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Comparisons of in-hospital complications between total hip arthroplasty and hip resurfacing arthroplasty

Yuanyuan Huang[1†], Qinfeng Yang[2†], Ziqi Wang[2†], Zhijie Pan[2], Yang Zhang[2*], Zhanjun Shi[2*] and Sheng Yang[2,3*]

Abstract

Background Hip resurfacing arthroplasty (HRA) is a less common but effective alternative method to total hip arthroplasty (THA) for hip reconstruction. In this study, we investigated the incidences of in-hospital complications between patients who had been subjected to THA and HRA.

Methods The National Inpatient Sample data that had been recorded from 2005 to 2014 was used in this study. Based on the International Classification of Disease, Ninth Revision, Clinical Modification, patients who underwent THA or HRA were included. Data on demographics, preoperative comorbidities, length of hospital stay, total charges, and in-hospital mortality and complications were compared. Multiple logistic regression analysis was used to determine whether different surgical options are independent risk factors for postoperative complications.

Results A total of 537,506 THAs and 9,744 HRAs were obtained from the NIS database. Patients who had been subjected to HRA exhibited less preoperative comorbidity rates, shorter length of stay and extra hospital charges. Moreover, HRA was associated with more in-hospital prosthesis loosening. Notably, patients who underwent HRA were younger and presented less preoperative comorbidities but did not show lower incidences in most complications.

Conclusions The popularity of HRA gradually reduced from the year 2005 to 2014. Patients who underwent HRA were more likely to be younger, male, have less comorbidities and spend more money on medical costs. The risk of in-hospital prosthesis loosening after HRA was higher. The HRA-associated advantages with regards to most in-hospital complications were not markedly different from those of THA. In-hospital complications of HRA deserve more attention from surgeons.

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Keywords Hip resurfacing arthroplasty, Total hip arthroplasty, In-hospital complications, Nationwide inpatient sample database, Osteoarthritis

Introduction

Hip resurfacing arthroplasty (HRA) is a less common but effective alternative method to total hip arthroplasty (THA) for hip reconstruction [1, 2]. Based on its design philosophy, HRA has gained popularity among young, active patients [3–5]. However, since it was first reported in the 1940s, HRA has been associated with various complications, including femoral neck fractures, component loosening, and adverse local tissue reactions among others [2]. With continuous advances in prosthesis materials, HRA procedures have been improved, and metal-on-metal hip resurfacing, particularly Birmingham hip resurfacing became one of the most popular alternative surgeries of THA [6, 7].

Various studies have compared HRA and THA. Some studies showed that HRA improves functions and reduces pain at short- and mid-term follow-up [8, 9]. Other studies reported that HRA prosthesis has a higher revision rate than THA [10]. Besides, regarding the safety of the two procedures, THA was associated with higher mortality rates, compared to HRA [11, 12]. Overall, the main advantages of HRA were with regards to reproduction of natural joint biomechanics, conservation of femoral bone stock, meeting the functional demands and the option for future THA [6, 13]. However, the higher incidences of long-term complications after HRA have limited its clinical applications [2, 14, 15].

While the studies attempted to detect the long-term outcomes after the two procedures, a limited number of studies focused on postoperative complications during hospitalization. Therefore, we used data from a large-scale database to assess the demographics of HRA and THA patients and to detect in-hospital outcomes. We particularly focused on whether there were differences in incidences of in-hospital complications after HRA and THA.

Methods

Data source

The data was collected from the National Inpatient Sample (NIS) database, which is part of the Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality. The NIS represents the largest all-payer database of hospital admissions in the United States. The NIS collects a stratified sample from more than 1000 hospitals, of approximately 20% of the hospitalizations each year. Patients were included based on the diagnostic and procedural codes defined by International Classification of Diseases (ninth revision) Clinical Modification (ICD-9-CM).

Data collection

According to the ICD-9-CM system, patients underwent THA were identified by the procedure code 81.51, and patients underwent HRA were identified by code 00.85. Exclusion criteria included pathological fractures, osteomyelitis and emergency admissions.

