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Seating of the Femoral Stem after Washing versus Un-washing the Femoral Canal in Cementless Short Stem Hip Arthroplasty

Thanut Tippimanchai, MD, Yingyong Suksathien, MD, Jithayut Sueajui, MD

Department of Orthopaedics, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand

Purpose: This study aimed to evaluate the effect of washing the femoral canal on the seating of the short femoral stem in cementless short-stem hip arthroplasty.
Methods: This single-center randomized controlled trial included 50 patients divided into unwashed and washed groups. All patients underwent cementless short-stem hip arthroplasty with the Metha® short-stem. The primary outcome measured was the discrepancy between the final rasp and implanted stem, with a mismatch of >2 mm considered clinically significant. Secondary outcomes included intraoperative factors associated with a significant mismatch. Univariate logistic regression analysis was used to identify factors related to a clinically significant mismatch between the final rasp and implant. The subsidence and revision were recorded at 4 years follow-up.
Results: The study found that 44% of the cases in the unwashed group had a clinically significant mismatch, compared with 8% in the washed group (P=0.001). The mean discrepancy was 2.4 mm in the unwashed group and 1.2 mm in the washed group (P<0.001). Univariate regression analysis indicated that not washing the canal was associated with a higher rate of significant mismatches (odds ratio [OR]=9.05, P=0.009). No cases of stem subsidence or revision were observed at 4 years follow-up in either group.
Conclusions: Washing the femoral canal with saline significantly reduced the discrepancy between the final rasp and the implant in cementless short-stem hip arthroplasty, potentially improving surgical outcomes and reducing leg length discrepancies.

Keywords: Total hip arthroplasty, Short stem, Rasp, Wash, Seating, Metha

Cementless conventional stems have been reported to achieve reliable clinical and radiological outcomes in total hip arthroplasty (THA), including long-term survival rates[3]. However, successful outcomes require meticulous intraoperative surgical techniques to ensure proper fit and alignment, restore normal hip biomechanics, and promote osseointegration[10-12].

Short-stem THA was developed to address several challenges, including minimizing metaphyseal-diaphyseal mismatch, stress shielding, thigh pain, periprosthetic fracture, and loss of bone stock, as well as simplifying removal during revision surgery. The design focuses on true metaphyseal anchoring without diaphyseal engagement, thereby facilitating anatomical reconstruction. This

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Correspondence to: Thanut Tippimanchai, MD
Department of Orthopaedics, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand
E-mail: Thanut.ti@cpird.in.th

approach avoids disruption of the greater trochanter and preserves bone in the femoral canal, thereby improving the potential for revision situations in which a standard implant can replace the need for a long revision stem[7,9,13,18].

Differences between the final rasp used for femoral preparation and the implanted femoral stem can affect leg length, implant fit, fill, and stability, potentially compromising the clinical outcomes of surgery[16]. The effectiveness of a rasp in preparing the proximal femur for a short metaphyseal uncemented femoral stem depends on the rasp design, tolerance between the rasp and implant, and surgical technique. Husseini et al.[8] demonstrated that washing the femoral metaphysis with saline to remove bone debris after rasping and before inserting the final implant significantly decreased the mismatch between the seating of the final rasp and the implant in this cementless short, metaphyseal-filling, tapered design stem. Our randomized controlled trial (RCT) extended this by examining the effects of canal washing, thus providing a higher level of evidence on this topic. An advantage of RCT is the minimization of bias and confounding factors, which enhances the validity of the findings.

The design of the rasp is crucial for determining the fit and stability of the implants. The Metha® short-stem used in this study features a trapezoidal shape, providing a geometry that helps distribute stresses evenly across the bone-implant interface, thus reducing the risk of stress shielding and promoting bone remodeling. The rasp has a double-tapered profile, narrowing in both the mediolateral and anterior-posterior dimensions, which facilitates secure metaphyseal fixation and provides a snug fit in the femoral canal, enhancing primary stability. Additionally, the rasp is collarless, which minimizes interference with the trochanteric region and allows for a more anatomical fit. This is particularly beneficial for preserving bone stock and reducing stress concentrations. The curved distal end of the rasp was designed to contact the proximal lateral cortex, enhance the lateral load transfer, and contribute to a three-point fixation system that ensures implant stability. The rasp surface was textured to mimic the surface characteristics of the implant, assisting in preparing the bone surface for optimal osseointegration by compacting the cancellous bone and creating a favorable environment for bone ingrowth. The rasp set includes a range of sizes that correspond precisely to the Metha® short-stem implants.

