

Short-Term Radiographic Result of Cementless Hemiarthroplasty Using Tapered Wedge-Shaped Femoral Component in Older Patients with Femoral Neck Fractures

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Objective: To evaluate the short-term radiographic results of cementless hemiarthroplasty using a tapered wedge-shaped femoral component in elderly patients with displaced femoral neck fracture. Specifically, the authors assessed the prevalence of intraoperative crack and rate of subsidence associated with tapered wedge-shaped femoral component in patients with femoral neck fracture.

Material and Method: Medical records were reviewed of 154 patients that underwent cementless hemiarthroplasty using tapered wedge-shaped femoral component between January 2009 and December 2012. Ninety-five patients had immediate postoperative and 12-month or greater postoperative follow-up radiographs available for reviewing. The average length of radiographic follow-up was 29.8 months. Radiographs from these 95 patients were reviewed to evaluate for intraoperative crack, stability, and subsidence of the femoral component.

Results: From 154 patients, 30 (19.5%) had intraoperative crack of the femoral neck, all of whom were successfully treated with cerclage wiring. The majority of intraoperative crack (86.7%) occurred in patients who were implanted with Corail® stem. Five patients (5.3%) had subsidence greater than 2 mm. Mean subsidence in these five patients was 5.4 mm. No patient was revised due to femoral stem loosening.

Conclusion: Cementless hemiarthroplasty using a tapered wedge-shaped femoral component design is a viable option for treating femoral neck fracture in elderly patients. However, tapered wedge-shaped femoral component, particularly the Corail® stem, is associated with a high incidence of intraoperative crack in these patients population.

Keywords: Cementless, Uncemented, Hemiarthroplasty, Tapered, Wedge-shaped femoral component, Femoral neck fracture

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Hip fracture is a common osteoporotic fracture in the elderly and represents a major public health concern. Hip fracture in the elderly results in serious health consequences, with approximately 10% to 20% mortality over six months and significant loss of mobility⁽¹⁾. Twenty-five percent of those who survive hip fracture require long-term domiciliary care⁽²⁾. As the population of older people continues to increase, the incidence of osteoporotic hip fracture is expected to increase worldwide, especially in Asian countries. It has been estimated that there will be a four-fold increase in osteoporotic hip fractures between 1990 and 2050 (from 1.7 million in 1990 to 6.3 million in 2050)⁽³⁾, with 50% of these fractures predicted to occur in Asia by the next century⁽⁴⁾.

Among all surgical treatments for osteoporotic hip fracture, hemiarthroplasty is a common procedure

for treatment of displaced femoral neck fracture in the elderly. In general, there are two modes of femoral component fixation: cementless and cemented fixation. The method that involves implantation with cemented fixation remains controversial. Cemented fixation is preferred in this type of osteoporotic fracture due to difficulty obtaining immediate stability with cementless stem implantation in some cases. Any absence of stability could result in fixation failure. For cemented fixation method, however, concerns persist regarding the risk of intraoperative cement embolism and subsequent cardiopulmonary complications⁽⁵⁾.

With improvements in implant design and surface coating, many investigators have reported satisfactory results after the use of modern cementless femoral stem, a tapered wedge-shaped femoral component design⁽⁶⁻⁹⁾. There are, however, few studies that support the effectiveness of these tapered wedge-shaped implants in patients with femoral neck fracture^(10,11). Accordingly, the objective of the present study was to evaluate the radiographic results of cementless hemiarthroplasty using a tapered

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wedge-shaped femoral component in elderly patients with displaced femoral neck fracture. Specifically, the authors assessed the prevalence of intraoperative crack and rate of subsidence associated with tapered wedge-shaped femoral component in patients with femoral neck fractures.

Material and Method

Following approval of the study protocol by the Siriraj Institutional Review Board (SIRB), the authors retrospectively reviewed medical records and radiographs of patients who received cementless hemiarthroplasty after being diagnosed with femoral neck fracture caused by low-energy trauma. All the operations evaluated in the present study were performed between January 2009 and December 2012 at Siriraj Hospital, Thailand's largest university-based tertiary referral center. The exclusion criteria were patients with pathologic fracture, patients underwent total hip arthroplasty, patients received full-coated femoral component design, and patients received a previous generation femoral component (e.g., Austin Moore prosthesis).