Patient demographics, including age, sex, and race were evaluated. Outcome measures such as length of stay, Charlson Comorbidity Index (CCI), Elixhauser Comorbidity Index, total charges, and in-hospital mortality were analyzed. Subsequently, osteoarthritis, hip dysplasia, avascular necrosis of femoral head, traumatic arthritis, fracture, rheumatoid arthritis and ankylosing spondylitis were determined as reasons for surgery and proportion of different diagnoses were calculated.

Further, perioperative complications were searched in the database based on ICD-9-CM diagnostic code. Prosthesis-related complications were defined as dislocation, periprosthetic fracture, periprosthetic joint infection, prosthesis loosening, revision arthroplasty and other prosthesis-related complications. Other perioperative complications included postoperative shock, acute posthemorrhagic anemia, blood transfusion, deep vein thrombosis, pulmonary embolism, acute cerebrovascular disease, pneumonia, acute renal failure, urinary tract infection, nerve injury of lower limb, wound dehiscence and infection, wound debridement and mortality.

Data analysis

The statistical software, R version 3.5.3 (R Foundation for Statistical Computing, Vienna, Austria) was used to perform statistical analysis. Comparisons between the groups were performed by Wilcoxon rank sum test for continuous variables, chi-square test or fisher test for categorical variables. Multivariate logistic regression models were constructed to assess if the type of surgery influenced the postoperative complications rate independently. Odds ratios (ORs), p values, and 95% confidence intervals (CIs) of ORs were used to depict the effect instead of relying solely on statistical significance. Statistical significance was defined by $p \leq 0.001$ because of the large-scale sample volume, which had been utilized by other NIS-researches.

Results

Trends in the number of HRA and THA

A total of 537,506 THAs and 9,744 HRAs were identified in the NIS database from 2005 to 2014. The number of THA cases increased annually from 2005 to 2014 (Fig. 1). More than 60,000 THAs were performed in 2014. The

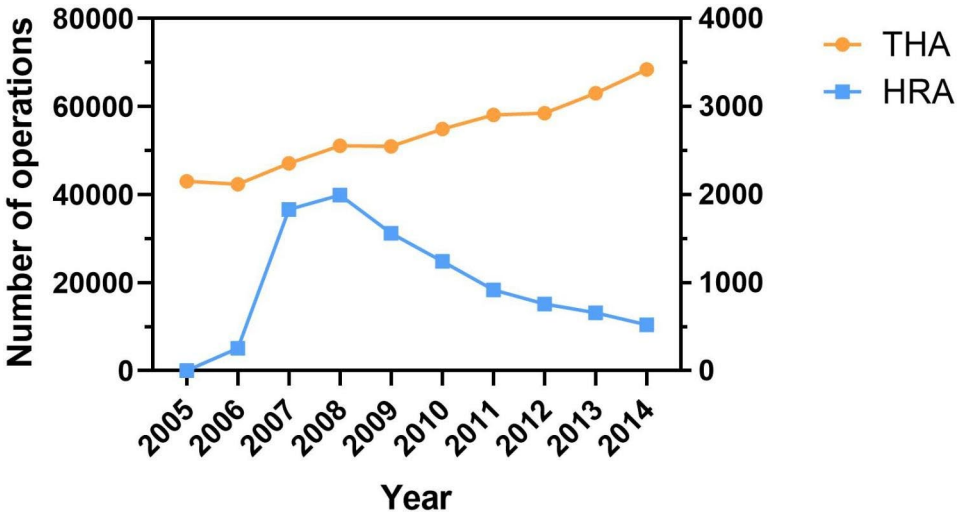

Fig. 1 Trends in the number of HRA and THA.
The left Y-axis represents the number of THA while the right Y-axis represents the number of HRA.

number of HRA cases peaked in 2008, and gradually decreased from then on.