This study aimed to investigate the effect of washing the femoral canal on the seating of the short femoral stem in cementless short-stem hip arthroplasty. We hypothesized that washing the femoral canal could reduce the mismatch between the seating of the final rasp and the implant in cementless short-stem THA.

METHODS

Study Design

This study was designed as a single-center randomized controlled trial (RCT). This trial aimed to evaluate the impact of washing the femoral canal on the seating of the short femoral stem in cementless short-stem hip arthroplasty. This study was approved by the Institutional Review Board of our hospital (054/2019). Patient enrollment was conducted between July 2019 and January 2020.

Participants

Fifty patients were enrolled and randomly assigned to one of two groups: unwashed or washed. The inclusion criteria included patients aged ≥15 years with good bone quality, defined by the Dorr classification[6] as types A and B. Poor bone quality was defined as Dorr type C. Patients who had undergone post-traumatic or previous hip surgery and those who refused to participate in the study were excluded.

Sample Size Calculation

The sample size was calculated based on the expected difference in the primary outcome (clinically significant mismatch) between the two groups[8]. Using a significance level of 0.05 and a power of 80%, the estimated sample size required was 25 patients per group, assuming an effect size sufficient to detect clinically significant differences between the washed and unwashed groups.

Randomization and Allocation Concealment

Randomization was conducted using a computer-generated sequence to ensure the unbiased allocation of participants to each group. Allocation concealment was achieved using sealed opaque envelopes that were opened only after the participants were enrolled and provided consent. This process minimized selection bias and maintained the integrity of randomization.

Blinding

Owing to the nature of the intervention, blinding of the surgeons was not feasible. However, the outcome assessors were blinded to the group assignments to reduce detection bias in evaluating the outcomes.

Fig. 1 Metha® short-stem.

Intervention

All procedures in this study were performed by three surgeons using the modified Hardinge approach with a Metha short-stem (Metha Short Hip Stem, B.Braun Aesculap, Tuttlingen, Germany) and a cementless acetabular cup (Plasmafit Acetabular Cup System, B.Braun Aesculap, Tuttlingen, Germany). The Metha® short-stem is a cementless, collarless, and tapered prosthesis (Figure 1). Fixation relies on a closed ring of the femoral neck and lateral neck support to ensure primary implant stability. For osseointegration, the stem was coated with a combination of plasmapore, a rough microporous titanium coating, and a thin bioactive calcium phosphate surface finish. Calcium phosphate is osteoinductive, and the porous plasmapore structure provides an optimal foundation for potential bone ingrowth. The femoral preparation of Metha® short-stem relies on a broach only technique. The implants were oversized by 0.35 mm on each side relative to the broach.

In the washed group, after rasping the canal to the proper size, canal was irrigated with 100 ml of normal saline using an Asepto syringe before femoral implantation. In the unwashed group, the femoral canal was rasped to the appropriate size for the stem but was not irrigated prior to implantation of the femoral implant.

Outcome Measurement

The primary outcome was the discrepancy between the final rasp and implanted stem, with a clinically significant mismatch defined as >2 mm[8,14]. Intraoperatively, the distance in millimeters from the medial cortex of the neck cut to the upper border of the final rasp and from the medial cortex of the neck cut to the upper border of the medial porous coating of the implanted stem, was measured using a metallic ruler by an assessor (Figures 2 and 3). Discrepancies in seating between the final rasp and implant were compared. Secondary outcomes included intraoperative factors associated with significant mismatch, subsidence, and revision rates at four years follow-up.

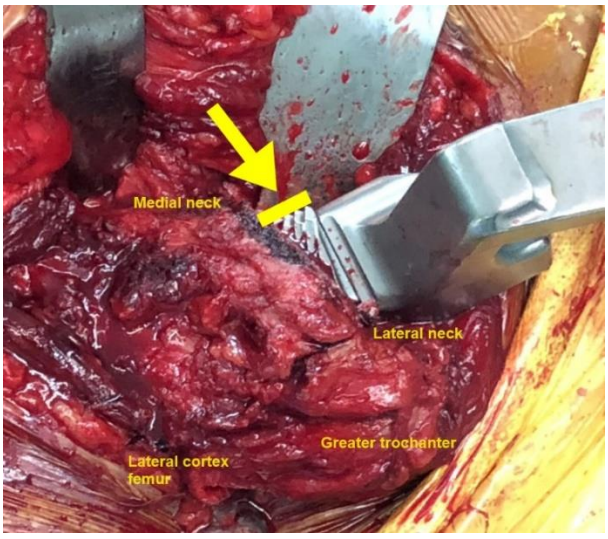

Fig. 2 The distance from the medial cortex of the neck cut to the upper border of the final rasp.

