Activities of daily living after total hip arthroplasty. Is a 32-mm femoral head superior to a 26-mm head for improving daily activities?

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Abstract Range of motion (ROM) of the hip joint after total hip arthroplasty (THA) could be increased by using a larger prosthetic femoral head, but it is not known whether the activities of daily living (ADL) are influenced by THA with different head sizes. Our objective was to compare postoperative ADL in patients who underwent THA using a head diameter of 26 mm or 32 mm. We assessed the range of motion and the mode of ADL after cementless primary THA. Comparison was performed between 25 joints of 24 patients who underwent THA with a 26-mm femoral head (26-mm group) and 24 joints of 20 patients with a 32-mm head (32-mm group). The postoperative range of flexion and abduction was significantly larger in the 32-mm group than in the 26-mm group. With respect to the mode of performing selected ADL such as putting on and removing pants, socks, and cutting toenails, many patients adopted the compensatory position of lumbar flexion with hip flexion plus knee extension in the 26-mm group, while a majority of the patients from the 32-mm group employed the mode of hip flexion with knee flexion. Patients with the 32-mm head showed better postoperative ADL of the ipsilateral side compared with the 26-mm head.

Introduction

Polyethylene wear and particle production are the main causes of periprosthetic osteolysis after total hip arthroplasty

(THA) [1]. Femoral head size has been known to influence such wear and larger head size might increase the amount of polyethylene particles [2–4]. However, it is now believed that the use of highly cross-linked polyethylene improves the wear behaviour even in combination with various femoral head sizes [5, 6]; therefore, larger femoral heads are considered as an option for THA. Among variables of the implant design that affect the motion of THA, larger femoral head or head neck ratio should increase the oscillation angle and the range of motion (ROM). Larger femoral head should also improve the stability of the joint because of an increase in the jump distance. Thus, the use of larger femoral head could potentially increase the functional ability of the hip joint after THA. However, little is known about the effect of the head size on the activities of daily living (ADL). We, therefore, investigated whether the ADL after THA was superior with a 32-mm diameter head than with a 26-mm head.

Patients and methods

Primary THA was performed on 65 joints of 59 patients using highly cross-linked polyethylene liners, Trilogy cementless acetabular cups and VerSys cementless stems (Zimmer, Warsaw, IN) from February 2002 to November 2005. Forty-nine joints of 44 patients who could be followed-up for 24 months or more were evaluated in this study. Sixteen joints of 15 patients with less than 120° of flexion of the ipsilateral knee joint or with limitation of ADL due to disorders of the upper extremities were excluded.

There were five males (six joints) and 39 females (43 joints). The preoperative diagnosis was osteoarthritis in 40 joints of 36 patients, rheumatoid arthritis (RA) in eight joints of seven patients, and necrosis of the femoral head in one

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joint. All operations were performed by two surgeons via a postero-lateral approach and used 26-mm or 32-mm prosthetic femoral heads at random. The neck taper of 6 degrees (9.5–11 taper) was identical in both prostheses.

When bony impingement was noted after insertion of the prosthetic joint, osteophytes were removed as required and the joint capsule was sutured posteriorly to the greater trochanter. The same postoperative protocol was applied to both groups. The 26-mm group comprised 25 joints of 24 patients with a body mass index (BMI) of 18.1–30.0 (mean 23.5) kg/m² and a follow-up period of 24–72 (mean 55.7) months. The 32-mm group comprised 24 joints of 20 patients with a BMI of 15.8–29.1 (mean 22.8) kg/m² and a follow-up period of 24–72 (mean 55.3) months. The number of RA was larger in the 32-mm group; however, there were no significant differences of background parameters between the two groups (Table 1).