Demographics of patients receiving HRA and THA

Demographic data of the included cases are shown in Table 1. There were significant differences in most indicators between the groups. Patients who underwent HRA were markedly younger (52 yrs. vs. 65 yrs., $p<0.001$) and less females (20.43% vs. 55.48%, $p<0.001$). Differences in in-hospital mortality rates between the groups were insignificant (0.09% vs. 0.01%, $p=0.132$).

Reasons for receiving surgeries

In Table 2, most patients in either THA or HRA groups were subjected to surgeries due to osteoarthritis. Only in less than 5% of patients was HRA not due to osteoarthritis.

Preexisting comorbidities

Table 3 shows the prevalence of preexisting comorbidities. Compared with HRA, patients who underwent THA had higher incidences of preexisting comorbidities, including deficiency anemias, arrhythmia, congestive heart failure, chronic pulmonary disease, depression, uncomplicated diabetes, diabetes with chronic complications, hypertension, hypothyroidism, fluid and electrolyte disorders, other neurologic disorders, obesity, peripheral vascular disorders, psychoses, pulmonary circulation disorders, renal failure, solid tumors without metastasis, and valvular disease. Differences in incidences of acquired immunodeficiency syndrome, alcohol abuse, chronic blood loss anemia, coagulopathy, drug abuse, liver disease, lymphoma, metastatic cancer, paralysis, as well as peptic ulcer disease excluding bleeding and weight loss were not significant between the two groups.

Prosthesis-related complications after THA or HRA during hospitalization

Comparisons of incidences of complications and multivariate regression results are shown in Table 4. In addition to prosthesis loosening, higher incidences of most prosthesis-related complications were observed after THA, including dislocation, periprosthetic fractures, periprosthetic joint infections and revision arthroplasty. However, differences in these outcomes between the groups were insignificant. Notably, HRA exhibited a significantly high OR for prosthesis loosening (OR=5.4054, $p<0.001$). Univariate analysis revealed that incidences of 'any prosthesis-related complications' were markedly high in the THA group, while multivariate analysis did not yield a significant difference.

Other complications after THA/HRA during hospitalization

Detailed data are shown in Table 4. Incidences of most complications after THA were higher than after HRA except nerve injury of lower limb, of which acute posthemorrhagic anemia, blood transfusion, pneumonia, acute renal failure and urinary tract infection exhibited significant differences. Moreover, multivariable analysis did not reveal significant differences in most of the complications. Unexpectedly, the HRA group had a higher OR (OR 1.2985, $p<0.001$) for 'any common complications' while a significant lower incidence was found in univariate analyses (26.02% vs. 37.09%, $p<0.001$).

Discussion

This study performed a large-scale analysis of in-hospital complications after THA and HRA. It is worth noting that this data represents the NIS and may not represent the surgical population as a whole.

Table 1 Demographic data of the patients who underwent Elective THA and HRA

Parameter	THA	HRA	p
Age (yrs.)	65	52	< 0.0001
Age group (%)			
0–20	0.14	0.31	< 0.0001
21–40	2.85	9.48	< 0.0001
41–60	32.59	77.94	< 0.0001
61–80	54.48	12.17	< 0.0001
≥ 81	9.94	0.09	< 0.0001
Sex (% female)	55.48	20.43	< 0.0001
Race (%)			
White	86.62	88.9	< 0.0001
Black	6.99	5.15	< 0.0001
Hispanic	3.16	2.58	< 0.0001
Asian or Pacific Islander	0.91	0.41	< 0.0001
Native American	0.31	0.17	< 0.0001
Other	2.01	2.79	< 0.0001
Charlson Comorbidity Index	3(2–4)	2(1–2)	< 0.0001
length of stay (d)	3(2–4)	3(2–3)	< 0.0001
Total charges ($)	43,802 (32,423–60,292)	47873.5 (35959.75-65693.25)	< 0.0001
In-hospital mortality (%)	0.09	0.01	0.0132
Payment type (%)			
Medicare	51.63	5.72	< 0.0001
Medicaid	3.5	1.6	< 0.0001
Private insurance	41.57	87.96	< 0.0001
Self-pay	0.73	0.91	< 0.0001
No charge	0.13	0.06	< 0.0001
Other	2.44	3.74	< 0.0001
Hospital location (% Urban)	90.42	96.23	< 0.0001
Bed size(%)			
Small	18.86	26.63	< 0.0001
Medium	24.86	20.83	< 0.0001
Large	56.28	52.54	< 0.0001

