HOOS JR, respectively, relative to the mTHA cohort at one year post-operative. These values exceed the MCID of the HOOS-PS and HOOS-JR [15,16]. In a related study, Singh et al. reported that one-year post-operative improvements in HOOS-JR scores were greater among mTHA patients compared to RA-THA (34.53 ± 8.91 vs. 35.48 ± 9.33; p=0.002) [17]. The improvement in HOOS-JR scores were substantially greater in our study, emphasizing the potential for differences in robotic platform and/or approach to impact PROMs in RA-THA [17].

5 Conclusion:

The findings of this investigation demonstrated that the use of a novel, fluoroscopy-based RA-THA system resulted in greater improvements in HOOS scores relative to manual technique at one-year post-operative. These findings \ represent the first PROMs-based investigation involving this system.

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Table 1. A comparison of pre- and post-operative patient-reported outcome measure (PROM) scores between cohorts.

	Treatment		
	Manual THA	**Robotic THA**	**p-value**
Pre-operative	n = 91	n = 85	
VR-12 PCS	27.5 (8.8)	26.3 (9.2)	0.384
VR-12 MCS	47.6 (13.7)	48.2 (13.1)	0.772
HOOS Pain	37.4 (19.6)	31.7 (20.9)	0.070
HOOS-PS	48.1 (22.9)	53.9 (23.4)	0.095
HOOS-JR	43.1 (17.7)	37.0 (19.4)	**0.031**
UCLA Activity	3.7 (1.9)	3.8 (2.0)	0.759
Post-operative	n = 66	n = 61	
VR-12 PCS	44.2 (10.1)	45.4 (11.2)	0.527
VR-12 MCS	51.3 (10.1)	50.3 (12.5)	0.646
HOOS Pain	83.5 (20.7)	84.0 (22.2)	0.897
HOOS-PS	14.4 (18.3)	12.4 (18.8)	0.555
HOOS-JR	81.0 (19.8)	83.9 (19.3)	0.444
UCLA Activity	5.2 (2.2)	5.5 (2.2)	0.432

VR-12 = Veterans RAND 12; PCS = Physical Component Score; MCS = Mental Component Score; HOOS = Hip Disability and Osteoarthritis Outcome Score; PS = Physical Function Shortform; JR = Joint Replacement; UCLA = University of California, Los Angeles; Quantitative variables expressed as mean (SD). Significance bolded at a level of $p<0.05$.

Table 2. A comparison of the change in patient-reported outcome measure (PROM) scores between pre-operative baseline and one-year post-operative.

	Treatment		
	Manual THA	**Robotic THA**	**p-value**
	n = 65	n = 60	
VR-12 PCS	16.0 (11.4)	18.3 (12.4)	0.286
VR-12 MCS	2.7 (11.7)	0.8 (14.1)	0.418
HOOS Pain	42.1 (25.8)	54.7 (26.3)	**0.009**
HOOS-PS	-28.7 (26.9)	-41.6 (25.3)	**0.007**
HOOS-JR	33.0 (23.7)	46.6 (21.7)	**0.002**
UCLA Activity	1.5 (2.0)	1.7 (2.1)	0.481

VR-12 = Veterans RAND 12; PCS = Physical Component Score; MCS = Mental Component Score; HOOS = Hip Disability and Osteoarthritis Outcome Score; PS = Physical Function Shortform; JR = Joint Replacement; UCLA = University of California, Los Angeles; Quantitative variables expressed as mean (SD). Significance bolded at a level of $p < 0.05$.