

Complete Joint Capsule-Preserving Posterior Approach in Hemiarthroplasty for Femoral Neck Fractures: A Technical Note and Learning Curve Analysis of Trainee Surgeons

Geriatric Orthopaedic Surgery

& Rehabilitation

Volume 16: 1–9

© The Author(s) 2025

Article reuse guidelines:

sagepub.com/journals-permissions

DOI: 10.1177/21514593251338596

journals.sagepub.com/home/gos



Takashi Fukushima, MD, PhD^{1,2} , Tsuneari Takahashi, MD, PhD² , and Katsushi Takeshita, MD, PhD²

Abstract

Introduction: The posterior approach is widely used in hemiarthroplasty for femoral neck fractures. However, it has a high dislocation rate. In hemiarthroplasty, the joint capsule is commonly incised. This study aimed to identify a posterior surgical technique that completely preserves the joint capsule without incision and the use of special devices to remove the head, perform a trial, and place an implant. Further, the learning curves (LCs) of trainee surgeons and the associated complications of the posterior approach were evaluated via a retrospective case series.

Materials and Methods: The LCs of trainee surgeons for surgical duration and volume of intraoperative blood loss in 60 cases were examined. The surgical procedures were conducted by three trainee surgeons for femoral neck fractures at a single institution between September 2018 and June 2021. Each surgeon consecutively performed 20 surgical procedures. Each surgeon's cases were divided into four groups, with 15 cases each: 1–5, group A; 6–10, group B; 11–15, group C; and 16–20, group D. Then, these cases were analyzed. Surgery-related complications, such as dislocation, femoral fractures, paralysis, and infection were investigated.

Results: The four groups significantly differed in terms of the median operative duration ($P = 0.017$). In particular, there was a significant difference between groups A and C ($P = 0.007$) and between groups A and D ($P = 0.006$). There was an LC for the surgical duration. In 10 cases, the surgical duration was shorter. However, there was no significant difference in the volume of intraoperative blood loss among the four groups. None of the patients presented with dislocation or major complications.

Discussion and Conclusions: An LC was observed for the surgical duration in 10 cases among the trainee surgeons. Moreover, the volume of intraoperative blood loss did not significantly increase during the LC period.

Keywords

hemiarthroplasty, joint capsule, posterior approach, femoral neck fracture, learning curve

Received: 16 December 2024; revised: 21 March 2025; accepted: 13 April 2025

¹Department of Orthopaedic Surgery, Tochigi Medical Center Shimotsuga, Tochigi, Japan

²Department of Orthopaedics, Jichi Medical University, Shimotsuke, Japan

Corresponding Author:

Tsuneari Takahashi, MD, PhD, Department of Orthopaedics, Jichi Medical University, 331 I-I Yakushiji, Shimotsuke, Tochigi 3290498, Japan.

Email: tsuneari9@jichi.ac.jp



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the

SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

Introduction

Hemiarthroplasty is a common procedure in older patients who have sustained a femoral neck fracture. This procedure can facilitate early return to daily activities. Hence, the risk of surgical complications in hemiarthroplasty should be decreased. Among the associated complications of hemiarthroplasty, dislocation is one of the most serious complications. Moreover, it may increase the prevalence of and risk of mortality in older patients.¹ The posterior approach is still used for hemiarthroplasty due to its low volume of blood loss and low risk of hip abductor damage. However, this approach is more associated with a risk of dislocation compared with the anterior approach.^{2,3} The postoperative dislocation rate of hemiarthroplasty using the posterior approach is 5.1%–13%.⁴ Some reports have recommended the anterior approach over the posterior approach for hemiarthroplasty. However, the former is controversial because it is associated with a high risk of femoral fracture and it requires a longer surgical time.^{5–7} However, recently, a posterior approach that preserves the short external rotators has been developed and found to have low dislocation rates. Han et al. reported that 28 patients who underwent hemiarthroplasty with a minimally invasive external rotation-preserving procedure did not present with postoperative dislocation.⁸ Nakamura et al. did not notice postoperative dislocation in 320 patients who underwent hemiarthroplasty with the conjoint tendon-preserving posterior approach.⁴ However, the abovementioned methods involve the incision of the capsule at the same level as the short external rotators. The posterior capsule contributes more to joint stability than the short external rotators.⁹ Even if total hip arthroplasty is performed using the posterior approach, the femoral head could not be dislocated without making an incision in the joint capsule. We developed a posterior surgical technique for hemiarthroplasty that can be used to completely preserve the joint capsule without incision. We hypothesized that there is a learning curve (LC) for this technique, and it can be easily mastered. We aimed to evaluate the use of a surgical technique that completely preserves the strong joint capsule in hemiarthroplasty. Further, the LC of trainee surgeons for surgical duration and volume of intraoperative blood loss and the associated complications of the surgical technique were investigated.