Table 2 Diagnosis of the patients who underwent Elective THA and HRA

Diagnosis (%)	THA	HRA	p
Osteoarthritis	90.13	95.25	< 0.0001
Hip dysplasia	0.05	0.03	0.6372
Avascular necrosis of Femoral head	6.44	3.09	< 0.0001
Traumatic arthritis	0.7	0.57	0.1465
Fracture	0.54	0.01	< 0.0001
Rheumatoid arthritis	0.54	0.16	< 0.0001
Ankylosing spondylitis	0.01	0.03	0.18
Other	1.59	0.85	< 0.0001

Table 3 Prevalence of Comorbidities in Patients who underwent Elective THA and HRA

Comorbidities (%)	THA	HRA	p
Acquired immunodeficiency syndrome	0.14	0.08	0.1684
Alcohol abuse	1.54	1.23	0.0165
Deficiency anemias	13.49	8.38	< 0.0001
Arrhythmia	3.75	1.01	< 0.0001
Chronic blood loss anemia	1.81	2.18	0.0077
Congestive heart failure	2.37	0.19	< 0.0001
Chronic pulmonary disease	13.84	6.51	< 0.0001
Coagulopathy	2.01	2.04	0.8669
Depression	10.59	7.29	< 0.0001
Diabetes uncomplicated	13.02	4.15	< 0.0001
Diabetes with chronic complications	1.11	0.19	< 0.0001
Drug abuse	0.67	0.61	0.4825
Hypertension	58.8	30.41	< 0.0001
Hypothyroidism	12.97	5.2	< 0.0001
Liver disease	0.98	0.67	0.0021
Lymphoma	0.34	0.12	0.0004
Fluid and electrolyte disorders	8.03	3.98	< 0.0001
Metastatic cancer	0.13	0.05	0.0415
Other neurologic disorders	3.21	1.17	< 0.0001
Obesity	14.6	10.77	< 0.0001
Paralysis	0.32	0.09	0.0001
Peripheral vascular disorders	2.16	0.41	< 0.0001
Psychoses	1.71	0.92	< 0.0001
Pulmonary circulation disorders	0.7	0.18	< 0.0001
Renal failure	3.5	0.53	< 0.0001
Solid tumor without metastasis	0.51	0.14	< 0.0001
Peptic ulcer disease excluding bleeding	0.02	0	0.4295
Valvular disease	3.78	1.86	< 0.0001
Weight loss	0.38	0.13	0.0001

From the year 2005 to 2014, the popularity of HRA gradually reduced. At its peak in 2008, HRA was used in 3.8% of hip arthroplasty cases. This proportion was lower compared to other studies. In England and Wales, HRA accounted for 10% of all primary total hip replacements in 2006 [16]. However, the decreasing trend is in line with reports from previous studies [17, 18]. In the past few years, several influential commentaries have even called for abolition of HRA prosthesis [19, 20]. Recent reports on resurgent use of HRA in elite sports people and the possibility to return to elite-level sporting activities have led to an increased interest from patients [21].