Clinical results before and after surgery were evaluated with the Japanese Orthopaedic Association (JOA) hip score [7] which is based on pain (40%), ROM (20%), ability to walk (20%) and ADL (20%). The total score is 100 points for a normal hip. The ROM was measured by one of the authors (Y.I.) in a blinded manner with regard to the head size using a goniometer. Postoperative alignment of the cup on the X-ray film was measured according to the method of Lewinnek et al. [8]. In addition, selected activities of daily living (ADL) including the ability to put on and remove pants, socks, and to cut toenails were evaluated with attention to the actual mode of performing these activities. When implements or assistance was required during the selected ADL, patients were classified as being unable to perform that activity.

The Mann-Whitney test was used for statistical analysis of the JOA score and the range of hip joint motion before and after surgery, as well as the postoperative alignment of the cup. The chi-square test was used for analysis of ADL.

Table 1 Characteristics of the 26-mm and 32-mm prosthetic femoral head groups

Parameter	26-mm femoral head group	32-mm femoral head group
Number of patients	24	20
Number of hips	25	24
Male, <i>n</i> (%)	2 (8.3)	3 (15.0)
Female, <i>n</i> (%)	22 (91.7)	17 (85.0)
Age, mean ± SD (years)	62.6±12.7	65.1±10.4
Follow up, mean ± SD (months)	55.7±12.7	55.3±10.4
Body mass index, mean ± SD	23.5±3.6	22.8±4.1
Aetiology		
Osteoarthritis, <i>n</i> (%)	22 (88.0)	18 (75.0)
Rheumatoid arthritis, <i>n</i> (%)	2 (8.0)	6 (25.0)
Avascular necrosis, <i>n</i> (%)	1 (4.0)	0 (0)

Results

The mean preoperative JOA hip score of the 26-mm and 32-mm groups was 40.3 and 42.7, respectively. After surgery, JOA scores of both groups improved significantly to 84.7 and 88.9, respectively. There were no significant differences in preoperative scores between the two groups. However, postoperative scores of ROM and ADL were significantly better in the 32-mm group than those in the 26-mm group (Table 2).

The mean hip flexion angle did not differ between the two groups before surgery. After the operation, however, flexion was greater in the 32-mm group than in the 26-mm group, with the mean flexion angle being 88.8° in the 26-mm group and 97.5° in the 32-mm group. In addition, greater postoperative abduction angle was observed for the 32-mm group (mean abduction 35.6°) compared with the 26-mm group (mean abduction 29.4°). The range of external rotation did not differ between the two groups postoperatively.

With regard to the postoperative alignment of the cup, there was no significant difference between the two groups, with the mean cup inclination angle being 44.2° and 44.8° in the 26-mm and 32-mm groups, respectively, and the anteversion angle being 13.8° and 12.6°, respectively (Table 2).

Dislocation occurred in one joint of the 26-mm group, but did not happen in the 32-mm group. The patient with dislocation in the 26-mm group was a 77-year-old female with a long history of RA. Dislocation occurred while rising from a low chair with poor posture. The inclination and anteversion angles of the cup were 42.0° and 19.9°, respectively, in this patient and cup alignment was within the safe range according to the criteria of Lewinnek et al. [8].

In addition to the standard ADL included in the JOA scoring, we further evaluated selected activities that could be affected by hip ROM. Before surgery, 88% of the patients from the 26-mm group and 79.2% of the 32-mm group could put on and remove their pants. After THA, all patients from both groups could do so at the final follow-up. With regard to putting on and removing socks, 64.0% of the patients from the 26-mm group and 50.0% of the 32-mm group could accomplish this before surgery and the rate increased postoperatively to 92.0% and 95.8%, respectively. Cutting toenails could be performed by 52.0% of the patients from the 26-mm group and 45.8% of the 32-mm group before surgery, and the rate also increased postoperatively to 76.0% and 91.7%, respectively. The rate was higher in the 32-mm group, although there was no significant difference between the two groups (Table 3).

