Relationships between the femoral neck-preserving ratio and radiologic and clinical outcomes in patients undergoing total-hip arthroplasty with a collum femoris-preserving stem

Zeming Liu, MD, Hongpeng Hu, MD, Sikai Liu, MD, Jia Huo, MD, Mengnan Li, MD, Yongtai Han, MD[*]

Abstract

The femoral neck-preserving ratio is crucial in arthroplasty with a collum femoris-preserving (CFP) stem. The aim of our study was to analyze the relationships between the neck-preserving ratio and the short-term radiologic and clinical outcomes of patients who underwent total-hip arthroplasty (THA) with a CFP stem.

The data of 325 hips from January 2015 to December 2016 were retrospectively reviewed. The demographic and radiologic data before and after surgery were obtained from patients. The neck-preserving ratio was defined as the ratio of the preserved femoral neck length to the preoperative femoral neck length. Correlations between the neck-preserving ratio and the radiologic and clinical outcomes of patients were analyzed.

The mean neck-preserving ratio was $66.38 \pm 6.91\%$ in the current study. We divided patients into 3 groups according to the neck-preserving ratio: group A (neck-preserving ratio $\leq 60.00\%$), group B ($60.00\% <$ neck-preserving ratio $< 70.00\%$), group C (neck-preserving ratio $\geq 70.00\%$). Radiologic features, including the neck-shaft angle ratio (0.96 ± 0.05), canal fill ratio (0.64 ± 0.07), anterior-posterior offset ratio (1.04 ± 0.10), and lateral offset ratio (2.55 ± 1.56) (ratios of the postoperative values to the preoperative values), and the prevalence of complications was significantly different among the groups ($\chi^2 = 21.173$, $P < .001$). In the correlation analysis, we found a moderate negative correlation between the neck-preserving ratio and neck-shaft angle ratio ($r = -0.308$, $P < .001$) and a slight positive correlation of the neck-preserving ratio with the anterior-posterior offset ratio ($r = 0.415$, $P < .001$) and the lateral offset ratio ($r = 0.164$, $P = .003$). In the linear regression analyses, the neck-preserving ratio was significantly linearly correlated with the neck-shaft angle ratio ($B = -0.232$, 95% confidence interval [CI] $= -0.311$ to -0.154, $P < .001$), anterior-posterior offset ratio ($B = 0.589$, 95% CI $= 0.447 – 0.730$, $P < .001$), and lateral offset ratio ($B = 3.693$, 95% CI $= 1.256 – 6.131$, $P = .003$). However, there was no significant linear correlation between the neck-preserving ratio and the canal fill ratio ($B = 0.073$, 95% CI $= -0.033$ to 0.180, $P = .174$). Logistic regression analyses also showed that a sufficient neck-preserving ratio was a protective factor for periprosthetic femoral fractures (odds ratio [OR] $= 0.924$, 95% CI $= 0.859 – 0.994$, $P = .035$), dislocations (OR $= 0.892$, 95% CI $= 0.796 – 0.999$, $P = .048$), and thigh pain (OR $= 0.886$, 95% CI $= 0.818 – 0.960$, $P = .003$).

For CFP stems, an insufficient neck-preserving ratio is significantly correlated with poor radiologic and clinical outcomes. Therefore, surgeons should be cognizant to preserve a sufficient femoral neck length during surgery to improve the outcomes for patients undergoing THA with CFP stems.

Abbreviations: ARCO = Association Research Circulation Osseous, BMI = body mass index, CFP = collum femoris-preserving, CI = confidence interval, DDH = developmental dysplasia of the hip, OA = osteoarthritis, ONFH = osteonecrosis of the femoral head, OR = odds ratio, PFFs = periprosthetic femoral fractures, THA = total-hip arthroplasty.

Keywords: arthroplasty, femoral neck, hip, short stem

1. Introduction

Total-hip arthroplasty (THA) represents a major surgical achievement for pain relief and restoration of lifestyle in younger and active patients due to the debilitating disease of osteoarthritis.[1] However, because young and more active patients have high requirements of movement after operation, they frequently face a high risk of complications, which has become the main reason for revision surgery.[2–4] To solve these problems, the concept of femoral neck-preserving hip arthroplasty was 1st introduced in the mid-1990s, and as 1 type of neck-preserving prosthesis, the collum femoris-preserving (CFP) stem came into being.[5,6] The CFP stem was designed to preserve the bone and physiologic load transfer along the trabecular systems by distributing the stress toward the medial lateral diaphysis, which may improve hip biomechanics restoration, triplanar stem stability, and long-term survival rate.[7,8]

