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Risk of Impingement on Polyethylene Liner of Total Hip Arthroplasty Prosthesis during Muslim Prayer (*Salat*) Activity

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Abstract

Total hip arthroplasty (THA) is one of the most successful orthopedic surgical procedures. Impingement believed to be the most common mechanism of dislocation after THA. Salat consist of several repeated physical movements which require several extreme hip joint movements. The potential impingement positions during *salat activity* have been revealed by the previous computer simulation study, some evidences of impingement from retrieved polyethylene liner also have been revealed from our recent preliminary data. Although further study is still needed in this field, we may give special advice to modify some movement for Muslim patient who receive THA when performing *Salat* activity.

Introduction

Total hip arthroplasty (THA) is one of the most successful orthopedic surgical procedures. Patient could obtain early return to ambulation and experienced considerable relieve of pain after the operation. However, dislocation remains known as one of the difficult problems following THA [1]. It could occur at around 2% of primary THA and increased to around 5% of cases in revision THA [2]. Several factors such as impingement, implant malposition, surgical approach, femoral head size, and lack of soft-tissue tension known as risk factors for dislocation after THA [3], [4], [5]. Although not all impingement associated with dislocation, still impingement believed to be the most common mechanism of dislocation after THA [3].

Salat (prayer) is one of the "5 pillars" of Islam (Table 1) [6]. A Muslim (people who practice the religion of Islam) has to do *salat* on a daily basis. *Salat* consist of several repeated physical movement which require several extreme hip joint movement. This short review aimed to discuss the possibility of impingement occurred to the polyethylene (PE) liner of THA prosthesis associated with salat activity.

Table 1: The "5 pillars" of Islam [6]

Arabic term	English term
Shahada	Declaration of belief
Salat	Prayers
Zakat	Charity
Sawm	Fasting
Hajj	Pilgrimage

Prosthesis Impingement

THA prosthesis impingement occurred when there is a repetitive direct contact of acetabular cup/liner to the femoral neck component during the range of motion of the joint [7] (Figure 1). Impingement could cause poor outcomes of hip arthroplasty due to instability,

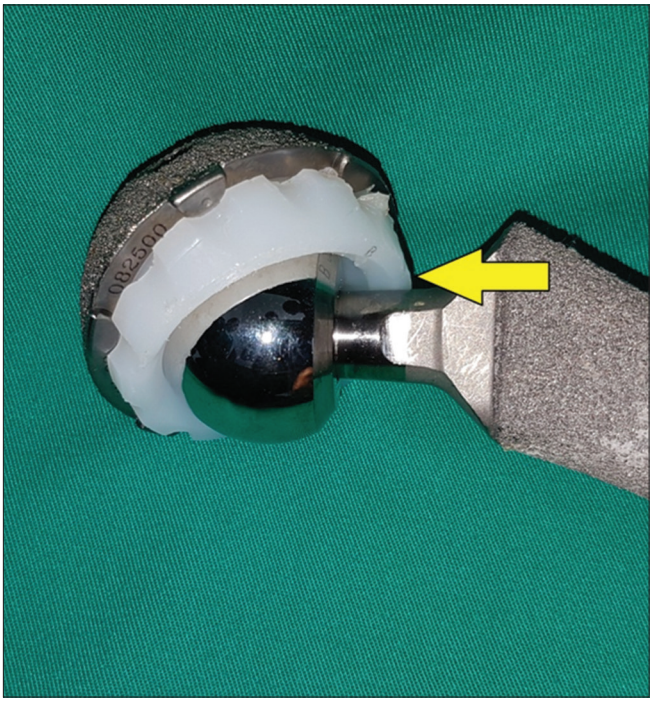

Figure 1: Site of impingement indicated by the arrow.

accelerated wear, and unexplained pain [8]. A large THA retrieval study from Western country showed that the prosthesis impingement rate could occur at as high as 50% of cases [9]. Impingement could cause PE liner damage. Muealler *et al*. [10] described three types of PE liner damage: *Collar fatigue, rim creep*, and *backside wear*. *Collar fatigue* defined as deformation and fatigue at the collar of the PE inlay in the area where the collar (outer rim) is in contact with the acetabular shell. *Rim creep* defined as deformation at the inner rim of the PE inlay leading to narrowing at the cup opening (Figure 2a), while *backside wear* defined as wear at the back of the PE liner (Figure 2b). Another author, French *et al.* [11] described the PE damage based on the presence of cracking/fracture into three categories based on their study to 129 retrieved Harris-Galante® PE liner: Type I (subsurface cracking), Type II (incomplete rim fracture), and Type III (complete rim fracture). Further, Marchetti *et al*. [9] classified the polyethylene impingement into four grades (Table 2). Their 416 PE liner retrieval study showed that the most common impingement occurred at Grade 1 and 2 by 20% and 19%, respectively.