All operations were performed using direct posterior approach. After exposure of the hip joint, the lesser trochanter was clearly identified. After measurement of neck length, the femoral neck was osteotomized above the lesser trochanter. The femoral canal was prepared for tapered femoral stems using the broach-only femoral canal preparation technique. The femoral canal was broached to a size necessary to achieve stable fixation. Posterior soft tissue structure was repaired in all cases. Patients were allowed full weight-bearing after surgery, as tolerated.

Data collection

Patient demographic and clinical characteristics were collected for all patients, including age, gender, weight, height, body mass index (BMI), the American Society of Anesthesiologists (ASA) score, and pre-fracture ambulatory status. BMI was calculated as weight in kilograms divided by the square of height in meters. Pre-fracture ambulatory status was divided into four levels: independent, ambulatory with walking aids, ambulatory with assistance, and non-ambulatory or wheel chair bound.

Perioperative data, including operative time, estimated blood loss, length of stay, and complications (e.g., intraoperative crack, wound complication, and postoperative dislocation) were collected. Thirty-day, 90-day, and 1-year mortality rates were also analyzed.

Mortality data were obtained from the hospital database and the Thailand National Registration System, which has information on the vital status of all Thai citizens, including date of death.

Radiographic evaluation

Radiographs were evaluated by an independent examiner (HU) who did not participate in any of the operations. Correction for magnification was performed by standardizing all measurements to the known size of the femoral head component. An immediate postoperative anteroposterior radiograph of both hips was used as baseline data for the present study. Because the objective of this study was to evaluate the stability and subsidence of the femoral component, only patients with postoperative radiograph of 12 months follow-up or longer, were selected for comparison. Femoral components were assessed for bone growth and stable fibrous fixation or unstable fibrous fixation, according to criteria established by Engh et al⁽¹²⁾. Subsidence of the femoral stem was determined by the relationship of the superolateral edge at the shoulder of the prosthesis to the tip of the greater trochanter on the anteroposterior radiograph. Presence of subsidence was defined as a decrease of at least 2 mm between baseline and the latest follow-up postoperative radiograph(s)⁽¹³⁾. Evidence of any reactive lines was recorded according to the seven zones described by Gruen et al⁽¹⁴⁾. Leg-length discrepancy (LLD) and heterotopic ossification were also assessed. Radiographic LLD was measured by subtracting the perpendicular distance from the inter-teardrop line to the proximal corner of the lesser trochanter of both sides. After the operation, if one leg was longer than the other, the discrepancy was recorded as '+' and vice-versa. A failure of leg-length equalization was considered when the distance was different by more than 1 cm between the two hips⁽¹⁵⁾. Heterotopic ossification, if present, was evaluated according to the system set forth by Brooker et al⁽¹⁶⁾.

Statistical analysis

Descriptive statistics are presented as mean \pm standard deviation (SD) for continuous variables, and frequencies and percentages for categorical variables. Data were analyzed using SPSS Statistics version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Between January 2009 and December 2012, 468 patients with femoral neck fracture were admitted

to the investigator's hospital. Of those, 26 patients received non-operative treatment due to poor medical condition, 58 had multiple screw fixation, 161 underwent cemented hemiarthroplasty, four had total hip arthroplasty, and 219 patients received cementless hemiarthroplasty. Of the 219 patients who received cementless hemiarthroplasty, 65 patients were excluded from the present study for the following reasons: 52 patients received full-coated femoral stems, 12 were implanted with a previous generation femoral component (Austin Moore prosthesis), and one was diagnosed with pathologic fracture. The remaining 154 hips (154 patients) were evaluated for the present study (Fig. 1).

Most patients were female (75.3%), with an average age among all patient participants of 77.1 years. Mean BMI was approximately 22.3 kg/m². The majority of patients had an ASA score of 2 or 3. Approximately 60% of patients could ambulate independently without the use of any assistive walking device before fracture. The most common femoral component used in this series was a Corail® double-tapered titanium stem fully coated with 150 mm hydroxyapatite (DePuy Synthes, Warsaw, IN, USA) (68.2%) (Table 1).

