Conjoined tendon preserving posterior approach in hemiarthroplasty for femoral neck fractures: A prospective multicenter clinical study of 322 patients

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Abstract

Purpose: The posterior approach is widely used in femoral hemiarthroplasty. The major problem with this approach is the high risk of postoperative dislocation. A modified posterior approach, the conjoined tendon preserving posterior approach (CPP), was developed to reduce postoperative dislocations. The objective of this multicenter study was to evaluate the efficacy and safety of hemiarthroplasty performed using the CPP approach for femoral neck fractures.

Methods: A total of 322 patients with femoral neck fracture, from 10 facilities, were prospectively studied. Bipolar hemiarthroplasty using the CPP approach was performed, using the same type of implants. Hip joint movement was not restricted following surgery, regardless of a patient’s cognitive status. Final follow-up was performed 9.1 ± 1.5 months after surgery.

Results: Hemiarthroplasty was undertaken in 320 patients using the CPP approach. The mean age, operative time, and intraoperative blood loss were 83.3 ± 7.4 years, 70.0 ± 22.7 min, and 134.8 ± 107.9 mL, respectively. No postoperative dislocations were observed during the study period. Intraoperative adverse events related to the hip joint included femoral fractures in five patients (1.6%) and trochanteric fractures in four patients (1.3%). Postoperative hip joint adverse events included a periprosthetic fracture in one patient (0.3%), deep infection in two patients (0.6%), and stem subsidence in one patient (0.3%). Postoperative deaths occurred in 23 patients (7.2%). One patient (0.3%) had a severe non-hip adverse event unrelated to surgery that prevented independent living, while five patients (1.6%) had a moderate non-hip adverse event that required treatment.

Conclusion: The CPP approach prevented postoperative dislocation following femoral hemiarthroplasty in elderly patients, with no CPP-associated specific adverse events.

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Introduction

Hemiarthroplasty is commonly performed for displaced femoral neck fractures in relatively inactive older patients. Surgeons can use a posterior, anterior, or lateral approach, each of which presents advantages and disadvantages. The posterior approach for hemiarthroplasty is used widely throughout the world as it provides easy exposure, a short operative time, and a low incidence of postoperative gait disturbances. However, postoperative posterior dislocation is a major complication of this approach, with 5.1% to 13% of patients experiencing a dislocation. Various studies have indicated that the posterior approach has a higher dislocation rate than anterior and lateral approaches. Postoperative dislocation is an important complication that adversely affects the quality of life and mortality of patients. The risk of dislocation in patients with femoral neck fractures may be increased by the enhanced postoperative hip range of motion, which can occur due to the absence of joint contracture and the concomitant presence of dementia and postoperative delirium. Since hemiarthroplasty is usually performed as an emergency procedure, it is performed by surgeons with various skill levels, which may also contribute to the increased postoperative dislocation rate.

Svenøya et al. found an 8-fold increase in the risk for prosthetic dislocations after the posterior approach compared to that after the lateral approach, and the high risk for recurrent prosthetic dislocations was followed by poor end results. Consequently, they recommended against the use of the posterior approach. Sijp et al. also reported that performing hemiarthroplasty through the posterior approach should be reconsidered since it is associated with higher rates of postoperative dislocation than other approaches and does not provide any major advantage. Thus, if hemiarthroplasty is performed through the posterior approach for femoral neck fractures, the procedure should be refined to prevent postoperative dislocations.

However, it is preferable to avoid imposing restrictions on motion and using additional equipment, which may delay rehabilitation. In fact, these measures are not applicable to patients with dementia. A stable hip joint regardless of any leg positions adopted by patients with dementia is the requirement of any surgical reconstruction. As for total hip arthroplasty (THA) with the posterior approach, Kim et al. reported that the incidence of postoperative dislocation was reduced by the minimally invasive external rotation preserving procedure (MIS-ERP), which preserves muscles ranging from the piriformis to the internal obturator. Han et al. reported that no postoperative dislocation was detected in 28 patients who underwent hemiarthroplasty performed with a similar procedure. At our institution, hemiarthroplasty had also been performed with the MIS-ERP. However, postoperative dislocation occurred with this approach. Therefore, since 2015 hemiarthroplasty has been performed in our institution using an approach that preserves the areas of the short external rotator muscles and capsular ligament through caudal expansion in order to achieve increased joint stability and prevent dislocation. This prospective multicenter study aimed to evaluate the efficacy and safety of hemiarthroplasty performed for femoral neck fractures through a conjoined tendon preserving posterior (CPP) approach. This approach preserves the piriformis muscles and the conjoined tendon composed of the superior gemellus, internal obturator, and inferior gemellus muscles, as well as the joint capsule covered by the conjoined tendon. We hypothesized that the CPP approach would therefore reduce the rate of postoperative dislocation compared to that occurring with other posterior approaches.