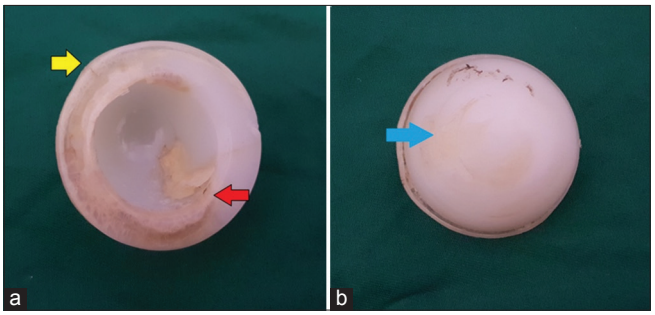

Figure 2: (a) Rim Creep (Red arrow) and Collar fatique (Yellow arrow) indicate in this retrieved PE Liner , (b) Backside wear indicate by the blue arrow. (Source: Author personal collection)

Table 2: Classification of acetabular polyethylene liner impingement according to Marchetti *et al*. [9]

Impingement	Acetabular ring aspect
Grade 0	No ring or visible abrasion at equator
Grade 1	Notch visible at equator, but ≤1 mm
Grade 2	Notch >1 mm ≤3 mm
Grade 3	Notch >3 mm

Our preliminary data from 10 retrieved acetabular liners are shown in Table 3 [12]. All PE liners were retrieved from revision THA surgery. Five of 10 (50%) PE liners were experienced impingement.

Table 3: Short analysis from the retrieved polyethylene liner from our 10 revision total hip arthroplasty cases

No.	Variables	Results (n: 10)
1	Classification PE liner according to Tanino *et al*. [12]	Type A: 9 Type B: 0 Type C: 1
2	Standard/Elevated rim (Figure 4a and b)	Standard : 6 Elevated: 4
3	Impingement site (Occurred at 5 of 10 PE liner*)	At elevated part: 2 At non-elevated part: 5
4	Backside wear (Yes/No)	Yes: 5 No: 5
5	Rim creep (Yes/No)	Yes: 4 No: 6
6	Collar fatigue (Yes/No)	Yes: 2 No: 8
7	Grading of impingement according to Marchetti *et al*. [9]	Grade 0: 5 Grade 1: 1 Grade 2: 2 Grade 3: 2

*2 PE liner experienced impingement both at elevated and non-elevated part. PE: Polyethylene.

Two of them were PE liner with elevated rim, which the impingement site was both at the elevated and non-elevated part (Figures 3 and 4).

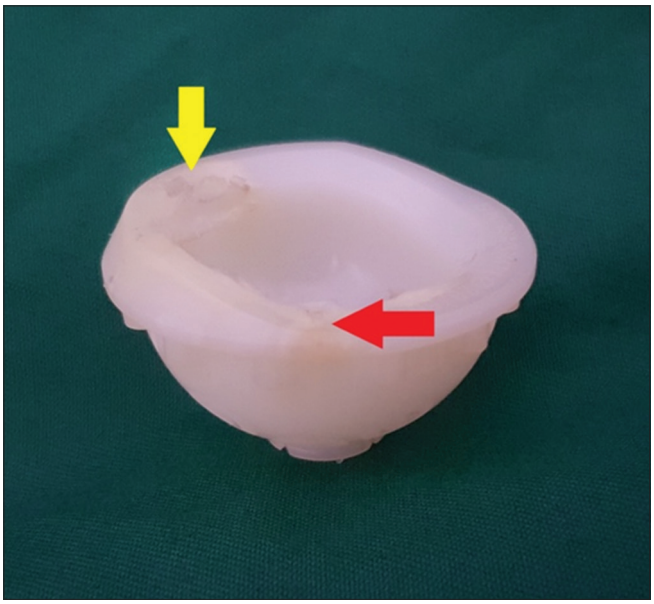

Figure 3: Impingement could occurred both on elevated (yellow arrow) and non-elevated part (red arrow) (Source: Author personal collection)

Salat activity

A Muslim person have to do prayer (*Salat*) 5 times a day which consist of several movements include standing (start), bowing (*ruku'*), straightening up (standing after bowing/*i'tidal*), prostrating (*sujud*), and sitting (*tahiyat*) [4], [13]. All those movements are sequenced in a *raka'at* (Figure 5). In one *raka'at,* there