Perioperative data were presented in Table 2. Mean operative time and mean estimated total blood

Table 1. Patient demographic and clinical characteristics of 154 femoral neck fracture patients

Clinical variables	Values
Number of patients	154
Female gender	116 (75.3)
Age (years)	77.1±7.7
Body mass index (kg/m ²)	22.3±3.4
ASA score	
1	2 (1.3)
2	63 (40.9)
3	89 (57.8)
4	0
Prefracture ambulatory status	
Non-ambulatory or wheel chair	0
Ambulatory with assistance	9 (5.8)
Ambulatory with walking aids	54 (35.1)
Independent	91 (59.1)
Type of implant	
Corail® (DePuy)	105 (68.2)
VerSys® Fiber Metal Taper (Zimmer)	46 (29.9)
Others	3 (1.9)

Data are presented as n, n (%), or mean ± standard deviation; percentage values are based on the total number of patients

Table 2. Perioperative data of 154 femoral neck fracture patients

Clinical variables	Values
Operative time (minutes)	90.0±31.2
Estimated total blood loss (mL)	524.4±267.9
Length of stay (days)	17.8±9.8
Intraoperative complications	
Intraoperative femoral crack	30 (19.5)
Dislocation	0
Wound complication	0
30-day mortality	1 (0.6)
90-day mortality	2 (1.3)
1-year mortality	15 (9.7)

Data are presented as n (%) or mean ± standard deviation

loss were 90 minutes and 524.4 mL, respectively. The average length of stay was 17.8 days (range 6 to 60, SD 9.8). Of the 154 included hips/patients, 30 hips (19.5%) had intraoperative crack of the femoral neck, all of which were treated with cerclage wiring. The majority of intraoperative cracks (26/30 hips, 86.7%) occurred in patients that received Corail® stem. No dislocations or wound complications were observed in any patients during hospital admission. The 30-day and 90-day mortality rate was 0.6% and 1.3%, respectively. However, the mortality rate increased substantially to

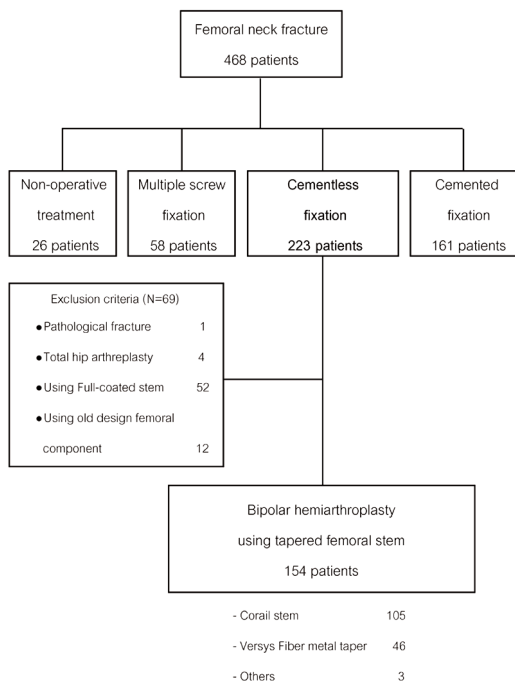


Fig. 1 Flow diagram of the patient inclusion process.

9.7% (15 patients) at one year after surgery. Fifteen patients expired as a result of medical co-morbidities.

Of the 154 eligible hips/patients, 95 had both baseline and 12 month or longer postoperative follow-up radiographs available for analysis. The average length of radiographic follow-up was 29.8 months (range 12 to 76, SD 16.5). From the latest follow-up radiograph, subsidence was observed in five patients (5.3%). The mean subsidence was 5.4 mm (range 3.3 to 9.2, SD 2.6). Fourteen patients (14.7%) had leg-length discrepancy, with a mean leg-length discrepancy of 13.1±3.3 mm. There was no radiographic evidence of femoral component loosening at latest follow-up in any patient. Brooker grade I heterotopic ossification was observed in nine hips (9.5%).