Materials and Methods

Surgical Technique

The surgical technique could be performed under regional or general anesthesia. During the procedure, the patients were placed in the lateral decubitus position. The standard skin incision in the posterior approach was made. After the

gluteus maximus was divided, the fat over the short external rotators was rubbed with gauze to expose the short external rotators. After the quadratus femoris was separated from the femoral attachment site, the space between the short external rotators and the joint capsule was dissected from the superior border of the piriformis muscle using an elevatorium or raspatorium to separate the short external rotators from the femoral attachment site and expose the capsule (Figures 1A and B). Osteotomy was performed with a bone saw at the site of the marginal edge of the capsule at the head–neck junction and at the planned osteotomy line based on the preoperative plan. The neck bone fragments were removed between the two sites (Figure 1C). Based on the fracture site, osteotomy on one side might not be necessary. The remaining femoral head in the joint was made as small as possible with a nucleus pulposus forceps. Then, a power-assisted femoral head extractor was inserted (Figure 2A). After confirming that the head had rotated with the rotation of the femoral head extractor (indicating that the attachment between the head and the capsule was removed), the femoral head extractor was tilted back toward the head, and the head was extracted. If the head could not be removed, the nucleus pulposus forceps was used to further reduce the femoral head size. The capsule was preserved (Figures 2B and C). Next, it was inserted via the helices of the trial cup against the round entrance of the capsule and was implanted with the hole in the trial head facing the ceiling (Figure 2D). If the trial cup could not be inserted into the joint with any method, the size of the trial cup should be reduced. Then, femur broaching was performed to the expected size. In trial reduction, the trial head was fixed to the trial stem and inserted into the joint by riding over the capsule (Figure 3A). Then, with traction on the legs, the trial cup, which had the hole facing the ceiling, was rotated to the proper position (Figures 3B and C). The dislocation test was then performed. In this test, if the leg length was not extremely short and the trial cup was in the proper position, internal rotation in the flexed position would not cause dislocation. Further, it stopped after some degree of internal rotation with braking. The dislocation method was the reverse of the previous procedure. With the leg in traction, the trial cup was turned with the elevatorium, and the hole was pointed toward the ceiling. The trial cup and head could then be disengaged in the joint and dislocated to overcome the capsule. The implanted trial cup was removed by hooking an elevatorium and tipping it cranially. During implant placement, if the bipolar cup and inner head were of the snap-in type, the same method as that used during the trial was applied. If they were not of the snap-in type, the bipolar cup and inner head were assembled first and then inserted into the joint capsule. The stem was fixed to the femur. Subsequently, the inner head and stem were fixed (Figure 3D). The wound was then closed without

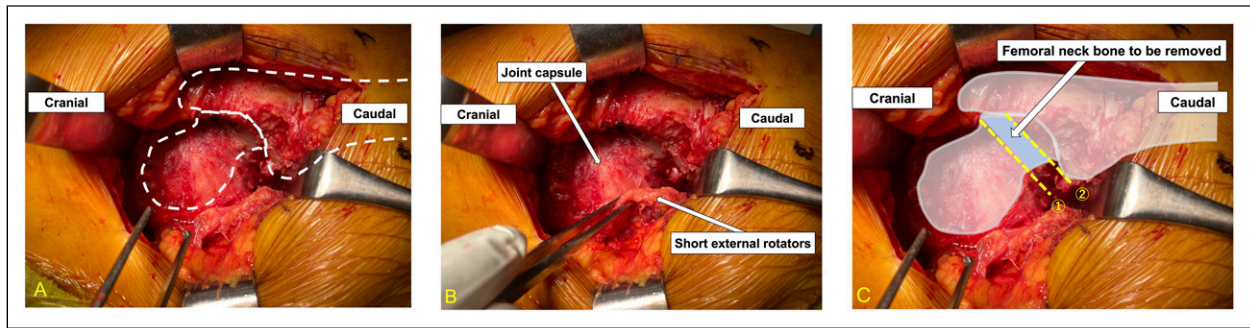


Figure 1. Right Proximal Femur. A Skin Incision was Made, and the Gluteus Maximus Fascia was Incised. The Short External Rotators were Separated From the Femur to Expose the Joint Capsule. The hip Joint was in Internal Rotation. (A) The white Dotted Line Indicates the Proximal Femur. (B) The Short External Rotator Muscles were Grasped Using the Forceps. (C) First, the Yellow Dotted Line Shows the Osteotomy Line at the Edge of the Joint Capsule. Second, the Yellow Dotted Line Shows the Planned Osteotomy Line in the Preoperative Plan. The Neck Bone Fragments were Removed Between the Two Sites.

reconstruction of the short external rotators. No restrictions were imposed on the hip range of motion, and external fixations were not used after surgery.

