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ORIGINAL ARTICLE

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Differences in activities of daily living after hip arthroplasty among hip resurfacing, anterolateral THA, and posterolateral THA: a propensity score matched analysis

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Abstract

The aim was to elucidate the differences in activities of daily living (ADL) after hip arthroplasty among hip resurfacing (HRA), anterolateral total hip arthroplasty (AL-THA), and posterolateral THA (PL-THA) patients after age, sex, body mass index, bilateral/unilateral hip arthroplasty, and postoperative duration were matched using propensity scores. A total of 673 hips from 540 consecutive patients who underwent hip arthroplasty were included. A self-completed questionnaire on preoperative and postoperative ADLs was administered during postsurgical visits at least ≥ 4 years postoperatively. Between HRA and PL-THA patients, the numbers of patients who performed heels-down squatting was significantly more in HRA than in PL-THA. Between AL-THA and PL-THA patients, there were significant differences in postoperative ADLs including bathing in a bathtub, riding on a train/bus, cutting toenails, bowing while straight sitting, heels-up/down squatting, riding on a bicycle, driving a car, and domestic travel. There were no significant differences in postoperative ADLs between ≥ 36 mm head and ≤ 32 mm head PL-THA patients, and between AL-THA and HRA patients. This propensity score matched study indicated that AL-THA and HRA patients were more active postoperatively than PL-THA patients.

Keywords Activities of daily living · Total hip arthroplasty · Hip resurfacing · Anterolateral (modified Watson-Jones) approach · Posterolateral approach

Introduction

Long-term pain relief and improved hip function are the outcomes of successful total hip arthroplasty (THA) [1, 2]. Evaluation is generally performed for common activities of daily living (ADL) after THA, which are represented by 17 physical function items in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) [3] including descending and ascending stairs, rising for sitting, standing, bending to the floor, walking on a flat surface, getting in/out of a car, going shopping, putting on socks/stockings, rising for a bed, taking off socks/stockings, lying in a bed, getting in/out of a bath, sitting, getting on/off a toilet seat, and performing heavy/light domestic duties. However, it is not clear how many patients perform "advanced" activities after THA, those need a high range of motion of the hip joint, such as heels-down squatting [4] or bowing while straight sitting [5].

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Recent advances in implant design and materials might decrease concerns about reduced longevity after THA if cup and stem alignment is controlled within a specific safe zone [6]. Moreover, accurate cup and stem placement in the safe zone could render imposing restrictions on some routine activities unnecessary after THA. Cup placement during THA is reportedly more accurate with computed tomography (CT)-based navigation than with a mechanical jig [7, 8]. CT-based navigation can help eliminate cup mal-alignment and minimize restrictions on routine activities that require deep hip flexion or extension [9], which can possibly help patients perform ADLs after THA [10]. Although modern hip arthroplasty with a large femoral head and a CT-based navigation system is expected to improve ADLs, including advanced ADLs after THA, this trend has not been reported in detail with a focus on the postoperative ADLs. Additionally, few reports have compared postoperative ADL among surgical approaches [11–13].

The present study aimed to compare postoperative ADLs (1) between posterolateral THA (PL-THA) and hip resurfacing arthroplasty (HRA), (2) between ≥ 36 mm head and ≤ 32 mm head PL-THA patients, (3) between anterolateral THA (modified Watson-Jones [14], AL-THA) and PL-THA, and (4) between AL-THA and HRA using propensity score matching to clarify whether postoperative ADLs after hip arthroplasty are related with the arthroplasty type or with the surgical approach. Additionally, the present study investigated why patients avoid postoperative ADLs.