The majority of the patients could perform the above-mentioned activities after THA; however, detailed observation indicated that the patients performed the activities in three different modes: hip flexion plus knee flexion (pattern

Table 2 Comparison of clinical and radiographic results

Parameter	Before operation			Final follow-up		
	26-mm femoral head	32-mm femoral head	<i>P</i>	26-mm femoral head	32-mm femoral head	<i>P</i>
JOA hip score (points)						
Total score, mean±SD	40.3±10.8	42.7±9.6	0.542	84.7±5.9	88.9±5.8	0.025
Pain, mean ± SD	10.8±7.6	12.5±4.4	0.368	39.0±2.0	39.6±1.4	0.484
ROM, mean ± SD	13.1±3.7	13.5±2.7	0.897	15.7±1.5	17.2±1.3	0.002
Ability to walk, mean ± SD	7.2±2.5	6.9±2.9	0.78	15.0±3.6	15.0±3.0	0.96
ADL, mean ± SD	9.2±2.7	9.8±3.9	0.43	15.0±2.5	17.1±2.4	0.005
ROM (degrees)						
Flex, mean ± SD	81.4±20.4	82.5±18.5	0.976	88.8±5.6	97.5±7.4	0.0001
Abd, mean ± SD	19.4±7.9	20.2±7.4	0.976	29.4±7.1	35.6±8.3	0.012
ER, mean ± SD	23.1±10.8	22.7±14.1	0.967	37.0±12.1	38.9±15.5	0.78
Cup alignment (degrees)						
Inc angle, mean ± SD				44.2±6.9	44.8±4.2	0.412
Ant angle, mean ± SD				13.8±7.5	12.6±6.6	0.741

ROM range of motion, ADL activities of daily living, Flex flexion, Abd abduction, ER external rotation, Inc inclination, Ant anteversion, *P* values for parameters were determined using the Mann-Whitney test

A) (Fig. 1a), lumbar flexion with hip flexion plus knee extension (pattern B) (Fig. 1b), and hip extension plus knee flexion (pattern C) (Fig. 1c). Pattern A is similar to the normal mode of the lower extremities in healthy persons when putting on and removing pants and socks or cutting toenails, and pattern B or C is compensation mode for the hip motion. The pattern of activity used by the patients was divided into three categories, i.e., pattern A, pattern B or C, and inability, and the number of the joints that adopted the respective patterns was analysed with a contingency table. When putting on and removing pants, eight joints adopted pattern A and 17 joints fitted other patterns (pattern B or C) in the 26-mm group (Table 4). On the other hand, 19 and five joints adopted pattern A and other patterns in the 32-mm group, respectively. With respect to the action of putting on and removing socks, eight joints adopted pattern A and 15 adopted other patterns in the 26-mm group, while 19 and four joints adopted pattern A and other patterns in the 32-mm group, respectively. When cutting toenails, eight joints adopted pattern A and 11 adopted other patterns in

the 26-mm group, while 17 and five joints adopted pattern A and other patterns in the 32-mm group, respectively. The number of joints that followed pattern A was significantly greater in the 32-mm group than in the 26-mm group.

Discussion

This study indicated that the patients receiving THA with a 32-mm femoral head had slightly but significantly better postoperative ROM of the hip joint and showed better ADL and mode of selected activities compared to those of the patients with a 26-mm head.

The ROM of THA is known to be determined by two major factors: implant design variables (head/neck ratio, cup design, and oscillation angle) and the surgical orientation of the prosthetic components (cup inclination, cup anteversion, angle of femoral neck component from the horizontal plane, and femoral neck anteversion) [9]. Use of a larger femoral head provides an increase in the oscillation

Table 3 Comparison of abilities to dress and cut toenails

Parameter (selected ADL)	Before operation			Final follow-up		
	26-mm femoral head	32-mm femoral head	<i>P</i>	26-mm femoral head	32-mm femoral head	<i>P</i>
Putting on and removing pants, <i>n</i> (%)	22 (88.0)	19 (79.2)	0.464	25 (100)	24 (100)	-
Putting on and removing socks, <i>n</i> (%)	16 (64.0)	12 (50.0)	0.148	23 (92.0)	23 (95.8)	0.999
Cutting toenails, <i>n</i> (%)	13 (52.0)	11 (45.8)	0.572	19 (76.0)	22 (91.7)	0.138