However, unlike traditional neck-resection prostheses, CFP stems require a subcapital femoral neck osteotomy.[9] Li et al reported that the osteotomy should be performed 1.5 cm above the intertrochanteric fossa for CFP stems.[10] Burchard et al concluded from a virtual model that the bone-preserving level of osteotomy has a significant influence on the prevalence of postoperative complications.[11] However, there are no other reports that involve the relationships between the preserved femoral neck ratio and the radiologic and clinical outcomes in patients who have received THA with a CFP stem.[12] The proper neck-preserving ratio for CFP stems remains unclear. Therefore, the current study aims to identify the relationships between the neck-preserving ratio and the prevalence of complications and the postoperative radiologic and clinical outcomes,[13] with the aim to identify the proper neck-preserving ratio for CFP stem THA. We believe that the results might help surgeons achieve a better surgical technique and further improve the prognosis for patients undergoing THA with CFP stems.

2. Materials and methods

2.1. Study population

From January 2015 to December 2016, 292 patients (a total of 325 hips) were retrospectively enrolled. Of these patients, 213 were males and 112 were females. Patients with osteonecrosis of the femoral head (ONFH) stages III and IV according to the Association Research Circulation Osseous classification, developmental dysplasia of hip grades I to III according to the Crowe classification, osteoarthritis grades III to IV according to the Kellgren–Lawrence classification or other end-stage hip diseases (such as femoral neck fracture and avascular necrosis after acetabular surgery)[14] were enrolled. Patients with malignant diseases, metabolic bone diseases, bacterial inflammation, or incomplete medical records or radiologic images were excluded. The study was approved by the Institutional Review Board of the Third Hospital of Hebei Medical University and was conducted in accordance with the Declaration of Helsinki. As this was a retrospective study and all patient information was deidentified before analysis, informed consent was not required.

2.2. Surgical procedure

All operations were performed via a posterior-lateral approach by the same group of surgeons. Preoperative templating was not routinely used for any patient. The surgical procedures are described briefly as follows. After dislocation of the hip joint, a subcapital osteotomy was made. Then, the acetabulum was exposed, and the acetabular component was implanted. Next, the CFP stem was implanted following diaphyseal reaming using a curved reaming file. Finally, a metal or ceramic head was used, and the joint was reduced. Patients were immediately allowed to attempt full weight-bearing on the next day after the surgery (expect those who had occurred periprosthetic fractures).

2.3. Outcomes

Demographic characteristics such as age, sex, smoking status, alcohol consumption status, and comorbidities along with stem size (range from XS to XL), affected side, body mass index (BMI), bone mineral density, preoperative diagnosis, and postoperative complications of all patients were recorded.

In all patients, anteroposterior view and lateral view X-ray examinations for the proximal femur were taken before and after the operation. The anteroposterior view radiograph, especially after surgery, was taken when patients were in standing posture with double support and a foot spacing equal to the shoulder width, while performing bilateral tiptoe slightly inward (15°). On these standard radiographs, preoperative femoral neck length was measured (on preoperative radiographs) as the shortest distance between the middle point of baseline of femoral head and the intertrochanteric line. Preserved femoral neck length was defined (on postoperative radiographs) as the shortest distance between the middle point of the osteotomy line and the intertrochanteric line (Fig. 1). The neck-preserving ratio was calculated as the ratio of preserved femoral neck length to preoperative femoral neck length. According to the neck-preserving ratio, we divided the patients into 3 groups (group A: ≤60.00%, group B: 60.00–70.00%, group C: ≥70.00%). Anterior-posterior offset ratio was defined as the vertical distance from the rotational center of the femoral head to the middle axis of the femur on the anterior-posterior view radiograph. The lateral offset ratio was defined as the vertical distance from the rotational center of the femoral head to the middle axis of the femur on the lateral view femoral radiograph. The offset ratio was defined as the ratio of the postoperative offset value to the preoperative offset value. The neck-shaft angle ratio was defined as the ratio of the postoperative neck-shaft angle to the preoperative neck-shaft angle. The canal fill ratio was defined as the ratio of prostheses widths to medullary cavity widths in the position of the lesser trochanter tip. All radiologic measurements were independently performed by 2 experienced orthopedic surgeons using data obtained from the Picture Archiving and Communication Systems of our hospital and then averaged. To test the intra- and interobserver reproducibility, 20 patients were sampled randomly, and each measurement was independently measured and repeated after 1 week. All intraclass correlation coefficients, which are used to evaluate reproducibility, were >0.9 in this study.