We found that patients who underwent HRA were significantly younger, which may be attributed to the poor long-term implant survival rate and difficulty in revision of THA [22]. In contrast, HRA is bone-preserving and therefore, potentially easy to revise [23]. There was a significant male preponderance in the HRA group. Generally, compared to female patients, male patients had larger diameters of femoral heads. A larger femoral head diameter improves the head-to-neck ratio and increases the range of motions without prosthetic impingement

Table 4 In-hospital Postoperative Complications Associated with Patients who underwent Elective THA and HRA

Complication	THA	HRA	p	OR [a]	95% CI [b]
Prosthesis-related complications					
Dislocation	1088(0.2%)	16(0.16%)	0.47	0.97	0.38–2.53
Periprosthetic fracture	554(0.1%)	4(0.04%)	0.08	0.63	0.13–3.13
Periprosthetic joint infection	905(0.17%)	13(0.13%)	0.47	2.11	0.77–5.75
Prosthesis loosening	455(0.08%)	17(0.17%)	0.005	5.41	2.13–13.71
Revision arthroplasty	6179(1.15%)	52(0.53%)	< 0.001	1.30	0.54–3.11
Other prosthesis-related complications	1670(0.31%)	27(0.28%)	0.62	1.59	0.86–2.92
Any prosthesis-related complication [c]	9485(1.76%)	99(1.02%)	< 0.001	0.54	0.22–1.30
Other common complications					
Postoperative shock	446(0.08%)	3(0.03%)	0.11	1.08	0.26–4.49
Acute posthemorrhagic anemia	132,010(24.56%)	1813(18.61%)	< 0.001	0.86	0.75–0.98
Blood transfusion	103,639(19.28%)	1024(10.51%)	< 0.001	0.84	0.74–1.04
Deep vein thrombosis	967(0.18%)	7(0.07%)	0.02	0.47	0.17–1.28
Pulmonary embolism	892(0.17%)	8(0.08%)	0.06	1.27	0.50–3.21
Acute cerebrovascular disease	561(0.1%)	2(0.02%)	0.016	0.96	0.23–3.98
Pneumonia	2284(0.42%)	2(0.02%)	< 0.001	0.16	0.03–0.64
Acute renal failure	8658(1.61%)	41(0.42%)	< 0.001	0.77	0.54–1.08
Urinary tract infection	15,040(2.8%)	74(0.76%)	< 0.001	0.62	0.47–0.82
Nerve injury of lower limb	237(0.04%)	11(0.11%)	0.0054	2.71	1.33–5.51
Wound dehiscence and infection	4833(0.9%)	68(0.7%)	0.042	0.97	0.72–1.31
Wound debridement	690(0.13%)	7(0.07%)	0.16	0.46	0.18–1.17
Mortality	491(0.09%)	1(0.01%)	0.01	0.45	0.06–3.63
Any common complications [d]	199,299(37.09%)	2535(26.02%)	< 0.001	1.30	1.12–1.50

[a] CI, Confidence Interval

[b] OR, Odds Ratio

[c, d] Any prosthesis-related complication or any common complications: patients with more than one complication were counted only once

[24], resulting in better implant survival rates [18]. Moreover, women have an increased risk of osteoporotic fractures of the femoral neck or a greater predisposition to reactions to metal debris [25].

The importance of patient selection for HRA has been reported [3, 4, 26–28]. In this study, we found that only less than 5% of patients that underwent HRA was not due to osteoarthritis. Hip dysplasia is an independent risk factor for failure following HRA [29]. Osteonecrosis of the femoral head may result in aseptic loosening and femoral neck narrowing secondary to osteonecrosis progression after HRA [30]. Robert Sershon et al. [3] reported femoral neck fractures and aseptic loosening as the two most common long-term complications and modes of failure in FDA-approved HRA. In previous studies, incidences of short- and middle-term prosthesis-related complications between the two operations were comparable. Ran Tao et al. [31] followed 68 patients that had been subjected to HRA or THA for a period of at least 5 years. They found that differences in major complications, including loosening, fractures, dislocations, infections, and adverse reactions to the metal debris (ARMD) were insignificant between the groups. After prospective follow up for 2 to 4 years, Vincent Fowble et al. [32] compared 50 metal-metal resurfacing replacements with 44 conventional total hip arthroplasties. There were no significant differences in major postoperative complications between the treatments. However, in our study, there were higher incidences of prosthesis loosening during hospitalization after HRA (0.08% vs. 0.17%, $p=0.0048$). Moreover, HRA was associated with significantly higher OR (OR = 5.4054, $p<0.001$) for prosthesis loosening. Rigorous patient selection criteria for clinical studies may be one of the reasons, which led to better outcomes after HRA. The risk of prosthesis loosening after HRA should be investigated further.