Materials and methods

Patient cohort

All institutions received approval from their respective ethics committees to participate in this study (overarching approval number, 55–19), which was conducted at 10 institutions between 1 January 2017 and 11 May 2018. Patients with femoral neck fractures aged ≥70 years or those aged <70 years with poor general health or frailty were included. Patients with concomitant acetabular dysplasia or hip deformity were excluded. After consent was obtained from patients or their families if they had dementia, 322 patients were enrolled. In all patients, Taperloc (Zimmer Biomet, Warsaw, IN) with a proximal press-fit design was used as the femoral stem, and RINGLOC Bipolar Cup (Zimmer Biomet, Warsaw, IN) was used as the bipolar head.

Surgical procedure

The procedure was performed with the patients in a lateral decubitus position with the affected side up. A straight skin incision of approximately 9 cm was made from the center of the vastus ridge in a proximal posterior direction with the body axis tilted at approximately 30° (Figure 1(a)).
The gluteus maximus was bluntly separated to expose the short external rotator muscles. The joint capsule was then incised along the caudal margin of the inferior gemellus muscle. Subsequently, the proximal part of the quadratus femoris and external obturator muscles and the joint capsule were resected en bloc in an “L” shape at the greater trochanter attachment site and inverted (Figure 1(b)). The femoral head was disconnected at the fracture site. After the femoral neck was cut along the final osteotomy line, the femoral head was removed using a corkscrew (Figure 1(c)). Next, the hip joint was flexed, adducted, and internally rotated to manipulate the femur in a similar way to the classical approach, followed by implant insertion (Figures 1(d) and (e)). Reduction of the bipolar head into the acetabulum was performed with the hip joint flexed approximately 90° and slightly abducted to minimize strain on the conjoined tendon. After reduction, the bipolar head was covered with the preserved external rotator muscles and the joint capsule to leave its lower margin slightly visible (Figure 1(f)). The external obturator and quadratus femoris muscles were repaired to the greater trochanteric region in a pull-out fashion, while the joint capsule was sutured side-to-side (Figure 1(g)). After surgery, gait training without weightbearing restrictions and strength and range of motion exercises were performed within tolerable pain levels. The hip precautions with the prescription of postoperative equipment and restrictions to functional activities were not taken.

**Assessment parameters**

The dislocation rate and adverse events were investigated as primary endpoints. Height, weight, body mass index (BMI), cognitive status, general health status, age at the time of surgery, operative time, volume of intraoperative blood loss, radiographs, and walking ability were investigated.

Figure 1. Black line shows the skin incision in the left hip joint in the conjoined-preserving posterior approach; the dotted line shows the lateral margin of the femur; and the asterisk identifies the vastus ridge (a). The white line indicates the L-shaped resection line on the external rotator muscles and the joint capsule, while the dotted line shows the posterior border of the greater trochanter (b). The femoral head was removed using a corkscrew (c). The retractors exposed the osteotomized femoral neck between the inferior gemellus and quadratus femoris muscles. The dotted line shows the lateral margin of the greater trochanter (d). The hip joint was flexed, adducted, and internally rotated to insert the implant (e). The bipolar head was covered with the preserved external rotator muscles and the joint capsule to leave its lower margin slightly visible after repositioning the head prosthesis (f). The external obturator and quadratus femoris muscles were repaired to the greater trochanter in a pull-out fashion (black arrow) and the joint capsule sutured side-to-side (white arrow). The dotted line shows the posterior border of the greater trochanter (g). Notes: BH: bipolar head; C: capsule (ischiofemoral ligament); EO: external obturator muscle; FN: osteotomized femoral neck; IG: inferior gemellus muscle; IO: internal obturator muscle; Q: quadratus femoris muscle; SG: superior gemellus muscle.
as secondary endpoints. Cognitive status was assessed by the independence degree criteria in daily living for elderly people with dementia (Ministry of Health, Labour and Welfare, Japan). The general health status of the patients was assessed according to the American Society of Anesthesiologists physical status classification system. The final assessment was performed 6–12 months postoperatively.