2.4. Statistical analysis

All statistical analyses were performed with SPSS version 19.0 (SPSS Inc, Chicago, IL). All data were collected, and a database was constructed for statistical analysis. Continuous variables are expressed as the mean ± standard deviation. Normality testing of
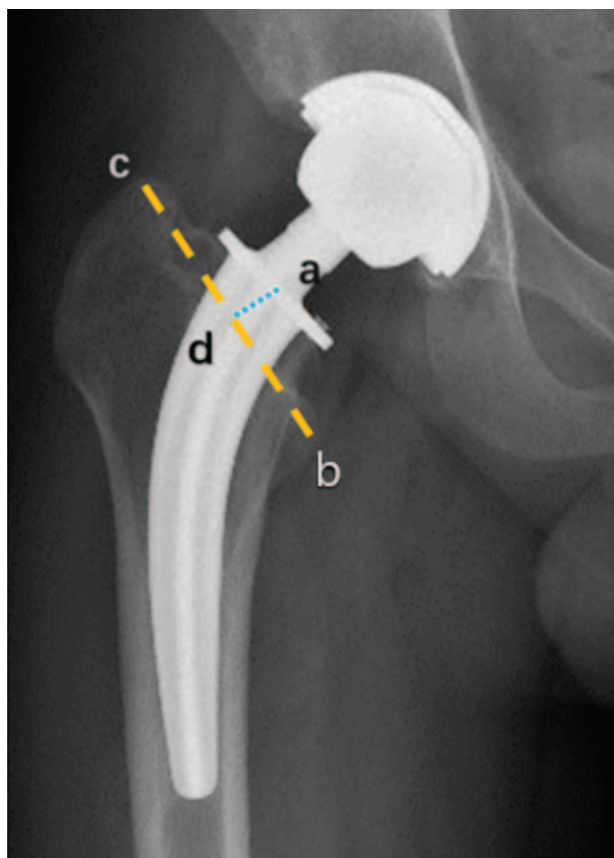
Figure 1. Point a is the midpoint of the stem neck at the collar level. Line bc is the intertrochanteric line, initiating from the tip of the lesser trochanter and terminating at the tip of the greater trochanter. Line ad is the shortest distance between point a and line bc. Line ad is considered as the neck-preserving length in the current study.

data was performed using the Shapiro–Wilk test, and homogeneity of variance testing was performed using Levene test. Nonparametric tests were used for comparisons between 3 groups. The Chi-squared test was used for comparisons between categorical variables. The correlations between the neck-preserving ratio and radiologic indicators, which did not meet the normal distribution criteria (different leg lengths, neck-shaft angle ratios, canal fill ratios, anterior-posterior offset ratios, and lateral offset ratios), were tested using the Spearman correlation coefficient. Linear regression analysis was used to assess the relationships between the neck-preserving ratio and indicators of the femoral prosthesis position. Univariate logistic regression models were built to explore the relationship between the neck-preserving ratio and the risk of complications. B or the odds ratio (OR) was calculated with the 95% confidence interval (95% CI) (for B or OR). A P-value $<.05$ was considered significant.

3. Results

3.1. General information

A total of 325 individuals (213 men and 112 women, mean age 52.54 ± 12.26 years) were included in our study. Indications for hip arthroplasty were ONFH (n=276, 126 patients had stage III, and 150 patients had stage IV), dysplasia (n=32, 29 patients had stage I, 3 patients had stage II), osteoarthritis (n=6), and other hip diseases (n=11). The average BMI was 25.14 ± 3.57 kg/m^2 (range from 14.52 to 40.90 kg/m^2). The mean neck-preserving ratio was $66.38 \pm 6.91\%$ ($57.51 \pm 3.05\%$ in group A, $66.85 \pm 2.67\%$ in group B, and $74.15 \pm 2.37\%$ in group C). There were 92 individuals in group A, 136 individuals in group B, and 97 individuals in group C. There were no significant differences in demographics (age, gender, BMI, smoking status, alcohol consumption, or indications) between the 3 groups (Table 1).

Table 1

General information of patients in different groups.

General characteristics	Group A	Group B	Group C	Test statistics	P
Age, yr	52.89 ± 13.12	52.49 ± 12.26	52.28 ± 11.53	0.472^{*}	.080
Gender					
Male	56	84	73	$5.803^{\dagger}$	.055
Female	36	52	24		
BMI, kg/m^2	24.78 ± 3.63	25.36 ± 3.29	25.17 ± 3.88	2.270^{*}	.321
Smoking status					
Yes	12	14	12	$0.463^{\dagger}$	.793
No	80	122	85		
Alcohol consumption					
Yes	9	21	12	$1.599^{\dagger}$	.450
No	83	115	85		
Indications					
ONFH	73	115	88	$7.176^{\dagger}$	.305
DDH	11	15	6		
OA	2	2	2		
Others	6	4	1		

BMI = body mass index, DDH = developmental dysplasia of the hip, Group A = neck-preserving ratio ≤60.00%, Group B = 60.00% < neck-preserving ratio < 70.00%, Group C = neck-preserving ratio ≥ 70.00%, OA = osteoarthritis, ONFH = osteonecrosis of the femoral head.