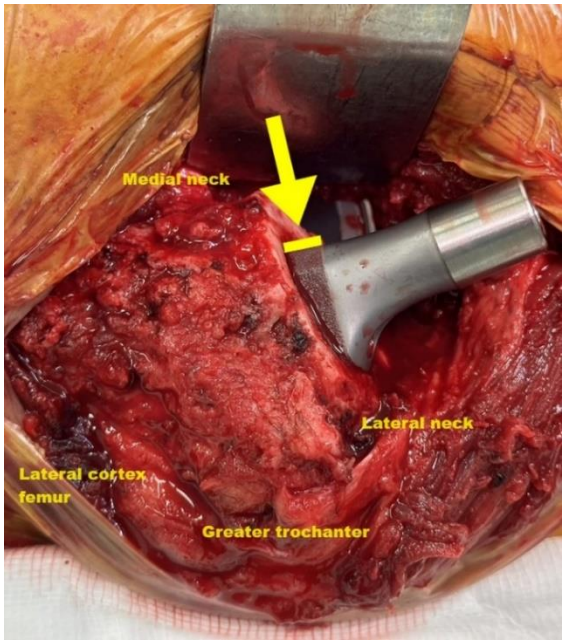

Fig. 3 The distance from the medial cortex of the neck cut to the upper border of the medial porous coating of the implanted stem.

Data Collection

Preoperative demographic data collected included patient sex, age, underlying disease, weight, height, body mass index (BMI), Dorr classification[6], surgical side, and diagnosis. The discrepancy between the distance from the medial cortex of the neck cut to the upper border of the final rasp and distance from the implanted stem was recorded.

Anteroposterior (AP) radiographs of both hips, with both legs in 15° internal rotation, and lateral cross-table radiographs were taken every 3 months during the first postoperative year, and then every 6 months thereafter. Stem subsidence >3 mm was defined as positive subsidence in comparison with radiographs taken after surgery[19]. The subsidence and revision were recorded at 4 years follow-up.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics software (version 21.0). The Pearson chi-square test was used for categorical variables and the t-test was used for continuous variables to compare patient demographic data and discrepancies between the final rasp and implant. Univariate logistic regression analysis identified factors associated with a clinically significant mismatch between the final rasp and implant. Statistical significance was set at $P<0.05$.

Table 1 Demographic data of patients.

Parameters	Group 1 (Unwashed) (N=25)	Group 2 (Washed) (N=25)	P-value
Mean age (years) (range, SD)	49.5 (27-77, 13.7)	50.2 (27-67, 11)	0.85
Side (left/right)	10/15	10/15	1.0
Sex (male/female)	22/3	19/6	0.28
BMI (range, SD)	23.8 (15.6-34.2, 4.2)	23.6 (15.6-32.9, 3.9)	0.86
Mean follow-up (months) (range, SD)	56.3 (54-58, 1.2)	56.5 (54-58, 1.2)	0.56
Diagnosis (hips) (%)			0.41
ONFH	18 (72%)	15 (60%)	
OA	2 (8%)	3 (12%)	
FNF	3 (12%)	3 (12%)	
DDH	1 (4%)	3 (12%)	
Secondary OA	1 (4%)	1 (4%)	
Dorr classification			0.40
Type A	13 (52%)	10 (40%)	
Type B	12 (48%)	15 (60%)	

BMI, body mass index; ONFH, osteonecrosis of the femoral head; OA, osteoarthritis; FNF, femoral neck fracture; DDH, developmental dysplasia of the hip; SD, standard deviation

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. All participants provided informed consent, and the study protocol was approved by the IRB.

RESULTS

Of the 50 patients included in the study, 41 (82%) were male and 9 (18%) were female. The mean age was 49.9 years (27-77, SD 12.3). 30 patients (60%) underwent surgery on the right side and 20 (40%) on the left side. The mean body mass index (BMI) was 23.7 (15.6-34.2, SD 4). Preoperative diagnoses included osteonecrosis of the femoral head (ONFH) in 33 (66%) patients, osteoarthritis in 5 (10%) patients, femoral neck fracture in 6 (12%) patients, developmental dysplasia of the hip (DDH) in 4 (8%) patients and post-traumatic osteoarthritis in 2 (4%) patients. The mean follow-up was 56.4 months (54-58, SD 1.2). According to the Dorr classification, the preoperative radiographic classification of the proximal femur was type A in 23 patients (46%) and type B in 27 patients (54%). There were no significant differences in the demographic data of the patients between the two groups (Table 1).