Case Series

The study was approved by the Institutional Review Board of the author's institution and was exempt from the requirement for informed consent from individual participants due to its retrospective nature and the fact that all patients received standard treatment. This study included 60 (14 men, 46 women) patients with femoral neck fractures at a single institution between September 2018 and June 2021. Three trainee surgeons under fellowship with 4-6 years of experience in orthopedic surgery performed capsule-preserving hemiarthroplasty. Each surgeon conducted the procedure on 20 consecutive patients. Patients with a follow-up period of <6 months were excluded. The stem used was J-taper® (KYOCERA, Kyoto, Japan), and the cup was a snap-in-type DUAL CUPHEAD® (KYOCERA, Kyoto, Japan). Data regarding age at the time of surgery; body mass index (BMI); presence of dementia; follow-up period; general health status; surgery-related complications, such as dislocation, femoral fractures, paralysis, and infection; maximum internal rotation angle at 90° flexion in trial reduction; surgical duration; intraoperative blood loss volume; radiographic findings; and walking ability were collected. The general health status of the patients was assessed using the American Society of Anesthesiologists physical status classification system. The coronal and sagittal alignments of the stem were evaluated using postoperative radiographic images. On the anteroposterior and lateral radiographs, the angle between the axis of the femoral shaft and the stem shaft axis was measured. The coronal alignment of the stem was defined as neutral, valgus (lateral deviation $\geq 3^\circ$), or varus (medial deviation $\geq 3^\circ$). The

sagittal alignment of the stem was defined as neutral, flexed implantation (anterior deviation $\geq 3^\circ$), or extended implantation (posterior deviation $\geq 3^\circ$). On the anteroposterior radiographs, stem subsidence, defined as distalization of the femoral stem in reference to the greater trochanter, was measured. The final assessment of surgery-related complications and radiographic parameters was performed at the final visit. The final assessment of walking ability was conducted 6-12 months after the surgery.

Statistical Analysis

The LC of surgical duration and the volume of intraoperative blood loss among the three trainee surgeons were investigated. Each surgeon's cases were divided into four groups, with 15 cases each: 1-5, group A; 6-10, group B; 11-15, group C; and 16-20, group D. One-way analysis of variance revealed significant differences in terms of surgical duration and the volume of intraoperative blood loss among the four groups. However, because the data did not follow a normal distribution, the Kruskal–Wallis test was used for multigroup testing. Further, post hoc analyses revealed significant differences between the two groups if significant differences were found on the initial comparison analyses among the four groups. $P < .05$ was considered statistically significant. All statistical analyses were performed using SPSS software for Windows, version 26 (IBM Corp., Armonk, NY, USA).

Results

The mean age of the participants was 83.6 (62.0-99.0, SD: 7.5) years, and their mean BMI was 20.5 (15.1-27.7, SD: 2.9) kg/m². Further, 40 (59.1%) of 60 patients presented with dementia, and the mean follow-up period was 13.8 (6.0-35.0, SD: 10.0) months. According to the American

