LACK OF SIGNIFICANT ASSOCIATIONS BETWEEN COMPONENT ALIGNMENT AND FUNCTIONAL OUTCOMES IN TOTAL HIP ARTHROPLASTY

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Abstract

Objective: To evaluate the functional outcome and hip range of motion (ROM) post total hip replacement (THR) associated with prosthesis orientation angle.

Methods: This cross sectional analytical study was conducted at the RSUPN Cipto Mangunkusumo Hospital, Jakarta, Indonesia from July to September 2014, selecting 38 subjects among 83 primary THR-treated through January 2008-May 2014. Patients were divided in two groups of safe and non-safe zones with at least six months postsurgery follow-up. Prosthesis orientation angle (acetabular abduction, acetabular anteversion, femoral anteversion and their combinations) were measured using AP and lateral radiographs. Functional outcomes were obtained from Harris Hip Score (HHS) and hip ROM, including Attahiyat praying position and squatting position.

Results: No significant differences were noted between prosthesis orientation angles in safe zone and non-safe zone groups compared with the HHS (p>0.05). No significant differences were observed between component orientation angles with the ROM, except on internal rotation at the safe zone (p=0.015). As many as 22.6% of hips had the ability to perform Attahiyat and squatting with more in the non-safe zone acetabular abduction group (p=0.035).

Conclusion: THR with prosthesis fixed in non-safe and safe zones of orientation gave similarly good functional outcomes. The non-safe zone of the acetabular abduction angle group showed more internal rotation range of motion. Patient's fears, habits and obesity status in performing such tasks were unable to be ruled out as confounders.

Keywords : Total hip replacement, Prosthesis component orientation, Functional outcome, Attahiyat position, Squatting position

J Southeast Asian Med Res 2018; 2(1): 28-36.
http://www.jseamed.org

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Introduction

Total hip replacement (THR) is one of the mainstays of therapy in the treatment of osteoarthritis or inflammatory pelvic disease that has been proven to relieve pain and increase both mobility and physical function of patients.(1-5) THR is exceedingly common and arguably one the most successful surgical procedures of modern time.(6-7) However, incorrect placement of THR implants and misalignments between the acetabulum components and femoral stem have been attributed to various complications, from ambulatory discomfort to hip osteolysis and secondary revisions.(8-17)

Many studies have been conducted to prove the effect of the THR prosthesis component orientation on various outcomes and complications represented by acetabular abduction and the anteversion and femoral anteversion angles or combinations. However, no studies have evaluated such parameters regarding patient's functional outcomes. We divided the patients according to Lewinnek (10) and Komeno(18) in safe and non-safe zones with the safe zone believed to present the least number of complications. Prosthetic component orientation, when tested with hip models, was proven to affect the hip's range of motion. We employed functional scoring using the Harris Hip Score (HHS) as an objective measure of THR outcomes. We also added the Attahiyat salat praying position and the squatting position as outcomes due to their specificity to the Indonesian population. This paper aimed to determine the effect of THR prosthesis component orientation on patient's functional outcomes.

Methods

This cross sectional analytical study was conducted at the Cipto Mangunkusumo Hospital (CMH), Jakarta, Indonesia from July to September 2014 and involved patients treated from January 2008 to May 2014. We obtained ethical approval from the Institutional Research Ethics Committee FKUI/RSCM (422/H2.F1/ETIK/2014).

Sample size was derived from two independent proportion difference test formula. Of 83 primary THR, 38 subjects were consecutively selected and divided in two groups of safe and non-safe zones with at least six months postsurgery follow-up. The prostheses implanted in this cementless THR included the pinnacle acetabular shell and corail femoral stem (Depuy Johnson-Johnson). We excluded complicated primary THR such as additional acetabuloplasty or femoral part reconstruction. Patients with prior hip arthroplasties (bilateral THR) or comorbidities were also excluded from the sampling.

Patients that matched our inclusion criteria were given thorough informed consent. Anteroposterior and cross table lateral radiographs were performed. We measured the acetabular abduction (safe zone = 40 ± 10^0) and anteversion (15 ± 10^0) angles. Femoral anteversion (10^0) was obtained from the lateral view. The anteversion combination angles, the sum of the femoral and acetabular components angles ($25\text{-}45^0$), and combination of abduction and anteversion of the acetabulum were also obtained (**Fig 1**).