"Others" include fracture of femoral neck, and femoral head necrosis after acetabular surgery.

* Kruskal–Wallis test.

† Chi-squared test.

Table 2

Radiologic indicators of the femoral prosthesis position in different groups (postoperation).

Radiologic indicators	Group A	Group B	Group C	Z	P
Difference in leg length, mm	3.05±2.36	2.92±2.75	3.47±2.44	4.693	.096
Neck-shaft angle ratio	0.99±0.06	0.96±0.05	0.94±0.04	24.499	**<.001**
Canal fill ratio	0.63±0.07	0.65±0.07	0.66±0.07	6.807	**.033**
Anterior-posterior offset ratio	1.01±0.11	1.04±0.09	1.08±0.08	29.784	**<.001**
Lateral offset ratio	2.02±1.20	2.84±1.78	2.64±1.41	13.783	**.001**

Statistically significant P values are marked as boldface.

3.2. Radiologic and clinical outcomes

We analyzed the radiologic indicators of the femoral prosthesis position between groups. Significant differences were found among the groups in the neck-shaft angle ratio (0.99 ± 0.06 in group A, 0.96 ± 0.05 in group B, 0.94 ± 0.04 in group C; $Z=24.499$, $P<.001$), canal fill ratio (0.63 ± 0.07 in group A, 0.65 ± 0.07 in group B, 0.66 ± 0.07 in group C; $Z=6.807$, $P=.033$), anterior-posterior offset ratio (1.01 ± 0.11 in group A, 1.04 ± 0.09 in group B, 1.08 ± 0.08 in group C; $Z=29.784$, $P<.001$), lateral offset ratio (2.02 ± 1.20 in group A, 2.84 ± 1.78 in group B, 2.64 ± 1.41 in group C; $Z=13.783$, $P=.001$). The other radiologic indicators showed no significant differences among the groups (Table 2).

There were 16 patients (4.92%) with periprosthetic femoral fractures (PFFs), 7 patients (2.15%) with dislocations, 5 patients (1.54%) with aseptic loosening, and 15 patients (4.62%) with thigh pain. The total prevalence of complications was 13.23%. The prevalence of complications in different groups was also analyzed (Table 3). In terms of the PFFs, the prevalence in group A was 9.78%, the prevalence in group B was 2.94%, and the prevalence in group C was 3.09%. The prevalence of dislocation in group A was 3.26%, the prevalence in group B was 2.94%, and no dislocation occurred in group C. In terms of aseptic loosening, the prevalence in group A was 3.26%, the prevalence in group B was 1.47%, and no patients incurred aseptic loosening in group C. The prevalence of thigh pain in group A was 10.87%, the prevalence in group B was 2.94%, and the prevalence in group C was 1.03% (Table 3).

3.3. Correlation analysis

We also explored the correlations between the neck-preserving ratio and some radiologic indicators of the femoral prosthesis position. No significant correlation was found between the difference in leg length and neck-preserving ratio ($r=0.040$, $P=.469$). No significant correlation was found between the canal fill ratio and neck-preserving ratio ($r=0.078$, $P=.174$). However, there was a moderate negative correlation between the neck-shaft angle ratio and neck-preserving ratio with statistical significance ($r=-0.308$, $P<.001$). The anterior-posterior offset ratio and the lateral offset ratio were positively correlated with the neck-preserving ratio, and the correlation coefficients were 0.415 ($P<.001$) and 0.164 ($P=.003$), respectively (Table 4).

3.4. Regression analyses

Finally, we performed linear regression analyses and univariate logistic regression analyses to further clarify the relationships between the neck-preserving ratio and some indicators of the femoral prosthesis position and the prevalence of complications (Table 5). For 1 increase in the neck-preserving ratio, the neck-shaft angle ratio decreased by approximately 0.232 ($B=-0.232$, 95% CI$=-0.311$ to -0.154, $P<.001$), the anterior-posterior offset ratio increased by approximately 0.589 ($B=0.589$, 95% CI$=0.447$–0.730, $P<.001$) and the lateral offset ratio increased by approximately 3.693 ($B=3.693$, 95% CI$=1.256$–6.131, $P=.003$). There was no significant linear relationship between the neck-preserving ratio and the canal fill ratio ($B=0.073$, 95%

Table 3

Complications in different groups.

