Utilisation trends and early outcomes of robotic arm–assisted total hip arthroplasty in a tertiary joint replacement centre in Hong Kong

KL Fong, Amy Cheung, Michelle Hilda Luk, Thomas KC Leung, Lawrence CM Lau, PK Chan, KY Chiu, Henry Fu *

ABSTRACT

Introduction: This study evaluated utilisation trends and early outcomes of robotic arm–assisted primary total hip arthroplasty (rTHA) compared with conventional THA (cTHA) in Hong Kong.

Methods: This retrospective cohort study included all patients who underwent primary THA in public hospitals under the Hong Kong West Cluster (HKWC) from 2019 to 2024. Data were retrieved from the Hospital Authority's electronic databases. The primary outcome was the percentage utilisation of rTHA relative to cTHA. Secondary outcomes included operating time (skin-to-skin), length of stay (LOS), 30- and 90-day reoperation rates, and 30- and 90-day emergency department attendance. Differences in these outcomes between rTHA and cTHA were examined.

Results: In total, there were 311 and 242 cases of rTHA and cTHA, respectively. Robotic utilisation increased from 32.0% in 2019 to 62.2% in 2024. Regarding patient outcomes, rTHA increased operating time by 14.59 minutes (142.02 ± 53.88 vs 127.43 ± 53.34; P=0.002). There was no significant difference in median LOS between the two groups. Robotic surgery was also associated with a lower 30-day reoperation rate (0.32% vs 2.07%; P=0.049). One reoperation due to dislocation was performed in the rTHA group. In the cTHA group, one dislocation, two periprosthetic fractures, and two infections required revision surgery.

Conclusion: Given the increasing use of rTHA in the HKWC, the present findings suggest that rTHA is associated with a lower 30-day reoperation rate. As the first local study on early outcomes of rTHA, these results may serve as reference data for other centres.

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New knowledge added by this study

- Utilisation of robotic arm–assisted primary total hip arthroplasty (rTHA) nearly doubled between 2019 and 2024.
- Robotic arm–assisted primary total hip arthroplasty was associated with a lower 30-day reoperation rate.

Implications for clinical practice or policy

- Early results suggested that rTHA was associated with fewer postoperative complications requiring reoperation.
- Long-term data are needed to further evaluate trends in operating time and length of stay, and to determine how these outcomes translate into improved functional outcomes.

Introduction

In Hong Kong, robotic surgery has gained popularity across various specialties, with the Da Vinci robot becoming the standard of care in urology and seeing widespread use in general surgery.[1] Orthopaedic robotic systems are often semi-active and partially controlled by the surgeon.[2] In total hip replacement, an image-based, semi-active, haptic-constrained robotic arm system is commonly used. The Mako Robotic Arm Assisted Surgical System (Stryker Corp, Fort Lauderdale [FL], US) is a surgical system for total hip replacement approved by the US Food and Drug Administration.[3] Surgical planning is performed using three-dimensional computed tomography scans, enabling accurate, patient-specific planning. Bone removal is performed under haptic control by the robotic arm, with component implantation angles also guided by the robot, enhancing precision

機械臂輔助全髖關節置換術在香港一所三級關節置換中心的使用趨勢及早期臨床結果

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引言：本研究比較香港機械臂輔助初次全髖關節置換術（rTHA）與傳統全髖關節置換術（cTHA）的使用趨勢及早期臨床結果。

方法：這項回顧性隊列研究納入2019至2024年期間在港島西聯網轄下公立醫院接受初次全髖關節置換術的所有患者，相關數據由醫院管理局的電子資料庫提取。主要研究結果為rTHA相對於cTHA的使用百分比。次要研究結果包括手術時間（由切皮至縫皮）、住院日數、術後30日及90日內再手術率，以及術後30日及90日內的急症室求診率。研究比較rTHA與cTHA在上述結果指標上的差異。

結果：研究共納入311宗rTHA及242宗cTHA個案。機械臂輔助技術的應用率由2019年的32.0%上升至2024年的62.2%。在患者手術結果方面，rTHA的手術時間較cTHA長14.59分鐘（142.02 ± 53.88比127.43 ± 53.34分鐘；P=0.002）。兩組患者在住院中位日數無顯著差異。rTHA亦與較低的30日再手術率相關（0.32%比2.07%；P=0.049）。rTHA組中有一宗因脫位須再做手術的個案；cTHA組中有一宗脫位、兩宗人工關節周圍骨折及兩宗感染需要翻修手術。

結論：鑑於rTHA在港島西聯網的應用日益普及，本研究結果顯示rTHA與較低的30日再手術率有關。作為本地首項針對rTHA早期臨床結果的研究，這些結果可供其他醫療機構作為參考。

and accuracy.[4,5] Western literature has shown that robotic arm–assisted primary total hip arthroplasty (rTHA) yields better radiological and clinical outcomes.[6-8] However, local data on the early clinical outcomes of robotic total hip replacement remain limited. Robotics was first introduced locally by the Hong Kong West Cluster (HKWC) in 2019, and its use has been increasing. Our cluster has since accumulated substantial experience and moved beyond the learning curve. This study aimed to evaluate utilisation trends and patient outcomes of rTHA compared with conventional THA (cTHA).