A clinically significant mismatch (>2mm) was found in 44% (11/25) of the cases in the unwashed group and in 8% (2/25) of the cases in the washed group. A significant difference in the incidence of clinically significant mismatches (>2mm) was found between the two groups (P=0.001). The mean discrepancy between the final rasp and the final implant was 2.4 mm (range 1-6, SD 1.2) in the unwashed group and 1.2 mm (range 0-3, SD 0.9) in the washed group. A significant difference was observed in the discrepancy between the two groups (P<0.001). There was no difference in femoral stem size between the two groups (Table 2). There were 3 cases (12%) with a mismatch of 4 mm or more in the unwashed group, and the maximum mismatch was 6 mm.

The univariate regression analysis showed that canal rasping without washing is associated with significantly higher rates of clinically significant mismatch (>2mm) compared to the washed group (Odds ratio [OR]=9.05, 95% confidence interval [CI]: 1.74-46.89, P=0.009). Additionally, the analysis showed that diagnosis, Dorr classification, and femoral stem size had no significant impact on the incidence of clinically significant mismatches (>2mm) (Table 3).

There were no cases of stem subsidence or revision at 4 years follow-up in either group. There were no significant differences in stem subsidence or revision between the two groups.

Table 2 Outcomes.

Parameters	Group 1 (Unwashed) (N=25)	Group 2 (Washed) (N=25)	P-value
Mismatch (hips) (%)			0.003
≤ 2 mm	14 (56%)	23 (92%)	
> 2 mm	11 (44%)	2 (8%)	
Height different (mm, SD)	2.4 (1-6, 1.2)	1.2 (0-3, 0.9)	<0.001
Stem size			0.82
Size 0	6 (24%)	6 (24%)	
Size 1	4 (16%)	6 (24%)	
Size 2	8 (32%)	6 (24%)	
Size 3	6 (24%)	6 (24%)	
Size 4	1 (4%)	1 (4%)	

SD, standard deviation; mm, millimeter

Table 3 Association factors with a clinically significant mismatch.

Variables	Univariate Analysis		
	OR	95% CI	P-value
Unwashed vs. Washed	9.05	1.74 – 46.89	0.009
Diagnosis			
ONFH	1	-	-
OA	0.67	0.07-6.79	0.73
FNF	0.53	0.06-5.21	0.59
DDH	0.89	0.08-9.69	0.92
Secondary OA	2.67	0.15-47.30	0.50
Dorr Classification Type A vs. B	0.99	0.28-3.52	0.99
Stem Size			
Size 0	1	-	-
Size 1	0.35	0.05-2.41	0.29
Size 2	0.38	0.07-2.13	0.27
Size 3	0.28	0.04-1.88	0.19
Size 4	1.40	0.07-28.12	0.83

OR, Odds Ratio; CI, Confidence Interval, ONFH, osteonecrosis of the femoral head.
OA, osteoarthritis; FNF, femoral neck fracture; DDH, developmental dysplasia of the hips.

DISCUSSION

Leg length discrepancy (LLD) in total hip arthroplasty (THA) is a common complication that can result in patient dissatisfaction, leading to symptoms such as limping; pain in the hip, knee, or lower back; and difficulties in balancing and walking. It occurs when there is a difference in leg length after hip replacement surgery. Achieving equal leg lengths is challenging owing to factors such as preoperative planning accuracy, intraoperative techniques, and patient anatomical variations. The issue of LLD highlights the complexity of THA and the need for meticulous planning and surgical techniques. Differences between the final rasp used for femoral preparation and the implanted femoral stem can affect the leg length, implant fit and fill, and stability, potentially compromising the clinical outcomes of surgery. Therefore, achieving an accurate match between the rasp and implant is crucial to ensure the best possible surgical results. This study aimed to investigate the effect of washing the femoral canal on the seating of the short femoral stem in cementless short-stem hip arthroplasty.

The Metha® short-stem THA was developed to minimize issues such as metaphyseal-diaphyseal mismatch, stress shielding, thigh pain, periprosthetic fracture, loss of bone stock, and difficulties encountered during removal for revision. This is achieved through the true metaphyseal anchoring of the short-stem, which avoids diaphyseal engagement. This design enables better anatomical reconstruction, eliminates disruption to the greater trochanter, and preserves bone within the femoral canal[2,17,20,21]. Suksathien et al.[21] found that the Harris Hip Score improved from 44.7 to 99.6 over 7 years in 83 patients with Metha® short-stem THA, with significant bone trabeculae development indicating good implant support. Tippimanchai et al.[22] reported 98% patient satisfaction and 96.4% felt that their expectations were met, linking these outcomes to improve quality of life.