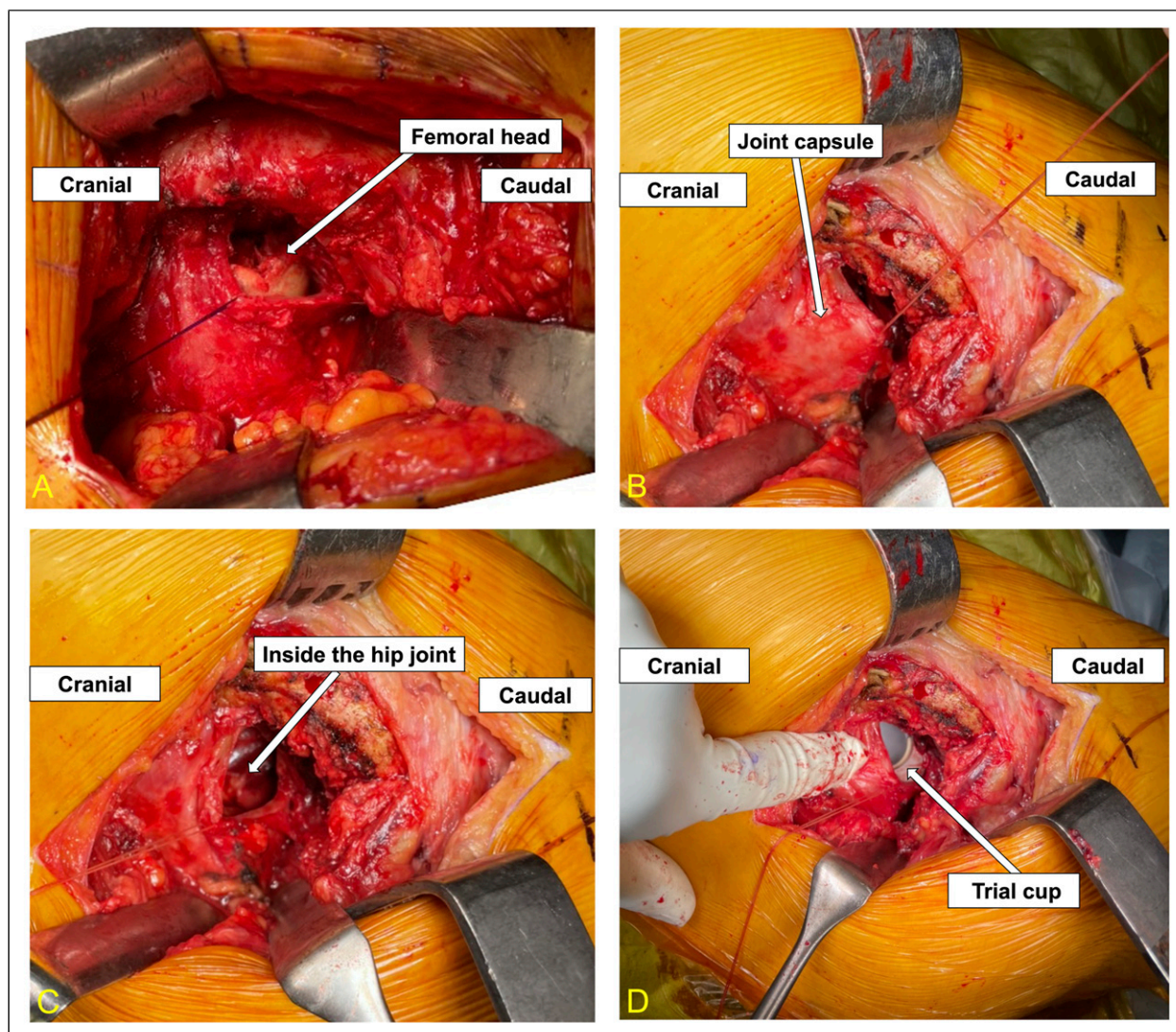


Figure 2. (A) The Neck Bone was Removed, Leaving the Femoral Head within the Joint. A Suture was Pulled Cranially Over the Edge of the Joint Capsule. (B) Power-Assisted Extraction of the Femoral Head and the Preserved Joint Capsule Could be Observed. The Suture was Caudally Pulled Over the Edge of the Joint Capsule. (C) The Suture was Cranially Pulled Over the Edge of the Joint Capsule. (D) The Bipolar Trial was Manually Inserted Into the Joint and Placed with the Hole Facing the Ceiling.

Society of Anesthesiologists physical status classification system, 80% of patients presented with grade II condition and 20% with grade III. The mean surgical time was 70.2 (35.0-115.0, SD: 17.0) min. The mean volume of intraoperative blood loss was 175.8 (25.0-401.0, SD: 88.8) mL, and the mean maximum internal rotation angle at 90° flexion at trial reduction was 63.6° (45.0°-80.0°, SD: 9.6) (Table 1). In all cases, the trial cup was not dislocated during internal rotation in the flexed position, and internal rotation was broken and stopped. No patient presented with dislocation during the observation period. During the observation period, none of the patients experienced other surgery-related complications such as femoral fracture, paralysis, or infection. One patient developed complication

in which the bipolar cup and femoral head could not be fixed on postoperative radiography. The wound was re-expanded and fixed. Regarding coronal stem alignment, varus was observed in one case, valgus in three cases, and neutral in the remaining cases. Regarding sagittal stem alignment, extended implantation was observed in five cases and neutral in the remaining cases. A 4-mm stem subsidence was observed in one case. Regarding walking ability, 32 (53.3%) patients did not require canes or assistance before surgery. However, this number declined to 18 (30%) after the surgery (Table 2).

The median surgical durations of groups A, B, C, and D were 78.0 (70.0-82.5), 70.0 (60.5-80.0), 62.0 (53.5-73.5), and 60.0 (55.0-72.5) min, respectively. Thus, the results