Complications	Group A	Group B	Group C	Chi-squared value	P
None	67 (72.83%)	122 (89.71%)	93 (95.88%)	21.173	**<.001**
Yes	25 (27.17%)	14 (10.29%)	4 (4.12%)		
Periprosthetic fracture	9 (9.78%)	4 (2.94%)	3 (3.09%)		
Dislocation	3 (3.26%)	4 (2.94%)	0 (0.00%)		
Aseptic loosening	3 (3.26%)	2 (1.47%)	0 (0.00%)		
Thigh pain	10 (10.87%)	4 (2.94%)	1 (1.03%)		

The prevalence of complications in each group is described in the parentheses.

Table 4

Correlation coefficients between the neck-preserving ratio and some indicators of the femoral prosthesis position.

	Difference in leg-length	Neck-shaft angle ratio	Canal fill ratio	Anterior-posterior offset ratio	Lateral offset ratio
R	0.040	−0.308	0.078	0.415	0.164
P	.469	**<.001**	.174	**<.001**	**.003**

Spearman correlation analysis was used.

Table 5

Linear (or logistic) regression analyses of the neck-preserving ratio vs characteristics of and complications related to the femoral prosthesis.

	B (or odds ratio)	95% CI	P
Difference in leg length	0.491*	−3.633 to 4.615	.815
Neck-shaft angle ratio	−0.232*	−0.311 to −0.154	<.001
Canal fill ratio	0.073*	−0.033 to 0.180	.174
Anterior-posterior offset ratio	0.589*	0.447–0.730	<.001
Lateral offset ratio	3.693*	1.256–6.131	.003
Periprosthetic fractures			
No	Ref.		
Yes	0.924†	0.859–0.994	.035
Dislocation			
No	Ref.		
Yes	0.892†	0.796–0.999	.048
Aseptic loosening			
No	Ref.		
Yes	0.945†	0.855–1.045	.268
Neck absorption			
No	Ref.		
Yes	1.008†	0.886–1.147	.903
Thigh pain			
No	Ref.		
Yes	0.886†	0.818–0.960	.003

CI = confidence interval.
* Logistics analyses.
† Linear analyses.

CI = −0.033 to 0.180, $P = .174$). In logistic regression analyses, a sufficient neck-preserving ratio was a protective factor for periprosthetic fractures (OR = 0.924, 95% CI = 0.859–0.994, $P = .035$), dislocations (OR = 0.892, 95% CI = 0.796–0.999, $P = .048$), and thigh pain (OR = 0.886, 95% CI = 0.818–0.960, $P = .003$).

4. Discussion

To our knowledge, no data regarding the relationship between the length of the remaining femoral neck and patient outcome are available in the literature. However, as a neck-preserving prosthesis, incorrect osteotomy position might potentially be associated with malpositioning of CFP stems and further result in a poor prognosis.[15]