Discussion

Hemiarthroplasty is widely accepted as an appropriate treatment for displaced femoral neck fracture in the elderly⁽¹⁷⁾. Although method of femoral component fixation remains controversial, there is a current trend towards using cementless stems in hemiarthroplasty for femoral neck fractures⁽¹⁸⁾. Previous investigators reported satisfactory results after use of modern cementless stems in elderly patients with femoral neck fractures⁽⁶⁾. The success of modern cementless stems may be due to design improvements and surface treatments that enhance biologic fixation⁽¹⁹⁾.

Cementless fixation is associated with shorter operative time, potentially less cardiopulmonary complications, and an absence of complications associated with bone cement implantation syndrome (BCIS)⁽²⁰⁾. However, intraoperative fracture is a potential major complication of cementless hemiarthroplasty⁽²¹⁾. Kuo et al retrospectively reviewed medical records of 76 men and 202 women who underwent cementless bipolar hemiarthroplasty for femoral neck fracture between 2009 and 2010⁽²²⁾. The authors found a rate of intraoperative fracture of 8.6%, which was comparable to the 5 to 10.9% range reported in other previous studies⁽²³⁻²⁵⁾. In the present study, the rate of intraoperative crack (19.5%) was much higher than previous reports. Interestingly, the authors found that approximately 87% of intraoperative cracks occurred in patients who received Corail® stem. Although the causes of these cracks remained unclear, the authors speculated that a high rate of intraoperative cracking in the present study was related to the design of this particular femoral implant. The Corail® femoral component is a wedge-shaped femoral stem that could increase bone stress and cause cracking as the femoral

component is impacted down into the metaphysis⁽²⁶⁾. In addition, this stem has a long femoral trunnion that creates a high vertical offset, which may not be suitable for Asian elderly who normally have a small body frame and short vertical offset⁽²⁷⁻²⁹⁾. In settings where the femoral trunnion is too long, the surgeon may need to impact the femoral component further down into the metaphysis, potentially resulting in an intraoperative crack. The present study, however, was not designed to evaluate association between length of femoral trunnion and rate of intraoperative cracking. Future study to explore this issue is warranted.

The subsidence rate of a tapered wedge-shaped femoral component design ranges widely from less than 1% to approximately 80% (Table 3). Skoldenberg et al evaluated 50 patients who underwent total hip arthroplasty after displaced femoral neck fracture and followed them prospectively for two years⁽¹¹⁾. Using radiostereometric analysis, the authors found that 60% of the femoral components migrated beyond the detection limit within six weeks after surgery and that four patients had migrated further at the 3-month follow-up, after which all had stabilized. Mean subsidence in this series was 0.2 mm. Using radiostereometric analysis, Schewelov et al analyzed 38 patients who received cementless femoral component fixation for femoral neck fracture. They found that the majority of stems (81.6%) moved significantly distally at a mean distance of 2.7 mm during the first three months⁽⁶⁾. However, this distal migration did not result in any clinically adverse effects, including stem loosening. Conversely, Klein et al reported results of 85 patients who underwent total hip arthroplasty using tapered wedge-shaped femoral stem with proximal circumferential plasma-sprayed coating (Taperloc® (Biomet) in 54 hips and Accolade® (Stryker) in 31 hips)⁽¹⁰⁾. At a mean follow-up duration of 3.8 years, all femoral components were stable with evidence of bone ingrowth (84 hips) or fibrous fixation (1 hip). There were no hips with subsidence greater than 2 mm. Lee et al evaluated outcome of femoral neck fracture patients who received micro-arc oxidation (MAO) coated femoral stems⁽³⁰⁾. Of 98 patients, subsidence was observed in only one hip (1%) at a distance of approximately 7 mm at six weeks on postoperative radiograph and not found to be progressive on later follow-up radiographs. The present study found a subsidence rate of 5%. Similar to other investigations, none of these patients with stem subsidence had clinical loosening at longer-term follow-up.