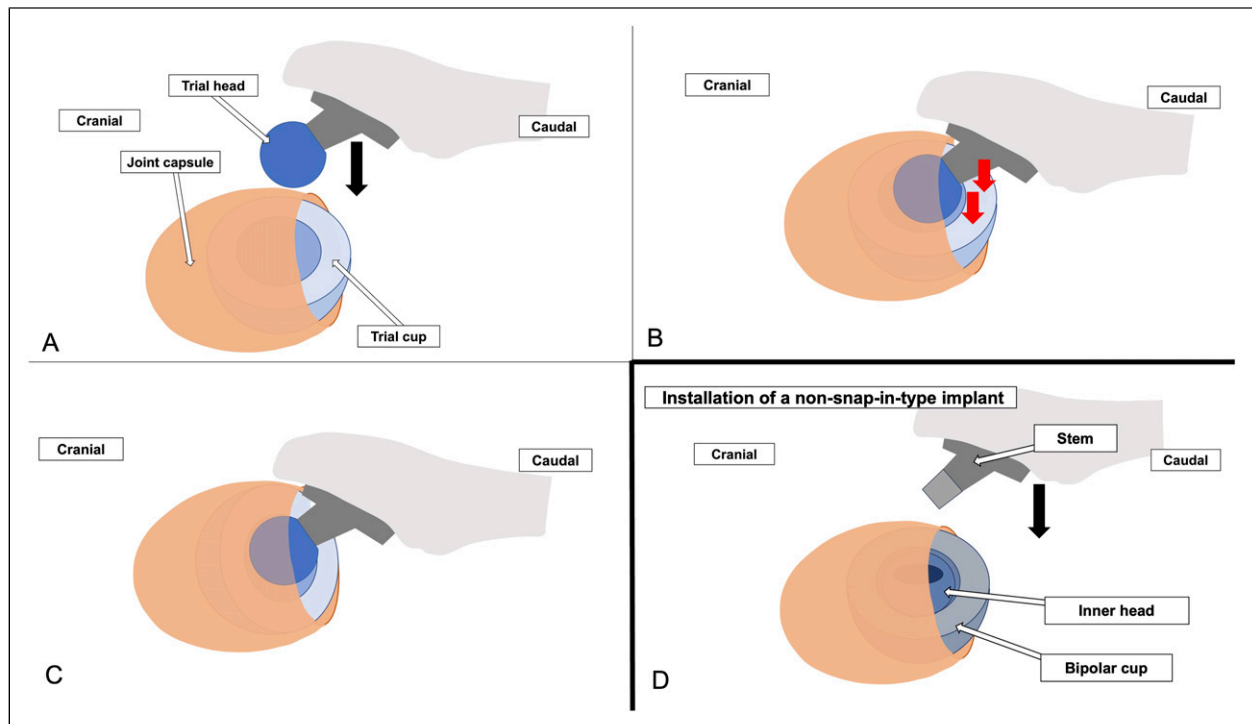


Figure 3. The Trial Reduction Method was Performed while Preserving the Joint Capsule after Rasping. A Snap-in-type Implant was Placed Using the Same Method. (A) The Trial Head was Inserted Into the Joint, Thereby Passing Over the Joint Capsule in the Direction of the Black Arrow. (B) With Traction on the Legs, the Trial cup was Rotated. Hence, the Hole, which Faced the Ceiling, Reached the Proper Position. (C) The Trial cup was now in the Proper Position. (D) Installation of the Non-snap-in-type Implant. The Assembled Bipolar cup and Femoral Head were Inserted Into the Joint Capsule. The Stem was Fixed to the Femur, and the Taper was Fixed within the Joint.

significantly differed among the four groups ($P = .017$). In particular, there was a significant difference between groups A and C ($P = .007$) and between groups A and D ($P = .006$) (Figure 4A). The median volumes of intraoperative blood loss of groups A, B, C, and D were 184.0 (119.0-264.0), 200.0 (156.0-227.5), 150.0 (86.5-185.5), and 110.0 (87.0-194.5) mL. Thus, there were no

significant differences among the four groups (Figure 4B).

Discussion

A posterior approach that can completely preserve the joint capsule in hemiarthroplasty was developed. In joint

Table 1. Characteristics of Patients and Surgical Outcomes.

	Total number of patients (N = 60)
Age (years)	83.6 (62-99, SD: 7.5)
BMI (kg/m^2)	20.5 (15.1-27.7, SD: 2.9)
Patients with dementia, n (%)	40 (59.1%)
Follow-up (months)	13.8 (6-35, SD: 10.0)
ASA score, n (%)	
ASA II	48 (80.0%)
ASA III	12 (20.0%)
Surgical duration (min)	70.2 (35-115, SD: 17.0)
Intraoperative blood loss volume (mL)	175.8 (25-401, SD: 88.8)
Maximum internal rotation angle	63.6 (45-80, SD: 9.6)
At 90° flexion at trial reduction	

BMI, body mass index; SD, standard deviation; ASA, American Society of Anesthesiologists.

Table 2. Walking Status Before and After the Surgery (N = 60).

	Before surgery, n (%)	6-12 months
		After the surgery, n (%)
Not requiring either canes or assistance	32 (53.3%)	18 (30.0%)
Requiring a single cane	13 (21.7%)	15 (25.0%)
Requiring two canes or a walker	9 (15.0%)	12 (20.0%)
Requiring assistance	4 (6.7%)	4 (6.7%)
Unable to walk	2 (3.3%)	10 (16.7%)

capsule-preserving hemiarthroplasty, there was an LC in surgical duration, and the surgical time significantly reduced in 10 cases. However, there was no significant difference in terms of the volume of intraoperative blood loss.

Hemiarthroplasty is commonly performed as an emergency procedure. Hence, it is conducted by surgeons with various skill levels, which may also contribute to the increased postoperative dislocation rate.¹⁰ At our institution, hemiarthroplasty for femoral neck fractures is currently performed by relatively young surgeons. In this report, the three trainee surgeons were under fellowship with 4-6 years of experience in orthopedic surgery. However, no patient developed dislocations after undergoing hemiarthroplasty with the joint capsule-preserving posterior approach.

Furthermore, the LC for surgical duration and volume of intraoperative blood loss was examined. Results showed LC for surgical time, but not for volume of intraoperative blood loss. Bjorgul et al. reported that the duration of hemiarthroplasty using the direct lateral approach performed by residents decreased in 25 cases, with an average surgical time of 92 min.¹¹ Nakamura et al. reported that the

average duration of the conjoined tendon-preserving posterior approach, which preserves the short external rotators, was 70 min.⁴ Using our method, the surgical duration reduced in 10 cases. Considering that the average surgical time is 70.2 min, the surgical method was not challenging. Femoral head removal with preservation of the joint capsule is a time-consuming procedure. The femoral head is not extracted appropriately, the femoral head is cracked, and the surgical duration is long. The femoral head should be reduced in size, as much as possible, to facilitate its smooth removal.