Statistical analysis

The postoperative dislocation rate of the CPP approach was compared to the rates of other posterior approaches that had been performed previously at our institution. The posterior approaches that were compared were as follows: (1) classical posterior approach with 1–2 weeks of postoperative restriction of hip motion (4 postoperative dislocations in 157 patients); (2) posterior approach with postoperative repair of the external rotators and joint capsule as a single mass without postoperative restriction of hip motion (2 postoperative dislocations in 37 patients); and (3) piriformis muscle-sparing posterior approach without postoperative restriction of hip motion (2 postoperative dislocations in 101 patients). These procedures were performed in a numbered transition in our institution between 2006 and 2015. The mean operative time in this study was compared to the mean operative time of 80.5 ± 17.3 min (range, 52–144 min) in 68 patients who underwent surgery at our institution using the CPP approach prior to this study being conducted. A statistical software package (EZR, Saitama Medical Center, Jichi Medical University, Saitama, Japan) was used to analyze the results. All the values are presented as the mean ± standard deviation (SD). Fisher’s exact test was used to compare the dislocation rates between CPP and the other posterior approaches. Student’s t-test was used to compare the mean operative time between the two groups. p values <0.05 were considered statistically significant.

Results

Demographics

In 2 of the 322 enrolled patients, the surgical procedure was changed to THA before surgery, resulting in 320 patients undergoing hemiarthroplasty with a CPP approach. The mean age, height, weight, and BMI were 83.3 ± 7.4 years, 153.0 ± 8.6 cm, 48.7 ± 9.7 kg, and 20.7 ± 3.3 kg/m², respectively (Table 1). In total, 28.4% of patients had severe dementia according to the independence degree criteria in daily living for elderly people with dementia (Ministry of Health, Labour and Welfare, Japan) and 20.3% patients had severe systemic disease graded Class III or higher according to the American Society of Anesthesiologists physical status classification system (Table 1).

| Table 1. Patient characteristics. |
|---------------------------------|
| Total, n = 320                  |
| Height (cm)                    | 153.0 ± 8.6 (130–180)*       |
| Weight (kg)                    | 48.7 ± 9.7 (28–81)*          |
| Body mass index (kg/m²)        | 20.7 ± 3.3 (11.4–28.9)*      |
| Age at the time of surgery (years) | 83.3 ± 7.4 (57–104)*        |
| Dementia status, n (%)         |
| Not affected                   | 110 (34.4%)                  |
| Independent                    | 72 (22.5%)                   |
| Able to care for oneself       | 44 (13.8%)                   |
| Requiring care                 | 48 (15.0%)                   |
| Always requiring care          | 32 (10.0%)                   |
| Requiring special treatment    | 11 (3.4%)                    |
| Unknown                        | 3 (0.9%)                     |
| ASA score, n (%)               |
| ASA I                          | 43 (13.4%)                   |
| ASA II                         | 212 (66.3%)                  |
| ASA III                        | 63 (19.7%)                   |
| ASA IV or higher               | 2 (0.6%)                     |

Abbreviations: ASA, American Society of Anesthesiologists physical status classification system.
*Mean ± standard deviation (minimum–maximum).

Operative details

The surgeons’ experience ranged from residents supervised by senior surgeons to surgeons with 30 years’ experience. The mean operative time was 70.0 ± 22.8 min (range, 28.0–179.0 min), which was significantly shorter than the mean operative time of 80.5 ± 17.3 min (range, 52-144 min) for the CPP approach performed at our institution before this study (p = 0.001). The mean volume of intraoperative blood loss was 134.8 ± 107.9 mL (range, 10–800 mL). A complete tear of the inferior gemellus muscle was intraoperatively detected in 14 of 320 patients (4.4%) who underwent hemiarthroplasty with the CPP approach. In 32 patients (10%), the capsulotomy was extended proximally from the caudal aspect of the inferior gemellus muscle to facilitate intraoperative maneuvers (Table 2). The observed intraoperative adverse events related to the hip joint included femoral fractures in five patients (1.6%) and fractures of the greater trochanter or trochanteric region in four patients (1.3%). Femoral fractures required additional wiring fixation (Table 3).