Table 3. Results from a review of the literature (including the current study) for studies in tapered wedge-shaped femoral component in patients with femoral neck fractures

Authors	Journal	N	Femoral component	Duration of follow-up	Results
Klein et al. ⁽¹⁰⁾	J Arthroplasty 2006	85 hips	Taperloc® (Biomet) 54 hips; Accolade® (Stryker) 31 hips	Mean 3.8 years	-No hips had subsidence greater than 2 mm
Skoldenberg et al. ⁽¹¹⁾	J Bone Joint Surg [Br] 2011	50 hips	Comprehensive® Fracture Stem (Biomet: titanium alloy with a grit-blasted surface)	48 months	-30/50 (60%) migrated beyond the detection limit -Mean subsidence of 0.2 mm
Schewelov et al. ⁽⁶⁾	Acta Orthopaedica 2012	38 hips	Hydroxyapatite-coated Corail® stem	24 months	-31/38 (81.6%) migrated distally -No stem loosening
Lee et al. ⁽³⁰⁾	J Arthroplasty 2014	98 hips	Micro-arc oxidation (MAO) coated stem	>24 months, mean 44 months	-1/98 (1%) subsidence -No stem loosening
The current study		95 hips	Hydroxyapatite-coated Corail® stem and VerSys® Fiber Metal Taper	>12 months, mean 29.8 months	-5/95 (5.3%) subsidence -No stem loosening

The present study had some mentionable limitations. First and similar to all retrospective studies, this investigation was subject to some inherent biases in patient selection. Since the choice of femoral fixation is based on each surgeon's discretion, it is possible that the bone quality of patients who received cemented fixation was poorer than that of the patients reviewed in this analysis. As such, the rate of intraoperative crack and subsidence could potentially be much higher if cementless fixation were used in all patients with femoral neck fracture. In addition, the authors have no or inadequate information regarding whether surgeons initially attempted to use tapered wedge-shaped cementless stem, but changed to other type of cementless stem (full-coated) or cemented stem because of failure to achieve immediate stability with a tapered wedge-shaped design. Second, the present study had a short follow-up period. However, longer-term follow-up is difficult due to a short life expectancy in this patient population⁽³¹⁾. Third, the authors do not have patient clinical information at the latest follow-up. The objective of the present study, however, was to evaluate only the radiographic outcome of cementless hemiarthroplasty using a tapered wedge-shaped femoral component in elderly patients with displaced femoral neck fracture. Lastly, only 61.7% of patients (95/154) had radiographs available from both baseline (immediate postoperative) and latest follow-up at a minimum of 12 months.

Conclusion

In conclusion, cementless hemiarthroplasty using a tapered wedge-shaped femoral component design is a viable option for treating femoral neck

fracture in elderly patients. However, tapered wedge-shaped femoral component, particularly the two designs used in the present study, are associated with high incidence of intraoperative crack (19.5%). In cases where intraoperative crack occurs, repair using cerclage wiring around the fracture area is recommended.

What is already known on this topic?

Hemiarthroplasty is a common surgical treatment for elderly patients with displaced femoral neck fracture. The method of femoral component fixation however remains controversial. Cemented fixation is preferred in osteoporotic bone due to difficulty in obtaining immediate stability with cementless femoral stem with some concerns regarding risk of intraoperative cement and fat embolism. Cementless fixation is beneficial because it is associated with shorter operative time, potentially less cardiopulmonary complications and an absence of complications associated with BCIS. Nevertheless, intraoperative crack is a common complication associated with cementless femoral component.

What this study adds?

Cementless hemiarthroplasty using a tapered wedge-shaped femoral component design is a viable option for treating elderly patients with femoral neck fracture. However, this stem design is associated with a high incidence of intraoperative crack of the femoral neck approximately 20% as shown in this study.

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Potential conflicts of interest

None.