Fig. 1 The measurement of (A) acetabular abduction angle, (B) femoral anteversion angle and (C) acetabular anteversion angle

Functional scoring using Harris Hip Score along with squatting and Attahiyat positions (**Fig 2**) were obtained during office or home visits with scores ranging from 90-100: excellent, 80-89: good, 70-79: fair, 60-69: poor and <60: failed. The results were then collected and analyzed using SPSS, Version 20 (IBM).

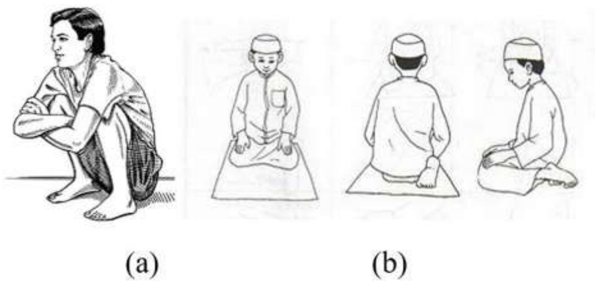

Fig. 2 (a) An oblique view of the squatting position, (b) Attahiyat praying position scheme, anterior, posterior and lateral view (From: Isbit J. 2008(18) and MN al-Alabani. 2005(19))

Results

The mean follow-up of this study was 21 months. The mean patient age was 16-79 (±15.90) consisting of 40% males and 60% females. **Table 1** shows postoperative outcomes such as functional outcomes and the ROM of the hip compared with pre-operative status. A significant difference was noted between before and after outcomes, covering Leg Length Discrepancy THR (LLD), HHS and ROM pre-THR. Other postoperative outcomes assessed included the incidence of dislocation, the ability to perform the squatting and the Attahiyat positions as shown in **Table 2**. For the outcomes of post-THR regarding dislocation level, we found two patients had dislocations and for the Attahiyat and squatting positions, we found 12 patients could perform these positions (**Fig 3**).

Table 1. Comparison of outcomes between pre- and post-THR. Outcomes of post-THR showed better results compared with pre-THR including LLD, HHS and Hip ROM.

Outcome variable	Pre-operation	Post-operation	*p*
Leg length discrepancy (LLD)			
0	11 (24.4)	27 (60.0)	
1	13 (28.9)	13 (28.9)	
2	13 (28.9)	3 (6.7)	
>2	8 (17.8)	2 (4.4)	
Harris hip score (HHS)	26 (13.0-36.0)	85,0 (73.0-95.0)	0.001
Range of movement (ROM)			
Flexion	70.0 (30.0-90.0)	105.0 (90.0-115)	0.001
Extension	0.0 (0.0-2.5)	5.0 (5.0-10.0)	0.001
Abduction	20.0 (10.0-30.0)	35.0 (30.0-40.0)	0.001
Adduction	10.0 (5.0-20.0)	27.0 (25.0-35.0)	0.001
Internal rotation	10.0 (5.0-15.0)	30.0 (24.5-35.0)	0.001
External rotation	15.0 (10.0-21.0)	32.0 (26.0-35.0)	0.001

The results are displayed in the median (inter-quartile range) for numerical data or frequency (percentage) for the proportion of data.

* *p*-values were calculated using the Pearson chi-square test or Fischer's exact proportion to the data, and the Wilcoxon signed rank test for paired numerical data.

Table 2. Relationship between acetabulum abduction angle, acetabulum anteversion angle and combination anteversion angle in the safe zone and non-safe zone groups with HHS post-THR regarding the ability to perform Attahiyat and squatting positions. Patients unable to perform Attahiyat and squatting positions post-THR were significantly more common among safe zone patients regarding the abduction angle of the acetabulum.