Primary endpoints

The observed postoperative adverse events related to the hip joint included a periprosthetic fracture in one patient, deep infection in two patients, and stem subsidence >1 cm in one patient. These patients underwent additional surgery and were lost to follow-up at this time point (Table 3). Postoperative deaths occurred in 23 patients (7.2%). The
Table 2. Surgical outcomes of the conjoined tendon preserving posterior approach.

|                               | Total, n = 320 |
|-------------------------------|--------------|
| Operative time (min)          | 70.0 ± 22.8 (28–179)* |
| Incision length (cm)          | 9.7 ± 1.6 (7–16)*  |
| Blood loss (mL)               | 134.8 ± 108.0 (10–800)* |
| Complete tear of the inferior gemellus muscle | 14 (4.4%)* |
| Capsulotomy extended proximally from the caudal aspect of the inferior gemellus muscle | 32 (10%)* |

*mean ± standard deviation (minimum–maximum); **, total number (%).

Discussion

In this multicenter study, patients with severe dementia accounted for 28.4% of participants, and surgery was performed by surgeons with varying skill levels, including residents. Thus, this study was conducted under conditions in which postoperative dislocation was likely to occur.6,9 Despite having only analyzed the short-term outcomes, we found no cases of postoperative dislocation after hemiarthroplasty using the CPP approach even when no restrictions were imposed on the hip range of motion and no external fixations were used after surgery. The postoperative dislocation rate observed in this study was significantly lower or tended to be lower than that of other posterior approaches that preserved less of the external rotator muscles and joint capsule. This suggests that the primary objective of joint stability by preserving most of the short external rotator muscles and the capsule was achieved. In addition, repair of the resected external obturator muscle and the joint capsule may have also contributed to joint stability.

Previous reports have described modifications to surgical procedures made to reduce the incidence of postoperative dislocations after hemiarthroplasty or THA with the posterior approach.11,12,14,15 In THA, the postoperative dislocation rate can be reduced by repairing the short external rotator muscles and joint capsule.14,15 However, the repaired short external rotator muscles and joint capsule have been reported to rupture soon after surgery,16,17 and follow-up magnetic resonance imaging of the repaired short external rotator muscles revealed atrophy in most cases.18 These reports suggest that when the short external rotator muscles and joint capsule are not resected but preserved during surgery, a more stable hip joint can be achieved, which may contribute to reducing the rate of postoperative dislocations. After performing hemiarthroplasty or THA with MIS-ERP, Han et al. and Kim et al. reported an absence of postoperative dislocations.11,12 Although hemiarthroplasty had been performed using MIS-ERP at our institution, postoperative dislocation has been detected. Thus, we determined that more soft tissues should be preserved to achieve a stable hip joint than that preserved by the MIS-ERP.

The short external rotator muscles and the joint capsule help to prevent hip joint dislocation by controlling the dynamic range of motion and through static restriction caused by a wrapping around effect.19 A cadaveric study revealed that subluxation is prevented during hip flexion, adduction, and internal rotation by the ischiofemoral...
ligament, which wraps around the femoral head. Preservation of the ischiofemoral ligament is also expected to exert a wrapping around effect on large prosthetic heads, such as a hemiarthroplasty head. In the CPP approach, preserving most of the ischiofemoral ligament appears to have a significant effect in preventing postoperative dislocations. Thus, in the CPP approach, it is better to avoid capsulotomy at a site proximal to the caudal aspect of the inferior gemellus muscle as much as possible.

Although no cases of postoperative dislocation were detected, there were some cases of complete inferior gemellus tear, and other patients in whom the capsulotomy was intentionally extended proximally from the caudal aspect of the inferior gemellus muscle to obtain a better surgical field. Variations in operative time and volume of intraoperative blood loss were also observed, which may be partly attributable to the fact that the surgeons performing the CPP approach in this study included some residents and surgeons who were performing the approach for the first time. However, the mean operative time in this study was predominantly shorter than the mean time when the CPP approach was initiated at our institution. This may be due to the fact that some of the doctors who participated in this study were already familiar with this approach.

Non-hip joint adverse events such as death occurred in 7% of patients postoperatively, but these adverse events were not related to the surgical approach. However, during surgery, femoral fractures requiring wiring fixation and trochanteric fractures were observed in 1.6% and 1.3% of patients, respectively. Han et al. reported intraoperative femoral fractures in 1 of 39 patients undergoing the standard minimally invasive posterior approach and in 1 of 28 patients undergoing the MIS-ERP approach. In a study of 74 patients who underwent hemiarthroplasty with uncemented stems, Inngul et al. reported 9 (12.2%) cases of intraoperative femoral fracture and 4 (5.4%) cases of greater trochanteric fractures. Thus, the incidence of intraoperative fractures in this study cannot be considered high. In this study, in which uncemented stems with the same metaphyseal fixation type were used in all patients, the observed intraoperative fractures may be attributable to the fact that some surgeons were not familiar with the use of the stem.