Some reports have recommended the anterior approach due to the high rate of dislocation in hemiarthroplasty using the posterior approach.¹² However, the anterior approach has a longer LC and a comparatively higher risk of complications, particularly in the early stages of implementation, including greater trochanteric fractures, nerve damage, higher volume of blood loss, and longer surgical time.⁵⁻⁷ In this report, one patient developed complication in which the bipolar cup and femoral head were not fixed on postoperative radiography, and the wound was re-expanded and fixed. However, there have been no other major complications related to the

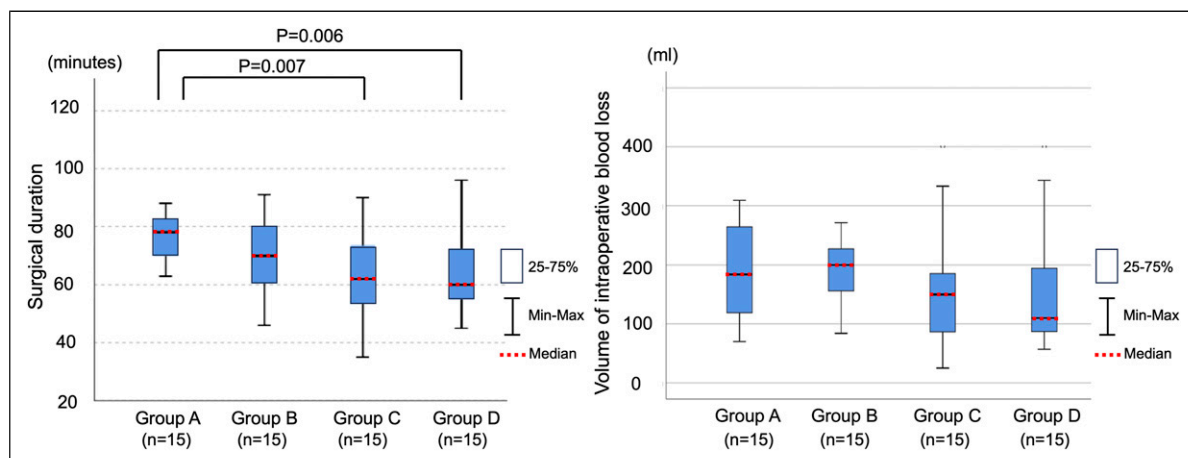


Figure 4. Boxplot Showing the Minimum, Maximum, Median, and First and Third Quartiles. (A) Surgical Duration Among the Groups. Comparison Between Groups Using the Kruskal–Wallis Test. Then, Post hoc Analysis was Performed. (B) Intraoperative Blood Loss Volume Among the Groups.

procedure, such as intraoperative femur fractures. Yoshitani et al. reported that flexed stem implantation can adversely affect intraoperative fracture.²¹ Our surgical technique used the posterior approach, which provides a good field of view and facilitates easy broaching of the stem. Therefore, there were no cases of flexed stem implantation on postoperative radiographic images. Considering these factors, the surgical technique was relatively safe. Further, in recent years, it has been claimed that preoperative planning using artificial intelligence and intraoperative feedback using robots can improve the accuracy of surgical procedures and reduce the risk of complications in THA.²² The introduction of these technologies into hemiarthroplasty can further decrease the risk of complications.

Recent posterior approaches have focused on the short external rotators and joint capsule to prevent dislocation. The methods used to preserve the short external rotators and joint capsule as much as possible have been reported. Nakamura et al. reported the preservation of the piriformis muscle to the inferior psoas muscle. Regarding the joint capsule, the ischiofemoral ligament was preserved.⁴ However, a partial incision was made in the joint capsule, which was then resutured. In this case, we only focused on the joint capsule. Our technique preserves all capsular ligaments, including the ischiofemoral ligament and the zona orbicularis. The posterior joint capsule contributes more to joint stability than the short external rotators, and it is more effective in preventing dislocation in hemiarthroplasty.⁹

Additionally, there is a tissue referred to as the zona orbicularis that circles the femoral neck in the joint capsule. The incision made at the entrance of the joint capsule is always severed. However, with our technique, preservation is possible. The ring band has a locking ring mechanism that contributes to joint stability.¹³ Our technique preserves the posterior joint capsule such as the ischiofemoral ligament and the zona orbicularis. Thus, it has a high resistance to dislocation. In an intraoperative trial, in all cases, the trial cup did not dislocate during internal rotation in the flexed position, and internal rotation was broken and stopped. The dislocation period for hemiarthroplasty is 6 months or less. If there is no dislocation until then, the soft tissue recovers, and it is less likely to dislocate.^{14,15} Therefore, the early postoperative dislocation braking ability is important for the presence or absence of dislocation. Further, reconstruction of the short external rotators and joint capsule reduces the dislocation rate, even with the common posterior approach.¹⁶ The short external rotators in this study were not reconstructed. However, there were no postoperative dislocation cases. Our surgical technique only requires the presence of a complete remaining joint capsule, which allows the strong

braking of the dislocation from the early postoperative period, not the reconstruction of the short external rotators.