Component orientation angle	HHS		*p*	Attahiyat-squatting position		*p*
	≤80	>80		Yes	No	
Abduction acetabulum						
Safe zone	18 (46.2)	21 (53.8)	0.105	6 (15.4)	33 (84.6)	0.035
Non-safe zone	3 (21.4)	11 (78.6)		6 (42.9)	8 (57.1)	
Anteversion acetabulum						
Safe zone	12 (38.7)	19 (61.3)	0.872	5 (16.1)	26 (83.9)	0.179
Non-safe zone	9 (40.9)	13(59.1)		7 (31.8)	15 (68.2)	
Anteversion combination						
Safe zone	14 (46.7)	16 (53.3)	0.231	7 (23.3)	23 (76.7)	0.891
Non-safe zone	7 (30.4)	16 (69.6)		5 (21.7)	18 (78.3)	

The results are displayed in the median (inter-quartile range) for numerical data or frequency (percentage) for the proportion of data.
* *p*-values were calculated using the Pearson chi-square test, linear-by-linear association, or Fischer's exact proportion to the data, and the student T independent test or Mann-Whitney for numerical data.

(a) (b) (c)

Fig. 3 (a) Squatting position in patient after THA procedures, (b) cross-legged sitting position, (c) Attahiyat praying position

We processed the data using bivariate analysis. The results did not differ in HHS functional outcomes in the safe zone group of patients with orientation angle of prosthesis components from the non-safe zone group both at the acetabulum abduction angle, acetabulum anteversion angle as well as combined anteversion angle (**Table 3**).

The angle of the femur anteversion and combined abduction- anteversion acetabulum angles (non-safe zone ranges appear in the literature) did not show a mean difference when comparing HHS score between groups with "Good to Excellent" (>80) and "Nongood to Excellent" (<80) (**Fig 5**). The same results were observed when the orientation angles were compared between groups with the ability to perform Attahiyat-squatting position and without. Likewise, almost all the prosthesis component orientation angles compared with the Attahiyat and squatting positions yielded no significant relationship. However, regarding the abduction angle of the acetabulum, more significant outcomes were found among patients who were unable to perform Attahiyat and squatting positions in the safe zone group (**Table 3**). Almost all the interaction analyses of the prosthesis component orientation angle with ROM post-THR operation showed no difference in ROM post-operative outcomes of both groups, with the exception of increased internal rotation in the abduction angle of the acetabulum in the non-safe zone group (**Table 3**).

Table 3. Interaction of prosthesis component angle with ROM post-THR. Significant results obtained regarding the internal rotation increase in the abduction acetabulum angle non-safe zone group.

ROM post-operation	Abduction acetabulum angle			Anteversion acetabulum angle			Femur anteversion combination angle		
	Safe zone	Nonsafe-zone	*p*	Safe zone	Nonsafe-zone	*p*	Safe zone	Nonsafe-zone	*p*
Flexion	100.0 (90.0-110.0)	110.0 (93.8-130.0)	0.462	100.0 (90.0-115.0)	107.5 (98.8-117.5)	0.763	105 (90.0-116.3)	100 (95.0-115.0)	0.962
Extension	5.0 (5.0-5.0)	5.0 (5.0-10.0)	0.163	5.0 (5.0-10.0)	5.0 (5.0-10.0)	0.866	5.0 (5.0-10.0)	5.0 (5.0-10.0)	0.995
Abduction	35.0 (30.0-40.0)	35.0 (29.3-40.0)	0.788	35.0 (30.0-40.0)	35.0 (30.0-40.0)	0.835	35.0 (30.0-40.0)	40.0 (30.0-40.0)	0.097
Adduction	27.0 (25.0-35.0)	27.5 (23.8-35.8)	0.675	27.0 (25.0-30.0)	30.0 (21.5-35.0)	0.389	27.0 (25.0-35.0)	26.0 (22.0-35.0)	0.962
Internal rotation	26.0 (23.0-35.0)	33.5 (29.3-36.3)	0.015	30.0 (24.0-35.0)	30.0 (24.5-35.0)	0.822	28.5 (23.0-33.5)	30.0 (25.0-35.0)	0.468
External rotation	30.0 (25.0-35.0)	35.0 (30.0-40.0)	0.127	30.0 (25.0-35.0)	35.0 (26.5-36.3)	0.341	30.0 (25.0-36.3)	35.0 (27.0-350)	0.219

The results are displayed in the median (inter-quartile range).