Methods

Objective

The primary outcome was the percentage utilisation of rTHA relative to cTHA in the HKWC from 2019 to 2024. Secondary outcomes included operating time (skin-to-skin), length of stay (LOS), 30-day and 90-day reoperation, and 30-day and 90-day emergency department attendance. Length of stay was defined as the duration of inpatient admission following THA. Discharge criteria included the ability to ambulate with a walking aid and the absence of impending medical conditions. Reoperation was defined as undergoing another hip procedure, such as revision or implant removal, within 30 or 90 days of surgery. Emergency department attendance was defined as presentation to the accident and emergency department within 30 or 90 days following discharge.

Additionally, postoperative complication rates were examined in terms of reoperation, emergency department attendance, and the corresponding diagnoses. Complications of interest included dislocation, periprosthetic fracture, and periprosthetic joint infection. The study adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guideline.

Surgical technique

Total hip arthroplasty in both groups was performed via a posterior approach with the patient in the left lateral decubitus position. All patients received a cementless, proximally coated femoral stem (Accolade II; Stryker Corp, Mahwah [NJ], US) and a porous acetabular shell (Trident Acetabular System; Stryker Corp, Mahwah [NJ], US).[3]

In the cTHA group, the femoral osteotomy site was marked based on a predetermined distance from the lesser and greater trochanters. The acetabulum was reamed freehand, down to the true floor and healthy bleeding bone. Cup impaction was guided by an alignment guide and intraoperative landmarks, including the transverse acetabular ligament and the anterior and posterior acetabular walls, to determine the orientation of the acetabular component.[9,10]

All rTHAs were performed using the Mako Robotic Arm Assisted Surgical System, which guided acetabular reaming and component placement within haptically confined boundaries. A trial cup was inserted at the appropriate abduction angle, with anteversion guided by the robotic arm.[10]

Study design and patient selection

This was a retrospective cohort study. Data were retrieved from the Clinical Data Analysis and Reporting System (CDARS) and the Clinical Management System (CMS). The CDARS is a database containing medical information for research purposes, whereas the CMS is primarily used for day-to-day clinical management. The function to distinguish between rTHA and cTHA was introduced in CDARS in 2021. Therefore, data from 1 January 2021 to 31 December 2024 were collected via CDARS, while data from 2019 to 2020 were obtained through CMS chart review. Both systems follow standardised data protocols and can be used concurrently.

All patients who underwent primary unilateral rTHA or cTHA in the HKWC were included. Diagnoses included osteoarthritis, avascular necrosis, aseptic necrosis, developmental dysplasia of the hip, dislocation, and fractures. Patients with diagnoses of bone malignancy, chronic osteomyelitis, or complex primary THA—such as Crowe type III/IV hip dysplasia or post-traumatic osteoarthritis

with retained hardware—were excluded. Patients who had staged bilateral procedures were included as separate cases. During the initial learning phase in 2019, all surgeries were performed by a single surgeon (corresponding author). From 2020 onwards, other surgeons within the division began performing rTHA.

Statistical analysis

All analyses were conducted using SPSS (Windows version 29.0; IBM Corp, Armonk [NY], US). A two-tailed significance threshold was set at P<0.05. The normality of continuous variables was assessed using skewness and kurtosis, as well as the Shapiro–Wilk and Kolmogorov–Smirnov tests. Normally distributed continuous variables, such as operating time, were compared using independent samples *t* tests. The non-parametric continuous variable, LOS, was analysed using the Mann-Whitney *U* test. Categorical data were compared via the Chi squared test.