Canal rasping is a crucial step in the placement of cementless femoral components. Several studies have explored different techniques for canal preparation and assessed their impact on the initial stability of the implant. Research involving cadaveric femora and animal models has demonstrated that canal preparation using a bone

compaction technique enhances initial rotational stability and reduces implant subsidence compared to a bone extraction technique, without compromising pullout strength[23-24]. Reduced initial stability may increase micromotion at the bone-implant interface, potentially leading to the formation of fibrous tissue instead of achieving bony osseointegration[1,4,5,15].

In this study, we demonstrated that washing the femoral canal with saline to remove tissue and bone debris after the final rasping and before implanting the final stem significantly reduced the discrepancy between the final rasp and the implant in the Metha® short-stem THA. Furthermore, we observed that not washing the canal was associated with significantly higher rates of clinically significant mismatch (>2mm) (OR=9.05, 95% CI: 1.74-46.89, P=0.009). Consistent with a previous study, Husseini et al.[8] demonstrated that washing the femoral metaphysis with saline to remove bone debris, after rasping and before inserting the final implant, significantly decreased the mismatch between the seating of the final rasp and the implant in this cementless short, metaphyseal filling, and tapered design stem. The implant used in their study was the Tri-Lock® Bone Preservation Stem (DePuy Orthopedics Inc., Warsaw, IN). This short-stem type was classified by Khanuja et al.[9] as type 4 (shortened tapered conventional stem). This stem type is similar to conventional proximally porous-coated tapered designs but with a shorter stem length. In our study, we used the Metha® short-stem, which Khanuja et al.[9] classified as type 2A (trapezoidal). The stem type is collarless, trapezoidal, and double-tapered. It features a curved distal end that contacts the proximal lateral cortex, enhances lateral load transfer and provides three-point fixation.

Washing the femoral canal before cement and stem implantation is a standard procedure in cemented total hip arthroplasty (THA). This technique is essential for ensuring optimal micro-interlocking at the cement-bone interface in cemented THA, which is crucial for the stability and longevity of the implant. In contrast to cemented THA, the effect of washing the femoral canal before the implantation of a cementless femoral stem is unclear. Cleaning the bone bed may reduce the risk of fat embolism during rasping and stem insertion, and decrease the incidence of heterotopic ossification. Conversely, arguments against cleaning include preserving the compressed bone within the femoral canal to avoid additional trauma to the cancellous bone and maintaining potential growth factors in the bone marrow. In this study, we found no stem subsidence or revision at 4 years follow-up, and there was no significant difference between the two groups. Consistent with a previous study, Zampelis et al.[25] conducted a study on 40 patients with primary osteoarthritis who underwent surgery using a cementless titanium grit-blasted stem. Patients were randomized to either the jet-lavage or no-lavage groups of the femoral canal before implant insertion. Stem migration patterns were monitored using radiostereometry (RSA) at 0, 3, 12, 24, and 72 months. They found no significant differences in the extent or pattern of migration as measured by RSA after six years, and no stems were revised or found to be loose. They concluded that washing the bone bed with jet-lavage prior to the insertion of cementless stems did not affect the stability of the cementless femoral components.

The limitations of this study include variations in surgical techniques among different surgeons, which may have introduced variability in the outcomes. This could be mitigated in future research by standardizing the surgical procedures or limiting the study to a single experienced surgeon. Additionally, the forces applied during rasping and insertion, which could influence implant seating, were not measured. Future research should include precise measurements of these forces to better understand their effect. The definition of a clinically significant mismatch of >2 mm may also be contentious, considering that head-length adjustments can potentially accommodate discrepancies of up to 3.5 mm. Future studies should explore different thresholds for clinical significance and employ more precise assessment methods. Furthermore, the single-center design and relatively small sample size of the study may limit the generalizability of the findings. Larger multicenter trials are recommended to enhance the

external validity of the results and provide more robust evidence on the effect of washing the femoral canal in hip arthroplasty procedures.

CONCLUSIONS

This study demonstrated that washing the femoral canal with saline before implanting the final stem in cementless short-stem hip arthroplasty significantly reduced the discrepancy between the final rasp and the implant. Washing of the canal significantly improves implant separation and enhances surgical outcomes. This mismatch reduction suggests that canal washing may be a beneficial step during surgical procedures.

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