* *p*-values were calculated using test or Mann-Whitney U test

(a) (b) (c)

Fig.4 (a) Before operation pelvis x-ray (b) postoperative x-ray and (c) 6-month postoperative x-ray

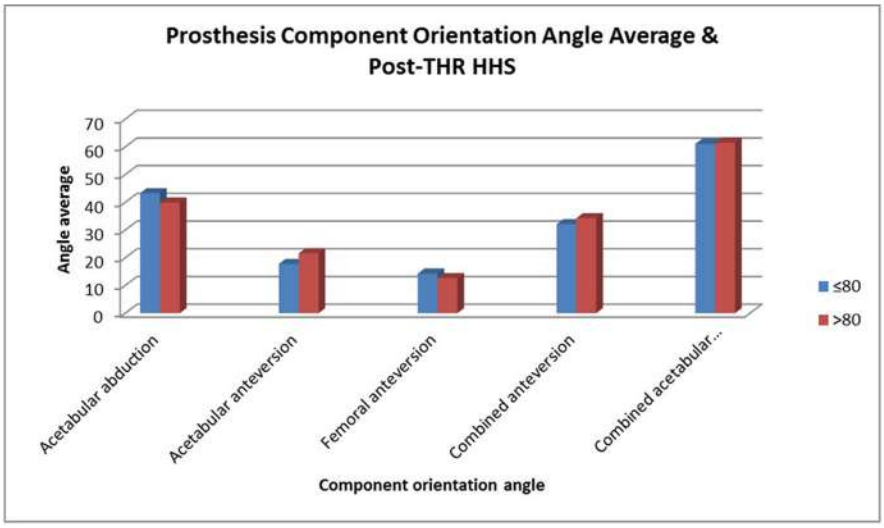

Figure 5. Relationship between THR component orientation angle with HHS post-THR and the ability to perform Attahiyat and squatting positions

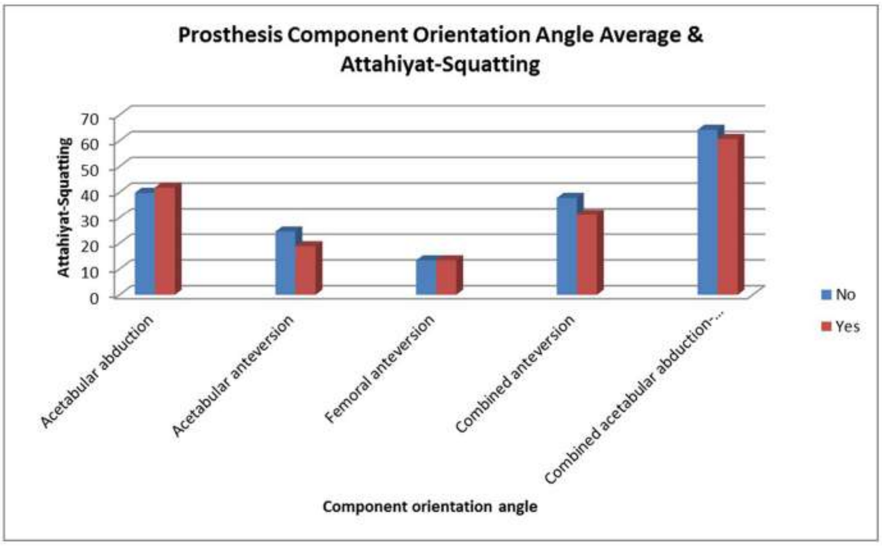

Figure 6. Relationship between THR component orientation angle and the ability of to perform Attahiyat and squatting positions

Discussion

Many studies have been conducted to assess functional outcomes of THR. Walker et al. stated that THA among patients less than 30 years yielded good functional THA outcomes.[26] However, Clement stated that THA among older patients developed poor outcomes due to more complications and higher mortality rates.[27] Ethgen et al. [20] conducted a systematic review in 2004 concerning the quality of life of patients with post-THR assessed using the Short Form-36 (SF-36) and the Western Ontario and McMaster University Osteoarthritis Index (WOMAC). The results showed significant improvements in their quality of life. However, Laupacis et al.[5] showed a significant increase in the mean HHS of 44 to 98. We used two types of approaches, i.e., anterolateral or posterior. Graves et al. stated that different types of approaches yielded similar results regarding short term outcomes; thus, the selection of approach posed no bias.[28]

In this study alone, HHS post-THR significantly improved from a median of 26 to 85.