TABLE 1. Baseline characteristics*

	rTHA (n=311)	cTHA (n=242)	P value
Sex			0.647
Female	192 (61.7%)	154 (63.6%)	
Male	119 (38.3%)	88 (36.4%)	
Age, y	62.48 ± 12.88	66.10 ± 10.52	0.002
Diagnoses			
Osteoarthritis	182 (58.5%)	124 (51.2%)	0.088
Avascular necrosis	47 (15.1%)	51 (21.1%)	0.069
Developmental dysplasia of the hip	12 (3.9%)	12 (5.0%)	0.529
Aseptic necrosis	27 (8.7%)	12 (5.0%)	0.090
Post-traumatic osteoarthritis	13 (4.2%)	8 (3.3%)	0.594
Ankylosing spondylitis	4 (1.3%)	3 (1.2%)	0.961
Complex primary THA	5 (1.6%)	7 (2.9%)	0.304
Others	21 (6.8%)	25 (10.3%)	0.131

Abbreviations: cTHA = conventional total hip arthroplasty; rTHA = robotic arm–assisted primary total hip arthroplasty; THA = total hip arthroplasty

* Data are shown as No. (%) or mean ± standard deviation, unless otherwise specified

Results

From 2019 to 2024, a total of 311 and 242 THAs were performed in the rTHA and cTHA groups, respectively. Patient demographics are summarised in Table 1. In terms of sex distribution, 61.7% of patients in the rTHA group and 63.6% of those in the cTHA group were women. Patients undergoing rTHA had a lower mean age at the time of surgery compared with those receiving cTHA (62.48 ± 12.88 vs 66.10 ± 10.52 years; P=0.002). There was a tendency for rTHA to be performed in younger patients, although the distribution of diagnostic categories was similar between groups.

Osteoarthritis was the most common diagnosis in both groups, accounting for 58.5% of rTHA cases and 51.2% of cTHA cases. The second most common diagnosis was avascular necrosis, representing 15.1% of rTHA cases and 21.1% of cTHA cases (Table 1).

Utilisation trends

The primary outcome was the utilisation rate of rTHA in the HKWC. As shown in Table 2, a steady increase in robotic cases was observed, from 32.0% in 2019 to 62.2% in 2024. Notably, the highest proportion was recorded in 2023, at 75.2%. In contrast, the proportion of conventional cases steadily declined, almost halving from 68.0% in 2019 to 37.8% in 2024. The substantial increase in rTHA proportion illustrates a clear shift from cTHA to rTHA as the predominant surgical approach over the study period.

Operating time (skin-to-skin)

The secondary outcomes are presented in Table 3. Robotic arm–assisted primary total hip arthroplasty had a mean operating time of 142.02 minutes, which was 14.59 minutes longer than that of cTHA (127.43 minutes). For rTHA, the mean operating time was 131.53 minutes in 2019, increased to 139.58 minutes in 2020 with more surgeons beginning their learning curve, and then reached a plateau over the next 2 years (2021: 146.99 minutes; 2022: 152.79 minutes). In the final 2 years of the study, operating time decreased to 142.00 minutes in 2023 and 133.83 minutes in 2024, reflecting passing of learning curve by the whole surgical team. In contrast, cTHA operating times ranged from 111 to 139 minutes, without a clear trend. In the first 2 years, operating times were similar (2019: 131.04 minutes; 2020: 131.75 minutes), followed by a slight increase to 139.38 minutes in 2022, then dropped to 111.16 minutes in 2023, with a moderate increase to 120.04 minutes in 2024.

TABLE 2. Utilisation trends of robotic arm–assisted primary total hip arthroplasty and conventional total hip arthroplasty from 2019 to 2024

	rTHA	cTHA	Total
2019	33 (32.0%)	70 (68.0%)	103
2020	37 (41.6%)	52 (58.4%)	89
2021	81 (71.1%)	33 (28.9%)	114
2022	38 (52.8%)	34 (47.2%)	72
2023	76 (75.2%)	25 (24.8%)	101
2024	46 (62.2%)	28 (37.8%)	74
Total	311 (56.2%)	242 (43.8%)	553 (100%)

Abbreviations: cTHA = conventional total hip arthroplasty; rTHA = robotic arm–assisted primary total hip arthroplasty

TABLE 3. Secondary outcomes (n=553)*

	rTHA (n=311)	cTHA (n=242)	P value
Operating time, min			
2019	131.53 ± 43.99	131.04 ± 49.83	0.962
2020	139.58 ± 45.30	131.75 ± 53.48	0.475
2021	146.99 ± 46.08	121.30 ± 26.32	0.003
2022	152.79 ± 43.25	139.38 ± 77.99	0.374
2023	142.00 ± 61.13	111.16 ± 40.61	0.021
2024	133.83 ± 73.57	120.04 ± 62.70	0.418
All years	142.02 ± 53.88	127.43 ± 53.34	0.002
Length of stay, d			
2019	7.00	9.00	0.852
2020	8.00	5.00	0.001
2021	6.00	4.00	0.003
2022	6.00	8.00	0.004
2023	5.00	6.00	0.054
2024	4.00	4.00	0.848
All years	6.00	6.00	0.260
30-day reoperation	1 (0.3%)	5 (2.1%)	0.049
90-day reoperation	2 (0.6%)	6 (2.5%)	0.072
30-day emergency department attendance	7 (2.3%)	2 (0.8%)	0.189
90-day emergency department attendance	12 (3.9%)	10 (4.1%)	0.870