Materials and methods

The present study included 673 hips from 540 consecutive patients (83 male and 457 female patients) who underwent primary CT-based navigation THA between January 2005 and May 2011 at our institution and a related hospital. All patients answered a self-completed questionnaire during routine hospital visits, for at least ≥ 4 years postoperatively. The mean age was 62 years (range 26–98 years), and the mean body mass index (BMI) was 23.1 kg/m^2 (range 15–41 kg/m^2). The mean postoperative follow-up duration was 7 years (range 4–12 years). Of the 540 patients, 133 underwent bilateral arthroplasties and 407 underwent unilateral arthroplasty. HRA was performed through the posterolateral approach in 95 hips from 79 patients, and conventional THA was performed in 578 hips from 461 patients. A PL-approach was used in 363 patients and an AL approach was used in 98 patients. Patients who underwent bilateral THA with one THA and one HRA, or one PL-THA and one AL-THA, were excluded from the present study. All subjects enrolled in this research have given their informed consent, which has been approved by my institutional committee on human research, and this protocol has been found acceptable by them (no. 12300).

A CT-based navigation system (CT-Hip; Stryker, Mahwah, NJ) was used in all surgical procedures, and all acetabular components were fixed without cement. Birmingham Hip Resurfacing (Smith & Nephew, Warwick, UK) was used in 33 hips, and Adept (Finsbury Orthopaedics, Leatherhead, UK) was used in 62 hips undergoing HRA. The femoral component diameter in HRA was ≥ 40 mm. As a conventional THA acetabular component, Trident HA cup (Stryker Orthopaedics, Cork, Ireland) was mainly implanted. With regard to the conventional THA femoral component, cementless anatomical stems (Centpillar, Stryker Orthopaedics, Cork, Ireland) were mainly implanted. Metal-on-metal bearing articulations were used in 120 hips from 103 patients, ceramic-on-ceramic bearing articulations were used in 24 hips from 22 patients, and metal-on-polyethylene or ceramic-on-polyethylene bearing articulations were used in 529 hips from 415 patients. All polyethylene liners were made of highly cross-linked polyethylene.

We asked all patients questions concerning preoperative and postoperative ADLs for 11 items listed in a self-completed questionnaire including "advanced" ADL; bathing in a bathtub, riding on a train/bus, cutting toenails, straight sitting, bowing while straight sitting, heels-up squatting, heels-down squatting, riding on a bicycle, driving a car, domestic travel, and overseas trip. Generally we allowed patients who perform "advanced" daily activities at 1–3 months postoperatively; however, some patients were prohibited from performing activities to prevent dislocation. The number of preoperative and postoperative activities performed was recorded. After matching age, sex, BMI, bilateral/unilateral hip surgery, and postoperative duration using propensity scores, we compared preoperative and postoperative ADLs rates between HRA and PL-THA patients, between ≥ 36 mm head and ≤ 32 mm head PL-THA patients, between AL-THA and PL-THA patients, and between HRA and AL-THA patients. Additionally, we asked patients why they did not perform each postoperative activity. They selected a response from among the following options; reason 1 attempted to perform the concerned activity but could not because of hip conditions; reason 2 could not perform the concerned activity because of poor conditions except for those involving the hip joint; reason 3 wanted to perform the concerned activity, but could not because of anxiety; reason 4 was not allowed to perform the concerned activity by the surgeon, and reason 5 had no interest in the concerned activity.

As assessment of common ADL after THA, the WOMAC self-assessment questionnaire [3] and the University of California, Los Angeles (UCLA) activity scale [15] were administered when the self-completed questionnaire was answered. The WOMAC questionnaire consists

of a total score and three subscale scores for pain, stiffness, and physical function. The subscale scores range from 0 to 20, 0 to 8, and 0 to 68, respectively. Using the WOMAC questionnaire, the score obtained for an asymptomatic patient is 0, and the worst score is 96. The UCLA activity score ranges from 0 to 10.

Statistical analysis

After matching age, sex, BMI, bilateral/unilateral hip surgery, and postoperative duration using propensity scores, the Chi-square test was used for comparison of preoperative and postoperative ADL rates. The Wilcoxon test was used to compare the WOMAC score and UCLA activity score for each group. All statistical analysis were performed using JMP pro13 (SAS Institute Inc., Cary, NC) and SPSS version 20.0J for Windows (IBM Corp., Armonk, NY). Significance was established at a p value < 0.05.