In this study, there was a significantly negative correlation between the neck-shaft angle ratio and the neck-preserving ratio ($r = −0.308$, $P < .001$). Meanwhile, for 1 increase in the neck-preserving ratio, the neck-shaft angle ratio decreased by 0.232 ($B = −0.232$, 95% CI = −0.311 to −0.154, $P < .001$). An obvious varus malposition of the stem is often observed in patients with an insufficient neck-preserving ratio (Fig. 2). Because the neck-shaft angle is a fixed value for a certain femoral stem, when the stem is inserted in a varus malposition, there might be an increase in the angle ratio between the femoral neck and the prosthetic neck. This is the most important finding in the current study, which is also the reason for other clinical and radiologic change that affect the patient outcome.[16] Shoji et al[17] demonstrated that the appropriate offset with a low neck-shaft angle increased the range of motion in flexion and internal rotation, and a high neck-shaft angle increased the range of motion in external rotation. He also confirmed that using implants properly can avoid the risk of dislocation in THA. Another study[15] confirmed that compared with conventional prostheses, prostheses with CFP stems can lower the prevalence of dislocation. The author thought this could be due to a more correct reconstruction of hip biomechanics with the use of a CFP stem. Furthermore, there is also a positive correlation between the neck-preserving ratio and offset ratio. For 1 increase in the neck-preserving ratio, there is a 0.589 increase in the anterior-posterior offset ratio and a 3.693 increase in the lateral offset ratio. We consider that this result is partially because of the unique design of the curved CFP stem. When the femoral neck is preserved, the stem can be placed more lateral to the femoral cannel, which can lead to a decrease in offset.[18] On the contrary, as described above, an insufficient neck-preserving ratio leads to a decreased neck-shaft angle ratio, which further leads to a decrease in the offset ratio. Thus, the prevalence of dislocation might be elevated as a consequence of the decreased abductor force, which is caused by the decrease in offset ratio.[19] Similar to our study, You et al reported a dislocation prevalence of 2.17%. He thought that the use of CFP lowered the prevalence of dislocation compared with conventional arthroplasty with a regular prosthesis.[20,21] This finding
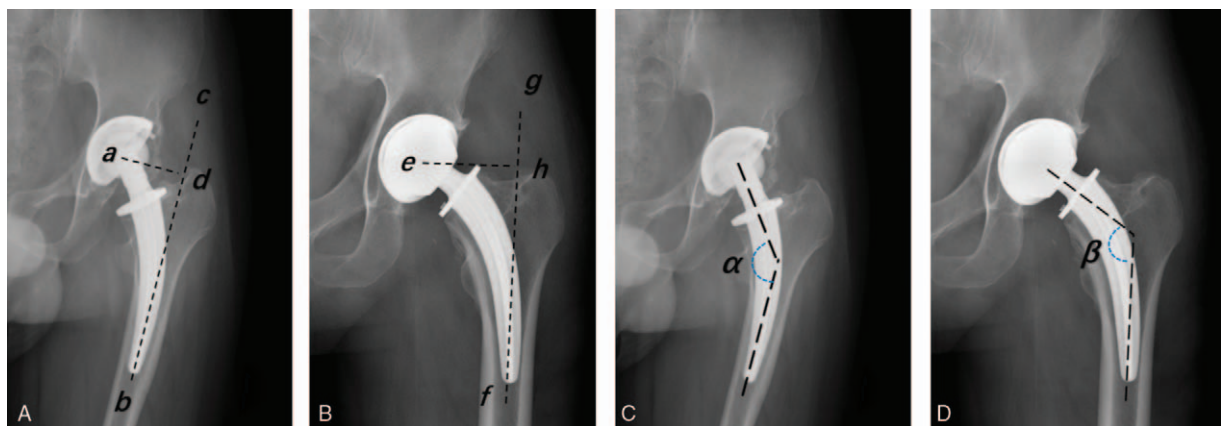
Figure 2. Comparisons of anterior-posterior offset ratio and neck-shaft angle ratio in 2 patients. The neck-preserving ratio in the 1st patient (A and C) was 51.08%, the anterior-posterior offset ratio was 96.89%, and the neck-shaft angle ratio was 102.74%. The neck-preserving ratio in the second patient (B and D) was 79.50%, the anterior-posterior offset ratio was 120.67%, and the neck-shaft angle ratio was 95.34%.
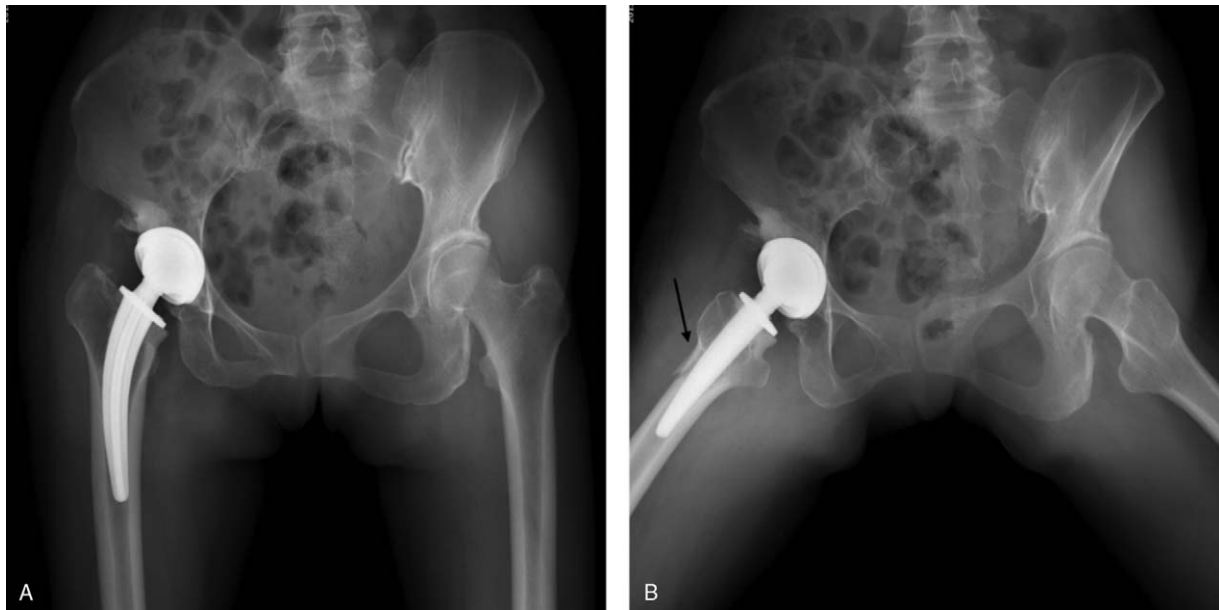
Figure 3. (A) A 50-year-old female patient with osteonecrosis of the femoral head in the right hip. The neck-preserving ratio of this patient was 50.68%, and periprosthetic femoral fracture occurred postoperation (the fracture position is the arrow position in B). We confirmed that an insufficient neck-preserving ratio is a certain risk for periprosthetic femoral fractures.