Intraoperative bleeding is one of the major challenges after THA [33–35]. It has been reported that since it preserves a relatively intact femur medullary cavity, HRA can effectively reduce bleeding [36]. In this study, incidences of acute hemorrhagic anemia (24.56% vs. 18.6%, $p<0.001$) and blood transfusion (19.28% vs. 10.51%, $p<0.001$) after HRA were markedly lower, but lost their statistical significance in multivariate analysis. These findings suggest that bleeding outcomes after THA may be attributed to poorer basic conditions of THA patients. Similar postulates were applied to other complications. We found that HRA had higher ORs for 'any common complications' while it exhibited significant lower rates in univariate analyses.

Patient demographic characteristics in this study were comparable to those reported in prior studies. Nevertheless, this study suggests a higher risk of in-hospital complications, such as prosthesis loosening after HRA.

Under the premise of fewer comorbidities in patients who underwent HRA, their total charges were higher. Considering the various long-term complications of HRA that have been previously reported, studies should be performed to clarify the indications of HRA.

However, a number of limitations remained associated with the present study. Firstly, the details of arthroplasty including surgery duration, head size, acetabular inclination angle and prosthesis type were not included in the NIS database. These factors influenced the final operative outcomes and could be potential confounders. Secondly, diagnosis of each patient was only recorded before hospital discharge and could not be distinguished from those diagnosis before admission. Therefore, the analysis of common complications might be imprecise, because these symptoms might already exist before surgery. Furthermore, as with any large database, there might be discrepancy or misclassification in coding and documentation. Thus, administrative data tend to have high specificity (low false positive rate) but low sensitivity (high false-negative rate) in identifying adverse events, which might also underestimate the incidence of each complication [37].

Conclusions

In conclusion, HRA is a less common but effective alternative method to THA for hip reconstruction. The popularity of HRA gradually reduced from the year 2005 to 2014. Patients who underwent HRA were more likely to be younger, male, have less comorbidity and spent more on medical costs. The risk of in-hospital prosthesis loosening after HRA was higher. The advantages of HRA in most in-hospital complications were comparable to those of THA. On the contrary, HRA showed higher risks for some common complications. In-hospital complications of HRA deserve more attention from surgeons.

Abbreviations

THA	Total hip arthroplasty
HRA	Hip resurfacing arthroplasty
NIS	Nationwide Inpatient Sample
ICD-9-CM	International Classification of Diseases (ninth revision) Clinical Modification
CCI	Charlson Comorbidity Index
OR	Odds ratio
CI	Confidence interval.

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Author contributions

SY and QY contributed to the study design, data acquisition and analysis, interpretation of results, and writing and revising the manuscript. YH and ZW contributed to the interpretation of results and revising the manuscript. ZP contributed to data acquisition, data analysis, and reviewing of the manuscript. YZ and ZS contributed to the study design, interpretation of results, and reviewing the manuscript. All authors read and approved the final manuscript.

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Data availability

This study is based on data provided by Nationwide Inpatient Sample (NIS) database, part of the Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality. The NIS database is a large publicly available all-payer inpatient care database in the United States. Therefore, individual or grouped data cannot be shared by the authors. Links to the database are as follows: https://www.hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp.

Declarations

Competing interests

The authors declare that they have no competing interests.

Ethics approval and consent to participate

This article does not contain any studies with human participants or animals performed by any of the authors. This observational study was deemed exempt by the Ethics Committee of Nanfang Hospital of Southern Medical University that waived the need for consent because it used deidentified publicly available data.

Consent for publication

Not applicable.

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