Results

Postoperatively, all patients could perform activities that they performed preoperatively. There were no significant differences in all preoperative/postoperative activities between bilateral patients and unilateral patients, but concerning the number of postoperative straight sitting: bilateral patients were significantly greater than unilateral patients (bilateral: 82.0% vs unilateral: 72.5%, $p = 0.029$). After matching age, sex, BMI, bilateral/unilateral hip surgery, and postoperative duration using propensity scores, there were no significant differences in diagnosis, osteoarthritis and osteonecrosis, in each comparison. On comparing postoperative activities between HRA patients ($n = 68$) and PL-THA patients ($n = 68$) using propensity score matching, there were significant differences in the numbers of patients who performed heels-down squatting (HRA vs PL-THA: 50 (74%) vs 37 (54%), $p = 0.02$) (Table 1). On the other hand, there were no significant differences in the postoperative WOMAC score (HRA vs PL-THA: 6.7 ± 11.0 vs 7.9 ± 11.1, $p = 0.46$) and

Table 1 Preoperative and postoperative activities between HRA patients and PL-THA patients

Hip arthroplasty	Preoperative			Postoperative		
	HRA	PL-THA	p value	HRA	PL-THA	p value
Patients	68	68		68	68	
Age (years)	55.2 ± 2	55.9 ± 11.6	0.444			
Gender (female/male, patients)	46/22	45/23	0.855			
BMI (kg/m^2)	23.0 ± 3.6	23.6 ± 3.5	0.391			
Diseases (OA/ON, patients)	57/11	53/15	0.513			
Bilateral/unilateral (patients)				14/54	11/57	0.507
Postoperative duration (years)				7.0 ± 1.6	6.9 ± 1.8	0.639
Activities of daily living (% of the number of patients)						
Bathing in a bathtub	87	85	0.805	99	97	0.559
Riding on train/bus	79	81	0.83	97	93	0.244
Cutting toenails	56	65	0.293	91	90	0.771
Straight sitting	59	57	0.862	82	71	0.106
Bowing while straight sitting	50	46	0.607	75	66	0.259
Heels-up squatting	53	53	1	82	78	0.519
Heels-down squatting	40	34	0.477	74	54	0.020*
Reason 1/2/3/4/5[a]				28/22/6/0/44	23/10/3/3/61	0.559
Riding on a bicycle	59	49	0.229	68	62	0.473
Driving a car	65	60	0.595	74	68	0.452
Domestic travel	72	80	0.428	81	85	0.493
Overseas trip	40	44	0.602	41	32	0.286

OA osteoarthritis of the hip, *ON* osteonecrosis of the femoral head, *HRA* hip resurfacing arthroplasty, *PL* posterolateral, *THA* conventional total hip arthroplasty

*The significance existed ($p < 0.05$)

[a]Reasons why the patients did not do the concerned postoperative activity: (1) attempted to perform the concerned activity but could not because of hip conditions; (2) could not perform the concerned activity because of poor conditions except for those involving the hip joint; (3) wanted to perform the concerned activity but could not because of anxiety; (4) was not allowed to perform the concerned activity by the surgeon; (5) had no interest in the concerned activity

UCLA score (7.9 ± 2.1 vs 7.5 ± 2.2, $p = 0.302$). Additionally, there were no significant differences in the reasons why patients did not perform heels-down squatting.

On comparing ≥ 36 mm head ($n = 68$) and ≤ 32 mm head ($n = 68$) PL-THA patients using propensity score matching, there were no significant differences in postoperative ADLs, the postoperative WOMAC score (≥ 36 mm vs ≤ 32 mm: 11.3 ± 13.1 vs 10.3 ± 14.2, $p = 0.427$), and the UCLA score (6.1 ± 2.4 vs 6.3 ± 2.6, $p = 0.687$) (Table 2).