could be due to a more correct reconstruction of hip biomechanics with the incorporation of the CFP prosthesis.[22] He also considered the neck-preserving ratio to be an important factor affecting the prevalence of dislocation.

In group A, there was a relatively higher prevalence of PFFs. Furthermore, an insufficient neck-preserving ratio is also a certain risk for PFFs in the current study. In patients with a normal neck-preserving ratio, the stem is located in the center of the medullary canal with proper intramedullary depth. However, in patients with an insufficient neck-preserving ratio, the stem tends to exhibit varus malpositioning. At the same time, the stem insertion level might be too deep. In this case, the distal-lateral part of the stem is tightly flattened on the lateral femur, and an aggressive compression force might cause PFF.[23,24] Thus, our suggestion is that surgeons should pay additional attention during the operation to sufficiently preserve the femoral neck length and evaluate the patients' femoral neck-preserving ratio preoperatively to help reduce the possibility of PFF (Fig. 3).

In the logistic regression analyses, we determined that the risk of thigh pain increases with a decrease in the neck-preserving ratio (OR = 0.886, 95% CI = 0.818–0.960, P = .003). We consider that a lower neck-preserving ratio may contribute to stress concentration in the distal femoral cortex, which leads to an increase in intramedullary pressure. We deem that the neck-preserving ratio is not the only factor affecting the risk of thigh pain. A meta-analysis[25] showed that the risk of chronic postsurgical pain after THA ranges from 7% to 23%, and persistent thigh pain after short stem THA might no longer be considered a simple transmission of nociception but rather a complex and multidimensional pain experience, implying that the CFP stem has a certain advantage in that aspect after surgery.[26]

Undoubtedly, our study has several limitations. First, the study is retrospectively designed, and the sample size is relatively small. Therefore, some potential relationships might be ignored from the current study. Second, only univariate regressions are used in the study; thus, some confounders might not be found. Finally, this study only had a follow-up time of 2 years. The long-term potential effect of the neck-preserving ratio remains unknown.

5. Conclusion

The current study demonstrates the relationships between the neck-preserving ratio following THA with a CFP stem femoral prosthesis and the short-term clinical and radiologic outcomes of patients. An insufficient neck-preserving ratio is significantly correlated with prosthesis malpositioning and a higher risk of complications. Therefore, surgeons should pay more attention during surgery to obtain a sufficient neck-preserving ratio to improve the outcome for patients undergoing THA with CFP stems.

Author contributions

Conceptualization: Zeming Liu, Jia Huo.
Data curation: Sikai Liu, Mengnan Li, Yongtai Han.
Formal analysis: Sikai Liu, Jia Huo, Mengnan Li, Yongtai Han.
Funding acquisition: Yongtai Han.
Investigation: Hongpeng Hu, Mengnan Li.
Methodology: Zeming Liu, Hongpeng Hu, Jia Huo, Yongtai Han.
Project administration: Zeming Liu, Yongtai Han.
Resources: Mengnan Li.
Software: Hongpeng Hu.
Validation: Jia Huo.
Writing – original draft: Zeming Liu, Yongtai Han.
Writing – review & editing: Zeming Liu, Hongpeng Hu, Yongtai Han.
Yongtai Han orcid: 0000-0002-0401-4210.

References

[1] Briem D, Schneider M, Bogner N, et al. Mid-term results of 155 patients treated with a collum femoris preserving (CFP) short stem prosthesis. Int Orthop 2011;35:655–60.

[2] Huo SC, Wang F, Dong LJ, et al. Short-stem prostheses in primary total hip arthroplasty: a meta-analysis of randomized controlled trials. Medicine 2016;95:e5215.