Kristensen et al revealed that despite the increased risk of dislocations, the posterior approach results in a favorable quality of life. Nevertheless, this should be specified for mentally competent patients who can comprehend their movement restrictions.¹⁷ The risk of dislocation is particularly high with the posterior approach, particularly in patients with dementia.¹⁸ The conventional posterior approach usually involves movement restrictions and external fixation. However, postoperative movement restrictions are challenging to understand, especially in patients with severe dementia. In this report, the incidence of dementia was 59.1%, which was higher than that in other reports. However, there were no cases of dislocation even without postoperative movement restrictions or external fixation.^{16,19} In addition, external fixation may be associated with an increased risk of postoperative delirium.²⁰ External fixation is not required. Thus, the risk of postoperative delirium can be reduced. Rehabilitation can be facilitated, and an early return to daily life can be expected.

Finally, hemiarthroplasty can also be performed for trochanteric fractures and proximal femoral endoprostheses. The procedure has good outcomes in trochanteric fractures. However, dislocation rates are high among patients undergoing proximal femoral endoprostheses.^{23,24} Therefore, surgery can be performed using the same technique in these cases. However, the evaluation of these cases will be a challenge in the future.

This study had several limitations. First, it only used one type of implant.

If the bipolar cup is not hemispherical and is larger than a hemisphere, it is challenging to insert into the joint capsule. However, in this case, the size of the bipolar cup can be reduced to 1 or 2 mm. Second, based on whether there is a teaching assistant or not, the surgical time and volume of blood loss may be affected. However, results showed that the surgical time decreased as the number of surgeries increased. Third, it is not a controlled trial. Hence, whether this technique has a significantly lower dislocation rate remains unclear.

Conclusion

The trainee surgeons presented with an LC for the surgical duration in 10 cases. Moreover, the volume of blood loss did not significantly increase during the LC period.

Acknowledgments

We want to thank Drs. Saki Onuma, Ko Hirata, and Takahiro Suzuki for performing this procedure.

ORCID iDs

Takashi Fukushima  <https://orcid.org/0000-0001-9276-2704>

Tsuneari Takahashi  <https://orcid.org/0000-0002-4198-6684>

Ethical Considerations

This study received ethical approval from Tochigi Medical Center Shimotsuga under the protocol number 219.

Consent to Participate

Considering of the retrospective nature of the study, the need for a formal written informed consent was waived.

Consent to Publish

This study was conducted in accordance with the principles of the Declaration of Helsinki. Our institute's Bioethics Committee for Medical Research approved the study and waived the requirement for informed consent from individual participants due to the study's retrospective nature. All patients received standard treatment (Approval ID: 219, Approval date: August 1, 2024).

Authors Contributions

Data collection and/or processing: T.F.; Analysis and/or interpretation: T.F, T.T.; Literature search: T.F.; Writing: T.F, T.T.; Critical review: T.T, K.T.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Declaration of Conflicting Interest

The authors declare that they have no relevant financial or non-financial interests to report.

Data Availability Statement

Derived data supporting the findings of this study are available from the corresponding author on request.