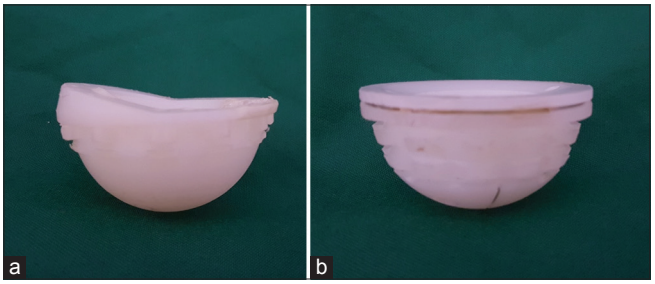

Figure 4: Different acetabular PE liner design with rim elevation (a) and without rim elevation/standard (b) (Source: Author personal collection)

are one standing (start), one bowing, one straightening up (standing), two prostration, and one sitting. In 1 day, a Muslim has to do *Salat* in totally 17 *raka'at*. Therefore, there will be a total of 17 times standing, 17 times bowing, 17 times straightening up, 34 times prostration, and 17 times sitting in a day (Table 4) [4], [14], [15].

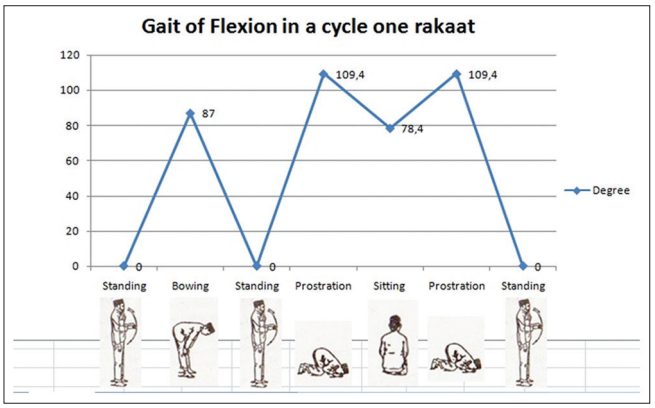

Figure 5: Sequence of hip joint movement (flexion) in Salat activity in one raka'at.15

There have been only few literature described the *salat* activity in correlation to impingement of THA prosthesis. A previous study by Jamari *et al*. [16] on simulation of hip joint movement during *Salat* activity showed that impingement of hip joint prosthesis could occur during three positions include sitting (*tahiyat*), prostration (*sujud*), and transition of standing toward prostration (Figure 6a and b) [16]. Impingement to the left hip during *tahiyat* sitting occurred as combination of hip flexion by 74.5°, abduction by 13.2°, and exorotation by 37.7° (Figure 7a-c), while the transition of standing toward prostration resulted an impingement due to extreme flexion at 121.5° [16].

Table 4: Range of hip joint movement (flexion) during *Salat* activity

Movements in Salat	Study by Ariff *et al*. [14] (mean and range)		Study by Towijaya *et al*. [15] (maximum)
	Right	Left	
Bowing (*Ruku*)	74.1 (60–85)	74.3 (56.3–86.7)	87
Sitting (*Tahiyat*)	77.3 (65–90)	77.7 (65–88.3)	78.4
Prostration (*Sujud*)	118.1 (91.7–138.3)	119 (95–140)	109.4

Another study involved a simulation test for repeated impingement of THA prosthesis during *Salat* activity. The result showed that the repetition of *tahiyat* sitting during *salat* movement induces repeated impingements and higher plastic deformation. The

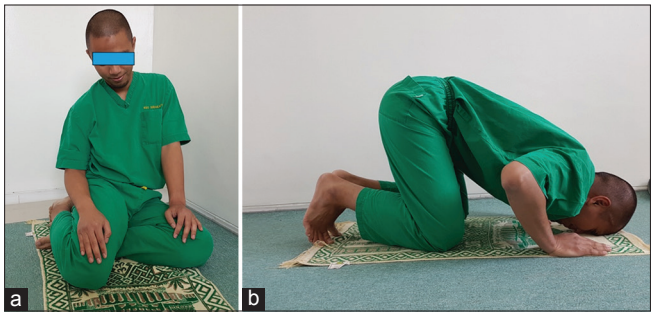

Figure 6: Tahiyat (sitting) position (a) and Sujud (prostration) (b) during Salat activity.

PE liner experiences dimensional change on the lip and has a potency to cause clinical failure of total hip replacement. A PE material with higher elastic moduli and lower in yield strength experiences higher plastic deformation and plastic strain than material with lower elastic moduli and higher in yield strength. The study suggested to make a new design of THA prosthesis to prevent impingement during *salat* activity; however, no specific point has been suggested about the design [17].