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ผลระยะสั้นของภาพถ่ายรังสีผู้ป่วยสูงอายุที่มีกระดูกคอสะโพกหักที่ได้รับการผ่าตัดเปลี่ยนข้อสะโพกเทียมแบบครึ่งข้อด้วยวิธีไม่ใช้ซีเมนต์โดยการใช้ก้านข้อสะโพกเทียมชนิดที่มีลักษณะรูปลิ้ม

อาติส อุณะนันท์, หาญชัย อังคนวราพันธ์

วัตถุประสงค์: เพื่อประเมินผลระยะสั้นของภาพถ่ายรังสีข้อสะโพกเทียมแบบครึ่งข้อชนิดที่ไม่ใช้ซีเมนต์ที่มีลักษณะรูปลิ้มในผู้ป่วยสูงอายุที่มีกระดูกคอสะโพกหัก ผู้นิพนธ์จำเพาะเจาะจงประเมินความชุกของการแตกร้าวของกระดูกต้นขาระหว่างการผ่าตัดและอัตราการหลุดตัวของก้านข้อสะโพกเทียมที่มีลักษณะรูปลิ้มที่ใช้ในการรักษาผู้ป่วยที่มีกระดูกคอสะโพกหัก

วัสดุและวิธีการ: ผู้นิพนธ์ได้ทบทวนบันทึกข้อมูลผู้ป่วยจำนวน 154 ราย ที่ได้รับการผ่าตัดเปลี่ยนข้อสะโพกเทียมแบบครึ่งข้อชนิดที่ไม่ใช้ซีเมนต์ที่มีลักษณะรูปลิ้มระหว่าง เดือนมกราคม พ.ศ. 2552 ถึง ธันวาคม พ.ศ. 2555 มีผู้ป่วยจำนวน 95 ราย ที่มีภาพถ่ายรังสีทันทีหลังผ่าตัดและภาพถ่ายรังสีที่ระยะติดตามหลังผ่าตัดมากกว่า 12 เดือนขึ้นไป โดยที่ระยะเวลาเฉลี่ยของภาพถ่ายรังสีที่ใช้ติดตามในการศึกษานี้ คือ 29.8 เดือน ผู้นิพนธ์ได้ทบทวนภาพถ่ายรังสีผู้ป่วยทั้ง 95 รายนี้เพื่อประเมินการเกิดกระดูกต้นขาแตกร้าวระหว่างการผ่าตัด ความมั่นคงของก้านข้อสะโพกเทียม และการหลุดตัวของก้านข้อสะโพกเทียม

ผลการศึกษา: จากจำนวนผู้ป่วยทั้งหมด 154 ราย พบมีกระดูกแตกร้าวที่บริเวณคอสะโพกระหว่างการผ่าตัด 30 ข้อสะโพก คิดเป็นร้อยละ 19.5 ซึ่งผู้ป่วยทั้งหมดรักษาสำเร็จได้ด้วยวิธีการมดลวดครอบบริเวณที่เกิดการแตกร้าว ส่วนใหญ่ของการเกิดกระดูกแตกร้าวระหว่างการผ่าตัด (ร้อยละ 86.7) พบในผู้ป่วยที่ได้รับการผ่าตัดด้วยการใช้ก้านข้อสะโพกเทียมชนิด Corail มีผู้ป่วยจำนวน 5 ราย (ร้อยละ 5.3) ที่มีการหลุดตัวของก้านข้อสะโพกเทียมมากกว่า 2 มิลลิเมตร โดยที่ค่าเฉลี่ยของระยะการหลุดตัวของก้านข้อสะโพกเทียมในผู้ป่วยทั้ง 5 รายนี้มีค่าเท่ากับ 5.4 มิลลิเมตร ไม่มีผู้ป่วยรายใดที่ได้รับการผ่าตัดแก้ไขซ้ำเนื่องจากก้านข้อสะโพกเทียมหลวมเลย

สรุป: การผ่าตัดเปลี่ยนข้อสะโพกเทียมแบบครึ่งข้อด้วยวิธีไม่ใช้ซีเมนต์โดยการใช้ก้านข้อสะโพกเทียมชนิดที่มีลักษณะรูปลิ้มเป็นทางเลือกหนึ่งของการรักษาโรคกระดูกคอสะโพกหักในผู้ป่วยสูงอายุ อย่างไรก็ตามการใช้ก้านข้อสะโพกเทียมที่มีลักษณะรูปลิ้มโดยเฉพาะก้านข้อสะโพกเทียมชนิด Corail จะสัมพันธ์กับอุบัติการณ์ของการเกิดกระดูกแตกร้าวระหว่างการผ่าตัดที่สูงขึ้นได้ในผู้ป่วยกลุ่มนี้