Abbreviations: cTHA = conventional total hip arthroplasty; rTHA = robotic arm–assisted primary total hip arthroplasty

* Data are shown as mean ± standard deviation, median or No. (%), unless otherwise specified

Length of stay

Discharge criteria remained consistent throughout the study period and included the ability to ambulate independently with a walking aid, effective pain control, absence of immediate wound complications, and no major medical issues. Most patients were discharged directly under the enhanced recovery after surgery protocol; only those undergoing complex primary THA (<10% of the cohort) were transferred to rehabilitation hospitals. The median LOS was the same in both groups (6.00 vs 6.00 days; P=0.260) [Table 3]. When rTHA was first introduced in 2019, all procedures were performed by a single surgeon, which may have influenced early outcomes. In 2020 and 2021, more surgeons began performing rTHA, which may partly explain the longer LOS observed during this learning-curve period.

Reoperation and emergency department attendance

Robotic arm–assisted primary total hip arthroplasty was associated with a lower 30-day reoperation rate compared with cTHA (0.32% vs 2.07%; P=0.049). Similarly, a trend towards a lower 90-day reoperation rate was observed for rTHA (0.64% vs 2.48%; P=0.072) [Table 3].

All 30-day reoperations were hip-related. As shown in Table 4, one reoperation was performed in the rTHA group and five in the cTHA group. In the rTHA group, reoperation was required for a hip dislocation, which was managed by closed reduction. In the cTHA group, two periprosthetic fractures of the proximal femur were treated with open reduction and internal fixation. Two additional reoperations were performed for wound infections, and one hip dislocation was managed by closed reduction.

All 90-day reoperations were also hip-related. In the rTHA group, one additional case of dislocation was noted. In the cTHA group, one new case of periprosthetic fracture was identified (Table 4).

Discussion

The number of THAs utilising robotic assistance increased over the study period. The proportion of robotic cases relative to cTHA also rose, with rTHA accounting for 56.2% of all THAs when all years were combined. These findings indicate a shift in the primary surgical approach within the HKWC from conventional to robotic techniques. At present, four public hospitals in Hong Kong have acquired robotic systems, with several additional systems available on loan. Brinkman et al[11] reported that public interest in rTHA substantially increased between 2011 and 2020. Compared with online search volumes for conventional arthroplasty, this growth was statistically significant.

Clement et al[12] reported that, despite the higher costs associated with robotics, rTHA was a cost-effective intervention compared with cTHA owing to greater gains in health-related quality of life, as measured by the EuroQol 5-Dimension. In addition, the rising popularity of rTHA may be attributed to its favourable clinical, functional, and radiological outcomes, which are discussed further below.

Robotic THA was associated with an increase in operating time of approximately 15 minutes, which is slightly less than the 20-minute increase reported by Han et al (20.72 minutes; P=0.002).[13] This difference may be attributable to the need for system registration or placement of positioning pins, as well as the effects of the learning curve. When rTHA was first introduced in Hong Kong in 2019, only one experienced surgeon was using the procedure, with an average operating time of 131 minutes. As more surgeons began using the robotic system, a learning-curve effect was suggested by an increase in operating time over the next 3 years (139.6, 147.0, and 152.8 minutes, respectively). Notably, robotic operating time then decreased by 11 minutes from

2022 to 2023, and by a further 8 minutes to 133.83 minutes, suggesting increased familiarity with the system and the possible completion of the learning curve. Kayani et al[14] similarly reported that robot-assisted acetabular cup positioning during THA was associated with a learning curve of 12 cases.

There were no statistically significant differences in LOS between the rTHA and cTHA groups; both had a median LOS of 6.00 days. In a retrospective study, Remily et al[15] matched patients in a 1:1 ratio between robotic and conventional groups (4630 patients per group) and reported a significantly shorter mean LOS in the rTHA group (3.4 vs 3.7 days; P=0.001). These findings may reflect the ability of robotic technology to execute preoperative plans tailored to each patient's unique anatomy. The results may also be related to reduced iatrogenic trauma and faster postoperative rehabilitation. Similarly, Heng et al[16] found that the mean LOS in the robotic group was approximately 1 day shorter. Nevertheless, differences in data distribution and reporting methods should be noted. While previous authors reported mean LOS, we reported the median LOS due to the non-parametric distribution of our data.