On comparing postoperative activities between AL-THA patients ($n = 96$) and PL-THA patients ($n = 96$) using propensity score matching, there were significant differences in the numbers of patients who performed activities, including bathing in a bathtub, riding on a train/bus, cutting toenails, heels-up squatting, lying on the floor, bowing while straight sitting, heels-down squatting, riding on a bicycle, driving a car, and domestic travel (Table 3). Additionally, there were significant differences in the postoperative WOMAC score (AL-THA vs PL-THA: 4.6 ± 7.4 vs 10.6 ± 15.6, $p = 0.009$) and the UCLA score (7.2 ± 2.2 vs 6.3 ± 2.5, $p = 0.017$). On the other hand, there were no significant differences in the reasons why the patients did not perform activities.

On comparing HRA patients ($n = 45$) and AL-THA patients ($n = 45$) using propensity score matching, there were no significant differences in all postoperative ADLs, the WOMAC score (HRA vs AL-THA: 7.3 ± 12.9 vs 3.5 ± 7.3, $p = 0.113$) and the UCLA score (7.6 ± 2.1 vs 7.3 ± 2.0, $p = 0.287$) (Table 4).

Discussion

In this study, postoperative ADLs after hip arthroplasty depend on the arthroplasty type and the surgical approach. This propensity score matched analysis indicated that AL-THA and HRA patients were more active postoperatively than PL-THA patients, although there were no differences between ≥ 36 mm head patients and ≤ 32 mm head PL-THA patients, and between AL-THA and HRA patients.

A CT-based navigation system can help eliminate cup mal-alignment that could cause impingement-related complications. Ideal cup alignment should minimize restrictions on routine activities that require deep hip flexion or extension [9], and should possibly help patients perform ADLs after THA [10] and reduce the need to restrict hip ROM after THA [7–9, 16–18]. Patients who undergo THA using CT-based navigation might theoretically be able to increase their postoperative activity levels if there are no postoperative complications. Postoperatively, all patients could perform the activities that they performed preoperatively, and postoperative ADLs after hip arthroplasty improved under ideal cup alignment in the present study.

Table 2 Preoperative and postoperative activities between ≥ 36 mm head and ≤ 32 mm head patients in PL-THA

Head diameter	Preoperative			Postoperative		
	≥ 36 mm	≤ 32 mm	*p* value	≥ 36 mm	≤ 32 mm	*p* value
Patients	68	68		68	68	
Age (years)	65.1 ± 12.7	66.8 ± 9.5	0.82			
Gender (female/male, patients)	58/10	58/10	1			
BMI (kg/m^2)	22.9 ± 4.4	22.8 ± 3.2	0.35			
Diseases (OA/ON, patients)	60/8	62/6	0.778			
Bilateral/unilateral (patients)			18/50		13/55	0.307
Postoperative duration (years)			7.1 ± 1.5		7.2 ± 1.4	0.26
Activities of daily living (% of the number of patients)						
Bathing in a bathtub	69	85	0.025*	88	96	0.116
Riding on train/bus	66	81	0.052	84	84	1
Cutting toenails	57	60	0.121	84	84	1
Straight sitting	47	62	0.085	71	66	0.58
Bowing while straight sitting	38	49	0.226	66	60	0.477
Heels-up squatting	21	31	0.038*	43	49	0.714
Heels-down squatting	21	31	0.17	43	49	0.491
Riding on a bicycle	25	41	0.045*	40	44	0.602
Driving a car	44	29	0.075	37	32	0.589
Domestic travel	56	75	0.019*	63	72	0.271
Overseas trip	22	38	0.04*	16	25	0.203

OA osteoarthritis of the hip, *ON* osteonecrosis of the femoral head, *PL* posterolateral, *THA* conventional total hip arthroplasty

*The significance existed ($p < 0.05$)

Table 3 Preoperative and postoperative activities between AL-THA and PL-THA patients