The score of "Good" HHS showed that patients improved pain management, improved mobilization function and improved social function in the patient community.

Concerning Hip ROM outcomes, this study showed significant improvement in each component of the Hip ROM. ROM was limited among patients undergoing primary THR caused by pelvic pain due to arthritis. THR removes a source of pain and replaces the hips with a prosthesis that serves to simulate the previous pelvic functions. Thus, a significant increase in ROM can occur.

In a study conducted by Le Duff et al. [21], the ROM postprimary THR increased flexion to 123° (90-140), abduction to 43° (25-50), adduction to 28° (20-40), external rotation to 35° (15-60) and internal rotation to 40° (10-70). In our study of post-THR, we discovered that the ROM was slightly lower, with a flexion of 105° (90-115), abduction of 35° (30-40), adduction of 27° (25-35), external rotation of 32° (26-35) and internal rotation of 30° (24, 5-35). This significant increase in ROM has become a component of HHS as a measure of the patient's improved quality of life.

Attahiyat and squatting positions could be performed by 12 patients with postprimary THR at a proportion of 22.6%. Both of these positions are the expectations, often a necessity, among Indonesian patients undergoing THR procedures with respect to beliefs and culture. The majority of Indonesia's population is Muslim and required to use the Attahiyat position to pray. In addition, some Indonesians frequently use the squatting position everyday life. We believed that our study evaluated this outcome for the first time. Our study showed no difference in functional outcomes for HHS with a good prosthesis component orientation angle whether with a safe area zone or not. However some literature has indicated otherwise such as that conducted by Fujishiro et al.[24] This is may be because the HHS itself has many aspects of assessment including pain, walking difficulties, walking aids, walking distance, interference in sitting, the ability to use public transportation, the ability to climb stairs, the ability to wear shoes, the existing deformity and Hip ROM. Prosthesis component orientation angles have the greatest influence on aspects of Hip ROM with the maximum value at only 5 for HHS (HHS maximum value of 100). HHS score >80 was categorized as the "Good to Excellent" group. Thus indirectly, the influence of the orientation angle of the prosthesis component to HHS is not great.

Another case investigated the influence by the prosthesis component orientation angle of the post-THR ROM. Studies conducted by Seki et al. [23], and D'lima et al.[24], in a three-dimensional computer model, showed that the abduction angle of the acetabulum and the anteversion combination angles at the safe zone area produced optimal THR prosthesis. This has yet to be proven in an actual patient's pelvis and the results of research on the computer model remain unproven in this study. The only significant association found was increased internal rotation in the abduction angle of the acetabulum in the non-safe zone group. However, the internal rotation of the pelvis was not a major focus because relevant literature revealed internal rotation is not an issue in the impingement prosthesis.[23] ROM pelvic post-THR is not only influenced by the prosthesis component orientation angle, but also by the head-to-neck ratio prosthesis, soft tissue tension and post-THR rehabilitation. These factors were not present in studies using computer models.

The interaction between the prosthesis component orientation angles with one component of the ROM in this study was also non-significant. For example, one study of computer models reported that the increase in abduction angle of the acetabulum would increase flexion, extension and abduction of the pelvis and lower adduction range of motion and axial rotation. However, the correlations of the test results obtained were without meaning. This indicated that studies using computer models could not simulate the real pelvis. The prosthesis component orientation angle also did not have a meaningful relationship with the patient's ability to perform Attahiyat and squatting positions, except in the safe zone group regarding abduction angle of the acetabulum where more patients were unable to perform Attahiyat or squatting positions. Basically, both positions involve a combination of various ROM, with flexion as the dominant ROM. In addition, the relationship between the prosthesis component orientation angles with Hip ROM post-THR has been known to have no meaningful relationship. Moreover, some factors remain unable to be ruled out as confounders, e.g., patients' fears, habits and obesity status.

A significant difference was found between functional outcomes and hip ROM in pre- and post-THR, with a mean score of "Good". Patients in the safe zone group regarding the acetabular abduction angle were more frequently unable to perform "Attahiyat" and squatting positions.

Conclusion

The application of the THR prosthesis component orientation angle in the non-safe or safe zone areas produced comparable results (within certain ranges) based on HHS score. The non-safe zone group showed greater internal rotation range of motion regarding the acetabular abduction angle.

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