ADL activities of daily living

Fig. 1 The actual mode of putting on and removing pants, socks, or cutting toenails, could be classified into three patterns. Pattern A was hip flexion plus knee flexion (**a**), pattern B was lumbar flexion with hip flexion plus knee extension (**b**), and pattern C was hip extension plus knee flexion (**c**)

angle. Although the size of the femoral head is related to the ROM of the hip, its relationship is not linear and there is a complex interplay between the angle of orientation of the femoral and acetabular components. An *in vitro* study by D'Lima et al. [10] indicated that the difference in flexion between 32-mm and 26-mm heads was about 10° when the inclination angle of the cup was 45° . According to the formula proposed by Yoshimine et al. [11], the angle of flexion is estimated to be 125° with a 26-mm head and 133° with a 32-mm head when the cup is set with an inclination angle of 45° and an anteversion angle of 20° , the stem with an anteversion angle of 20° , and the neck with a diameter of 12 mm. Using experimental models, Burroughs et al. [12] demonstrated that femoral heads larger than 32 mm provided greater ROM and elimination of component-to-component impingement. Thus, the larger femoral heads offer the potential of greater ROM.

The actual postoperative ROM could be less than the theoretical value regardless of the femoral head sizes because of the interposition of the soft tissues, scars, and bony impingement. In fact, the mean postoperative flexion

angle measured in our study was $37\text{--}38^\circ$ less than that of the theoretical value. Nevertheless, the 32-mm head group showed significantly greater hip flexion and abduction angle. This slight but important increase in the ROM should be related to the better mode of ADL in our study. It should be noted, however, that there may be little advantage in ROM by having a further large head size because the impingement for the heads as large as 36 mm and greater is no longer component-to-component impingement; rather, it is bone-on-bone impingement, which is dependent on the bony anatomy independent of head size [12].

As reported by Johnston et al. [13], hip flexion of 120° or more is needed for fastening shoelaces, although the action can be performed with much less flexion when abduction and external rotation are employed. They also stated that patients would generally rely on different modes by increasing motion in the knee or lumbar spine for fastening their shoelaces when hip joint flexion was 90° or less. In our study, patterns B and C for socks and toenail cutting were used by a larger number of patients in the 26-mm group, in which the mean hip flexion angle

Table 4 Contingency table of ADL at final follow-up

Mode pattern	Putting on and removing pants			Putting on and removing socks			Cutting toenails		
	26-mm femoral head	32-mm femoral head	<i>P</i>	26-mm femoral head	32-mm femoral head	<i>P</i>	26-mm femoral head	32-mm femoral head	<i>P</i>
Pattern A, <i>n</i>	8	19	0.004	8	19	0.004	8	17	0.024
Pattern B or C, <i>n</i>	17	5		15	4		11	5	
Inability, <i>n</i>	0	0		2	1		6	2	
Total, <i>n</i>	25	24		25	24		25	24	

ADL activities of daily living

P values were determined using the chi-square test

was 90° or less after surgery. On the other hand, the majority of the patients followed pattern A in the 32-mm group that had mean hip flexion angle of 97.5° after surgery. Therefore, it might be possible that the hip flexion angle of 90–95° is critical and slight improvement around this angle could significantly alter the mode of selected ADL.

In addition to the ROM, femoral head size is also known to influence dislocation. A larger head increases the jump distance of the components and improves the stability of the hip joint. The risk of postoperative dislocation should be lower with a large femoral head because of larger jump distance [14]. In our study, dislocation happened in only one joint from the 26-mm group and did not occur in the 32-mm group. This difference may have been due to an increase of the jump distance brought about by using a 32-mm head. Since the hip proprioception after THA is maintained by the extracapsular components such as tendons and muscles [15], increased jump distance at the extreme motion might also affect the protective position sense and joint stability.

In conclusion, a 32-mm head provided better functional mode and improvement of ADL as well as greater range of hip motion.

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