References

- Petersen MB, Jørgensen HL, Hansen K, Duus BR. Factors affecting postoperative mortality of patients with displaced femoral neck fracture. *Injury*. 2006;37(8):705-711. doi:10.1016/j.injury.2006.02.046
- Moore AT. The self-locking metal hip prosthesis. *J Bone Joint Surg Am*. 1957;39(4):811-827.
- Hardinge K. The direct lateral approach to the hip. *J Bone Joint Surg Br*. 1982;64(1):17-19. doi:10.1302/0301-620X.64B1.7068713
- Nakamura T, Yamakawa T, Hori J, et al. Conjoined tendon preserving posterior approach in hemiarthroplasty for femoral neck fractures: a prospective multicenter clinical study of 322 patients. *J Orthop Surg*. 2021;29(3):23094990211063963. doi:10.1177/23094990211063963
- Pala E, Trono M, Bitonti A, Lucidi G. Hip hemiarthroplasty for femur neck fractures: minimally invasive direct anterior approach versus postero-lateral approach. *Eur J Orthop Surg Traumatol*. 2016;26:423-427. doi:10.1007/s00590-016-1767-x
- Tsukada S, Wakui M. Minimally invasive intermuscular approach does not improve outcomes in bipolar hemiarthroplasty for femoral neck fracture. *J Orthop Sci*. 2010;15(6):753-757. doi:10.1007/s00776-010-1541-6
- Langlois J, Delambre J, Klouche S, Faivre B, Hardy P. Direct anterior Hueter approach is a safe and effective approach to perform a bipolar hemiarthroplasty for femoral neck fracture: outcome in 82 patients. *Acta Orthop*. 2015;86(3):358-362. doi:10.3109/17453674.2014.1002987
- Han SK, Kim YS, Kang SH. Treatment of femoral neck fractures with bipolar hemiarthroplasty using a modified minimally invasive posterior approach in patients with neurological disorders. *Orthopedics*. 2012;35(5):e635-e640. doi:10.3928/01477447-20120426-15
- Takao M, Otake Y, Fukuda N, Sato Y, Armand M, Sugano N. The posterior capsular ligamentous complex contributes to hip joint stability in distraction. *J Arthroplast*. 2018;33(3):919-924. doi:10.1016/j.arth.2017.10.026
- Svenøy S, Westberg M, Figved W, et al. Posterior versus lateral approach for hemiarthroplasty after femoral neck fracture: early complications in a prospective cohort of 583 patients. *Injury*. 2017;48(7):1565-1569. doi:10.1016/j.injury.2017.03.024
- Bjorgul K, Novicoff WM, Saleh KJ. Learning curves in hip fracture surgery. *Int Orthop*. 2011;35:113-119. doi:10.1007/s00264-010-0950-7
- Manzo MA, Hali K, Koucheiki R, Wolfstadt JJ, Edwards TC, Lex JR. Complications and early recovery following hip hemiarthroplasty through the direct anterior approach: a systematic review and meta-analysis. *Eur J Orthop Surg Traumatol*. 2023;33(8):3267-3286. doi:10.1007/s00590-023-03603-0
- Ng KCG, Jeffers JRT, Beaulé PE. Hip joint capsular anatomy, mechanics, and surgical management. *J Bone Joint Surg Am*. 2019;101(23):2141-2151. doi:10.2106/JBJS.19.00346
- Mukka S, Lindqvist J, Peyda S, et al. Dislocation of bipolar hip hemiarthroplasty through a postero-lateral approach for femoral neck fractures: a cohort study. *Int Orthop*. 2015;39:1277-1282. doi:10.1007/s00264-014-2642-1
- Salem KM, Shannak OA, Scammell BE, Moran CG. Predictors and outcomes of treatment in hip hemiarthroplasty dislocation. *Ann R Coll Surg Engl*. 2014;96(6):446-451. doi:10.1308/003588414X13946184903045
- Kim Y, Kim JK, Joo IH, Hwang KT, Kim YH. Risk factors associated with dislocation after bipolar hemiarthroplasty in elderly patients with femoral neck fracture. *Hip Pelvis*. 2016;28(2):104-111.

17. Kristensen TB, Vinje T, Havelin LI, Engesaeter LB, Gjertsen JE. Posterior approach compared to direct lateral approach resulted in better patient-reported outcome after hemiarthroplasty for femoral neck fracture. *Acta Orthop*. 2017; 88:29-34. doi:[10.1308/003588414X13946184903045](https://doi.org/10.1308/003588414X13946184903045)
18. Jobory A, Kärholm J, Hansson S, Åkesson K, Rogmark C. Dislocation of hemiarthroplasty after hip fracture is common and the risk is increased with posterior approach: result from a national cohort of 25,678 individuals in the Swedish Hip Arthroplasty Register. *Acta Orthop*. 2021;92(4):413-418. doi:[10.1308/003588414X13946184903045](https://doi.org/10.1308/003588414X13946184903045)
19. Rogmark C, Fenstad AM, Leonardsson O, et al. Posterior approach and uncemented stems increases the risk of re-operation after hemiarthroplasties in elderly hip fracture patients. *Acta Orthop*. 2014;85(1):18-25. doi:[10.3109/17453674.2014.885356](https://doi.org/10.3109/17453674.2014.885356)
20. Unal N, Guvenc G, Naharci M. Evaluation of the effectiveness of delirium prevention care protocol for the patients with hip fracture: a randomised controlled study. *J Clin Nurs*. 2022;31(7-8):1082-1094. doi:[10.1111/jocn.15973](https://doi.org/10.1111/jocn.15973)
21. Yoshitani J, Kabata T, Kajino Y, et al. The effect of flexion alignment in total hip arthroplasty with a cementless tapered-wedge femoral stem. *Eur J Orthop Surg Traumatol*. 2018; 28(8):1625-1632. doi:[10.1007/s00590-018-2227-6](https://doi.org/10.1007/s00590-018-2227-6)
22. Andriollo L, Picchi A, Iademarco G, et al. The role of artificial intelligence and emerging technologies in advancing total hip arthroplasty. *J Pers Med*. 2025;15(1):21. doi:[10.3390/jpm15010021](https://doi.org/10.3390/jpm15010021)
23. Andriollo L, Sangaletti R, Are L, Perticarini L, Benazzo F, Rossi SMP. Uncemented hemiarthroplasty may have a role in the treatment of unstable intertrochanteric fractures in elderly patient. a survival complications and functional outcomes analysis. *Int J Burns Trauma*. 2023;13(3): 126-135.
24. Henderson ER, Keeney BJ, Pala E, et al. The stability of the hip after the use of a proximal femoral endoprosthesis for oncological indications: analysis of variables relating to the patient and the surgical technique. *Bone Joint Lett J*. 2017; 99-B(4):531-537. doi:[10.1302/0301-620X.99B4.BJJ-2016-0960.R1](https://doi.org/10.1302/0301-620X.99B4.BJJ-2016-0960.R1)