[3] Ha YC, Koo KH, Jeong ST, et al. Cementless alumina-on-alumina total hip arthroplasty in patients younger than 50 years: a 5-year minimum follow-up study. J Arthroplasty 2007;22:184–8.

[4] Liu B, Ma W, Li H, et al. Incidence, classification, and risk factors for intraoperative periprosthetic femoral fractures in patients undergoing total hip arthroplasty with a single stem: a retrospective study. J Arthroplasty 2019;34:1400–11.

[5] Pipino F, Molfetta L. Femoral neck preservation in total hip replacement. Ital J Orthop Traumatol 1993;19:5–12.

[6] Pipino F, Molfetta L, Grandizio M. Preservation of the femoral neck in hip arthroplasty: results of a 13- to 17-year follow-up. J Orthop Traumatol 2000;1:31–9.

[7] Falez F, Casella F, Papalia M. Current concepts, classification, and results in short stem hip arthroplasty. Orthopedics 2015;38:S6–13.

[8] Banerjee S, Pivec R, Issa K, et al. Outcomes of short stems in total hip arthroplasty. Orthopedics 2013;36:700–7.

[9] Ghera S, Bisicchia S. The collum femoris preserving stem: early results. Hip Int 2013;23:27–32.

[10] Li M, Hu Y, Xie J. Analysis of the complications of the collum femoris preserving (CFP) prostheses. Acta Orthop Traumatol Turc 2014;48:623–7.

[11] Burchard R, Braas S, Soost C, et al. Bone preserving level of osteotomy in short-stem total hip arthroplasty does not influence stress shielding dimensions – a comparing finite elements analysis. BMC Musculoskelet Disord 2017;18:343.

[12] Formica M, Cavagnaro L, Basso M, et al. What is the fate of the neck after a collum femoris preserving prosthesis? a nineteen years single center experience. Int Orthop 2017;41:1329–35.

[13] Lecerf G, Fessy MH, Philippot R, et al. Femoral offset: anatomical concept, definition, assessment, implications for preoperative templating and hip arthroplasty. Orthop Traumatol Surg Res 2009;95:210–9.

[14] Wu T, Ren X, Cui Y, et al. Biomechanical study of three kinds of internal fixation for the treatment of sacroiliac joint disruption using biomechanical test and finite element analysis. J Orthop Surg Res 2018;13:152.

[15] Pipino F, Keller A. Tissue-sparing surgery: 25 years' experience with femoral neck preserving hip arthroplasty. J Orthop Traumatol 2006;7:36–41.

[16] Liu B, Zhu Y, Liu S, et al. National incidence of traumatic spinal fractures in China: data from China National Fracture Study. Medicine 2018;97: e12190.

[17] Shoji T, Yamasaki T, Izumi S, et al. The influence of stem offset and neck shaft angles on the range of motion in total hip arthroplasty. Int Orthop 2016;40:245–53.

[18] Stergios L, Per M, Jan M, et al. A prospective cohort study on the short collum femoris-preserving (CFP) stem using RSA and DXA. Acta Orthop 2013;84:32–9.

[19] Zahar A, Rastogi A, Kendoff D. Dislocation after total hip arthroplasty. Curr Rev Musculoskelet Med 2013;6:350–6.

[20] You RJ, Zheng WZ, Chen K, et al. Long-term effectiveness of total hip replacement with the collum femoris preserving prosthesis. Cell Biochem Biophys 2015;72:43–7.

[21] Liebs TR, Nasser L, Herzberg W, et al. The influence of femoral offset on health-related quality of life after total hip replacement. Bone Joint J 2014;96-B:36–42.

[22] Forde B, Engeln K, Bedair H, et al. Restoring femoral offset is the most important technical factor in preventing total hip arthroplasty dislocation. J Orthop 2018;15:131–3.

[23] Zhang Z, Zhuo Q, Chai W, et al. Clinical characteristics and risk factors of periprosthetic femoral fractures associated with hip arthroplasty: a retrospective study. Medicine 2016;95:e4751.

[24] Li M, Xu C, Xie J, et al. Comparison of collum femoris-preserving stems and ribbed stems in primary total hip arthroplasty. J Orthop Surg Res 2018;13:271.

[25] David BA, Vikki W, Rachael GH, et al. What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients. BMJ Open 2012;2:e000435.

[26] Wacha H, Domsel G, Herrmann E. Long-term follow-up of 1217 consecutive short-stem total hip arthroplasty (THA): a retrospective single-center experience. Eur J Trauma Emerg Surg 2018;44:457–69.