Table 3. Adverse events.

| Patients with intraoperative adverse events n (%) | Patients with postoperative adverse events n (%) | Treatment | Patients lost to follow-up n |
|-----------------------------------------------|-----------------------------------------------|-----------|----------------------------|
| **Hip joint-related adverse events**          |                                               |           |                            |
| Femoral fracture                             | 5 (1.6%)                                      | Wiring    | 0                          |
| Trochanteric fracture                         | 1 (0.3%)                                      | None      | 0                          |
| Greater trochanteric fracture                 | 3 (0.9%)                                      | None      | 0                          |
| Periprosthetic fracture                       | N/A                                           | Revision surgery | 1                        |
| Deep infection                                | N/A                                           | Stem removal | 2                        |
| Superficial wound infection                   | N/A                                           | None      | 0                          |
| **Stem subsidence**                           |                                               |           |                            |
| >1 cm                                         | N/A                                           | 1 (0.3%) | Revision surgery | 1                        |
| <0.5 cm                                       | N/A                                           | 3 (0.9%) | None                    | 0                          |
| Stem varus tilting >3°                         | N/A                                           | 1 (0.3%) | None                    | 0                          |
| Heterotopic ossification                      | N/A                                           | 1 (0.3%) | None                    | 0                          |
| Postoperative dislocation                     | N/A                                           | 0 (0%)   | N/A                      | 0                          |
| **Non-hip joint adverse events**              |                                               |           |                            |
| Pulmonary embolism (recovery)                 | 1 (0.3%)                                      | N/A       | N/A                      | 0                          |
| Ventricular fibrillation (death)              | N/A                                           | 1 (0.3%) | N/A                      | 1                          |
| Cardiac failure (death)                       | N/A                                           | 3 (0.9%) | N/A                      | 3                          |
| Cardiac failure (recovery)                    | N/A                                           | 2 (0.6%) | N/A                      | 0                          |
| Renal failure (death)                         | N/A                                           | 1 (0.3%) | N/A                      | 1                          |
| Cerebral infarction (death)                   | N/A                                           | 1 (0.3%) | N/A                      | 1                          |
| Cerebral infarction (no recovery)             | N/A                                           | 1 (0.3%) | N/A                      | 0                          |
| Cerebral infarction (amelioration)            | N/A                                           | 1 (0.3%) | N/A                      | 0                          |
| Pneumonia (death)                             | N/A                                           | 8 (2.5%) | N/A                      | 8                          |
| Senility (death)                              | N/A                                           | 3 (0.9%) | N/A                      | 3                          |
| Medical diseases (death)                      | N/A                                           | 2 (0.6%) | N/A                      | 2                          |
| Details unknown (death)                       | N/A                                           | 4 (1.3%) | N/A                      | 4                          |
| Drop foot (no change)                         | N/A                                           | 1 (0.3%) | N/A                      | 0                          |
This study has some limitations. First, it was not a randomized study. From an ethical perspective, we avoided study designs that would require the application of conventional approaches associated with a high risk of dislocation in patients. However, this study was conducted at multiple institutions, and the diverse surgeon profiles are consistent with real-world clinical settings. We considered these points to be the strengths of this study. Second, the rate of patients lost to follow-up was high. We had obtained consent for participation in follow-up observation at 6–12 months post-operation from the patients or their families, but 43 patients did not visit the participating institutions after discharge and could not be reached by telephone because of dementia. As this study was conducted in older patients, including those with dementia, the follow-up rate was low. However, we consider that the lack of postoperative dislocations in the 249 patients undergoing the final follow-up and those lost to follow-up until dropout is a positive result.

Conclusion

When using the posterior approach for hemiarthroplasty for femoral neck fractures, preserving the joint capsule and short external rotator muscles to a greater extent could reduce the incidence of postoperative dislocation without imposing restrictions on the postoperative hip range of motion. The CPP approach prevented postoperative dislocation without procedure-related adverse events and may be effective for hemiarthroplasty in older patients with femoral neck fractures who are likely to have risk factors for postoperative dislocation.

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