Social and cultural factors may also influence LOS. Western patients often have access to more spacious home environments, whereas patients in Hong Kong may reside in more confined living spaces, potentially reducing their willingness or readiness for early discharge. Furthermore, patients and their families in Hong Kong often adopt a more conservative approach to discharge, preferring extended care under medical supervision and a self-perceived burden to their family members if they return home early.[17] These factors may contribute to a prolonged LOS.

It was evident that rTHA was associated with a lower 30-day reoperation rate, with a trend towards a lower 90-day reoperation rate. Our findings are consistent with those of Shaw et al[18] who reported significantly lower dislocation rates with rTHA compared with cTHA (0.6% vs 2.5%; P<0.046). Notably, all cases of unstable rTHA were successfully managed conservatively in the absence of component malposition, whereas 46% of unstable cTHA cases required revision surgery for recurrent instability due to malalignment.[18] A previous postoperative analysis in Hong Kong[19] showed that 96% of robotically positioned acetabular cups fell within the Lewinnek safe zone (inclination 30°-50°, anteversion 5°-25°).

Although rTHA improves the accuracy of implant positioning and reduces outliers in acetabular cup placement,[20,21] there remains a lack of data concerning how these improved radiological outcomes translate into differences in long-term clinical recovery, functional outcomes, implant survivorship, and complication rates when compared with cTHA.[22]

TABLE 4. Reoperation and emergency department attendance causes (n=553)*

	rTHA (n=311)	cTHA (n=242)	P value
30-day reoperation			
Hip-related	1 (0.3%)	5 (2.1%)	0.049
Non–hip-related	0	0	
Medical	0	0	
Total	1 (0.3%)	5 (2.1%)	0.049
90-day reoperation			
Hip-related	2 (0.6%)	6 (2.5%)	0.073
Non–hip-related	0	0	-
Medical	0	0	-
Total	2 (0.6%)	6 (2.5%)	0.073
30-day emergency department attendance rate			
Hip-related	0	1 (0.4%)	0.257
Non–hip-related	3 (1.0%)	2 (0.8%)	0.865
Medical	3 (1.0%)	0	0.126
Total	6 (1.9%)	3 (1.2%)	0.525
90-day emergency department attendance rate			
Hip-related	1 (0.3%)	1 (0.4%)	0.859
Non–hip-related	6 (1.9%)	7 (2.9%)	0.458
Medical	5 (1.6%)	2 (0.8%)	0.415
Total	12 (3.9%)	10 (4.1%)	0.870

Abbreviations: cTHA = conventional total hip arthroplasty; rTHA = robotic arm–assisted primary total hip arthroplasty

* Data are shown as No. (%), unless otherwise specified

Limitations

To our knowledge, this is the first territory-wide study in Asia comparing cTHA and rTHA. However, several limitations should be acknowledged. First, the use of big data analysis through the CDARS precluded adjustment for certain confounding factors, such as surgeon- and hospital-related variables. Second, the dataset was confined to the HKWC as ethics approval could not be obtained for multi-cluster or private hospital data. Although other public-sector clusters are also managed by the Hospital Authority, caution should be exercised when comparing our findings to other settings. Nevertheless, the inclusion of multiple surgeons reflects real-world clinical practice. Finally, functional outcomes and patient-reported outcome measures were not assessed; as such, the impact of rTHA from the patient's perspective could not be evaluated.

Evaluation of longer-term outcomes and registry data from additional clusters will be essential

to develop optimal THA strategies, those that achieve key technical objectives, enhance patient outcomes, and reduce complications.

Conclusion

The use of rTHA nearly doubled between 2019 and 2024 and was associated with a lower 30-day reoperation rate compared with cTHA. However, as this study focused solely on early patient outcomes, further research is warranted to determine whether these findings translate into improved long-term functional outcomes.

Author contributions

Concept or design: KL Fong, H Fu.
Acquisition of data: KL Fong, H Fu.
Analysis or interpretation of data: KL Fong, H Fu.
Drafting of the manuscript: All authors.
Critical revision of the manuscript for important intellectual content: All authors.

All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

All authors have disclosed no conflicts of interest.

Declaration

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Ethics approval

This research was approved by the Institutional Review Board of The University of Hong Kong/Hospital Authority Hong Kong West Cluster, Hong Kong (Ref No.: UW 24-128). The requirement for informed patient consent was waived by the Board due to the retrospective nature of the study.

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