Approach	Preoperative			Postoperative		
	AL-THA	PL-THA	*p* value	AL-THA	PL-THA	*p* value
Patients	96	96		96	96	
Age (years)	62.2 ± 10.8	61.3 ± 10.7	0.311			
Gender (female/male, patients)	92/4	92/4	1			
BMI (kg/m^2)	23.5 ± 4.2	23.7 ± 4.3	0.932			
Diseases (OA/ON, patients)	89/7	91/5	0.767			
Bilateral/unilateral (patients)				17/79	21/75	0.469
Postoperative duration (years)				7.2 ± 1.1	7.2 ± 1.4	0.382
Activities of daily living (% of the number of patients)						
Bathing in a bathtub	84	74	0.699	100	93	0.007*
Reason 1/2/3/4/5[a]					14/43/14/0/29	–
Riding on train/bus	76	79	0.604	96	85	0.013*
Reason 1/2/3/4/5[a]				0/0/25/0/75	0/21/29/0/50	0.543
Cutting toenails	49	58	0.193	94	83	0.024*
Reason 1/2/3/4/5[a]				18/46/0/0/36	56/31/0/0/13	0.1
Straight sitting	57	65	0.301	82	71	0.061
Bowing while straight sitting	45	48	0.664	81	65	0.009*
Reason 1/2/3/4/5[a]				6/55/11/6/22	24/29/9/6/32	0.311
Heels-up squatting	40	46	0.381	89	70	0.001*
Reason 1/2/3/4/5[a]				37/18/27/0/18	28/35/10/10/17	0.466
Heels-down squatting	40	30	0.173	73	52	0.003*
Reason 1/2/3/4/5[a]				19/19/15/0/47	24/11/7/7/51	0.385
Riding on a bicycle	45	45	1	65	47	0.014*
Reason 1/2/3/4/5[a]				8/12/35/2/43	8/8/24/2/58	0.674
Driving a car	54	43	0.112	58	42	0.021*
Reason 1/2/3/4/5[a]				0/2/2/0/96	2/5/2/2/89	0.731
Domestic travel	72	71	0.873	86	63	0.0001*
Reason 1/2/3/4/5[a]				15/32/15/0/38	3/9/17/0/71	0.064
Overseas trip	33	34	0.879	33	22	0.076
Reason 1/2/3/4/5[a]				3/6/13/0/78	4/4/8/0/84	0.714

OA osteoarthritis of the hip, *ON* osteonecrosis of the femoral head, *AL* anterolateral, *PL* posterolateral, *THA* conventional total hip arthroplasty

*The significance existed ($p < 0.05$)

[a]Reasons why the patients did not do the concerned postoperative activity: (1) attempted to perform the concerned activity but could not because of hip conditions; (2) could not perform the concerned activity because of poor conditions except for those involving the hip joint; (3) wanted to perform the concerned activity but could not because of anxiety; (4) was not allowed to perform the concerned activity by the surgeon; (5) had no interest in the concerned activity

On comparing postoperative activities between HRA and PL-THA patients, although there were no significant differences in postoperative UCLA and WOMAC score with regard to common ADLs and same postoperative UCLA score as other reports of HRA [19], there were significant differences in the numbers of patients who performed heels-down squatting which requires deep hip bending. A large femoral head diameter in HRA (≥ 40 mm) acquired a larger range of motion of the hip joint under the same PL-approach, although there were no significant differences in postoperative ADLs between ≥ 36 mm head (36 mm, 40 mm) patients and ≤ 32 mm head (28 mm, 32 mm) PL-THA patients. As previous reports indicated that age influences on the postoperative QOL and younger patients gain more function postoperatively than older patients [20], age may affect these results using propensity score matching; average age was 55–56 years on comparing between HRA and PL-THA patients, and average age was 65–67 years on comparing between ≥ 36 mm head patients and ≤ 32 mm head PL-THA patients.

On comparing postoperative activities between AL-THA and PL-THA patients, there were significant differences in the postoperative UCLA and WOMAC scores with regard to common ADLs. Although it has been reported that

Table 4 Preoperative and postoperative activities between HRA patients and AL-THA patients