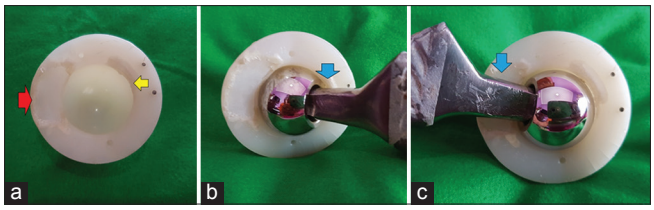

Figure 7: (a) Impingement occurred at different site at one PE liner, (b) Impingement at superolateral site possibly associated with hip flexion, abduction and external rotation (Tahiyat sitting for left hip), (c) Impingement at inferomedial site possibly associated with flexion, adduction and internal rotation of hip joint. (Source: Author personal collection)

Further study by Ismail *et al*. [18] suggested several point to consider in the making of the new design of artificial hip joint model which allows THA patients to perform *salat* in a normal manner. The reduction of inset at the liner, the new profile at circumferential edge inner liner, and the increase in the femoral head diameter were advised as a guideline for new design of the artificial hip joint for Muslim [18].

Consideration to Prevent Impingement in *Salat* Activity

The first classic factor to consider to prevent impingement is implant position. The acceptable (safe zone) acetabular cup orientation has been described by Lewinnek *et al*. [19]. They recommend 40° (±10°) of inclination and 15° (±10°) of anteversion. Cups placed outside this "safe zone" had an increased dislocation risk by 4 times compared to control group. However, a recent study by Tezuka *et al*. [20] showed that the concept of "functional safe zone" is better to predict stability after

THA compared to the Lewinnek safe zone. They found that 14.2% of prosthesis within the Lewinnek's zone were not in the functional safe zone, this gives a potential for prosthesis dislocation despite having "normal" cup position. A biomechanical study by Elkins *et al*. [21] showed that a cup placed more horizontal could induce prosthesis impingement during squatting. The squatting position is almost similar to "transition movement from standing toward prostration" which has been revealed as one of the high-risk movements in *Salat* activity [16]. Therefore, a more horizontal cup position maybe has to be avoided for Muslim population. Consideration of femoral stem position also important in order to prevent prosthesis impingement. A study by Renkawitz *et al*. [22] investigates the effect of femoral stem tilt (FT) to the risk of implant impingement of THA. They found that the FT has a significant impact on recommended cup positions within the concept of "femur first" or "combined anteversion." Ignoring FT may pose an increased risk of impingement as well as dislocation. Therefore, a further study to define "special safe zone" including the cup and femoral position of THA implant is needed for Muslim population to prevent impingement and dislocation during *Salat* activity. Furthermore, to increase the accuracy on implant placement, the use of navigation system also might be considered [23]. A recent study by Palit *et al*. [24] showed that the use of computer navigation system could significantly reduce impingement severity both on bone-to-bone and implant-to-implant impingement compared to conventional group [24].

Larger head diameter could reduce the risk of prosthesis impingement [8]. Several previous studies have been proved the benefit of using larger femoral head diameter. A study by Zijlstra *et al*. [25] revealed that there was a benefit in using 32 mm heads instead of 22–28 mm heads, regardless the type of surgical approach. They also found that the use of head diameter of ≥36 mm showed to significantly reduce the risk of dislocation in posterolateral approach [25]. Another study by Plate *et al*. [26] found no case of dislocation after THA with anterolateral approach when using ≥36 mm head diameter. Conversely, dislocation occurred at 3.8% of cases when using <36 mm head diameter. Although further study also still needed, we may recommend to use a ≥36 mm of head diameter for THA in Muslim population.

The last consideration is to modify the *Salat* movement itself. The religion of Islam allows the Muslim person to modify some of the *Salat* movement in special circumstances include sickness, disabled condition, or other morbidity high-risk conditions. The safest way to prevent impingement and dislocation is to advice the patient who received THA to perform *Salat* with "sitting on the chair" without prostration and *tahiyat* sitting, which it is allowed in the religion of Islam. Unfortunately, not all patients obey the advice, as some still wanted to perform *Salat* in the original manner to follow their believe.

Summary

Prosthesis impingement is an important event that could alter the outcome of THA. The potential impingement positions during *Salat activity* have been revealed by the previous computer simulation study, some evidences of impingement from retrieved PE liner also have been showed from our recent preliminary data. Some consideration to prevent prosthesis impingement from implant choice and position also modification of *Salat* movement has been described in this review, although further study is needed in this field.

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