Hip arthroplasty	Preoperative			Postoperative		
	HRA	AL-THA	*p* value	HRA	AL-THA	*p* value
Patients	45	45		45	45	
Age (years)	58.8 ± 10.4	57.6 ± 10.7	0.965			
Gender (female/male, patients)	40/5	41/4	0.725			
BMI (kg/m^2)	22.7 ± 3.4	23.3 ± 4.5	0.49			
Diseases (OA/ON, patients)	42/3	43/2	0.999			
Bilateral/unilateral (patients)				10/35	12/33	0.624
Postoperative duration (years)				7.7 ± 1.4	7.6 ± 1.2	0.912
Activities of daily living (% of the number of patients)						
Bathing in a bathtub	53	44	0.399	73	82	0.311
Riding on train/bus	80	76	0.612	96	98	0.557
Cutting toenails	56	51	0.673	91	96	0.398
Straight sitting	71	64	0.499	96	98	0.557
Bowing while straight sitting	67	62	0.66	80	84	0.581
Heels-up squatting	58	40	0.092	82	93	0.108
Heels-down squatting	42	49	0.525	76	76	1
Riding on a bicycle	56	47	0.399	62	64	0.827
Driving a car	60	69	0.378	62	71	0.371
Domestic travel	78	71	0.468	80	91	0.134
Overseas trip	38	36	0.827	38	44	0.52

OA osteoarthritis of the hip, *ON* osteonecrosis of the femoral head, *HRA* hip resurfacing arthroplasty, *AL* anterolateral, *THA* conventional total hip arthroplasty

there were no differences in ordinary daily physical activity between THA patients undergoing different surgical approaches on days 1–4 after discharge [13], and that there are no significant differences in the first year patient-reported function comparing between direct-anterior approach and posterior approach [12], there were significant differences in the numbers of patients who performed "advanced" ADLs in this study. The reason of these differences may be due to the different approach, and questionnaire time, within the first year in the previous report and ≥ 4 year in the present study. Another report indicated that at least 1 year required for the average hip osteoarthritis patients to gain the full benefit of THA [20], and we evaluated postoperative QOL at ≥ 4 years because there were no reports concerning postoperative QOL evaluation at > 2 years postoperatively. On the other hand, Greidanus et al. reported that outcomes of MIS-AL-THA are not superior to those of minimally invasive direct lateral and PL-THA using 28 or 32 mm heads at ≥ 2 years postoperatively [21]. Although AL-THA keeps muscles sparing so that remaining short rotators muscles avoid bony/prosthetic impingement in deep hip flexion position, MIS-AL-THA might occur muscle damage.

There were no significant differences between AL-THA and HRA patients. The effectiveness of muscle sparing in AL-THA may be similar to the effectiveness of a large femoral head diameter (≥ 40 mm) for "advanced" postoperative ADLs that need a larger range of motion of the hip joint.

The present study has some limitations. First, the surgical indication for HRA, AL-THA, and PL-THA are not always randomized. To minimize the selection bias, we analyzed the results after matching age, sex, BMI, bilateral/unilateral hip surgery, and postoperative duration using propensity scores. Second, the male-to-female ratio in the present study was disproportionate (83 men and 457 women) and may not reflect the THA population in Western countries. However, acetabular dysplasia is more commonly seen in women in Japan, and osteoarthritis of the hip secondary to acetabular dysplasia occurs in approximately 90% of all patients of hip osteoarthritis [22]. We believe that this sample accurately reflects the THA population in Japan and there were no selection bias in consecutive patients series. Third, we administered a self-completed questionnaire about ADLs that patients usually perform and not ADLs that patients could perform, and we did not confirm whether patients could actually perform each ADL. Fourth, there was no HRA/THA group without navigation. To eliminate the influences of implant malposition, we compared patients using CT-based navigation system.

Conclusions

Comparisons with matching of age, sex, BMI, bilateral/unilateral arthroplasty, and postoperative duration using propensity scores showed that postoperative ADLs after hip

arthroplasty depend on the arthroplasty type and the surgical approach. This propensity score matched analysis indicated that AL-THA and HRA patients were more active postoperatively than PL-THA patients, although there were no differences between ≥ 36 mm head and ≤ 32 mm head PL-THA patients, and between AL-THA and HRA.

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Compliance with ethical standards

Conflict of interest Takashi Sakai, Hirohito Abe, Nobuo Nakamura, Hidetoshi Hamada, Masaki Takao, and Nobuhiko Sugano declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

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