Midterm outcome analysis of bipolar hemiarthroplasty for unstable intertrochanteric femur fractures: A retrospective study

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Abstract

Background: Recent advances in medical systems and technologies have resulted in increased survival after intertrochanteric fractures of the femur, requiring the selection of appropriate femoral stems considering mid- to long-term durations. We performed hip hemiarthroplasty for unstable intertrochanteric fractures using a Wagner cone femoral stem (Group A) and double tapering right angled femoral stem (C2 stem, Group B), and evaluated the clinical imaging results.

Methods From January 2004 to December 2013, 79 patients (79 hips) who underwent hip hemiarthroplasty with a cone stem (36 cases) and C2 stem (43 cases) were included. During the follow-up period, clinically, changes in pain (visual analog scale [VAS] score), walking ability, and Harris Hip score were examined. Radiologically, changes in the proximal femur were observed. We also reviewed the complications that occurred.

Results Patients' mean ages were 77.2 (70-83) years and 78.6 (70-84) years, and mean follow-up periods were 84.7 (60-108) months and 85.4 (60-96) years in Groups A and B, respectively. Postoperative pain (VAS score) and the Harris hip score were not significantly different between the groups until 24 months and 36 months, respectively. However, VAS scores from 36 months postoperatively and Harris hip scores from 48 months postoperatively indicated that Group B patients had significantly higher VAS scores and lower Harris hip scores. There was no significant difference in walking ability between the groups; however, in Group B, walking ability was reduced by one grade in 13 patients and by two grades in nine. Cortical bone osteoporosis occurred in four and 14 cases in Groups A and B, respectively. In Group B, five patients developed cortical bone resorption, and four of them had nonunion of trochanteric fracture fragments.

Conclusions Hip hemiarthroplasty using a cementless femoral stem for unstable intertrochanteric fractures requires careful selection of the stem, considering the remaining life of the patient. When using a 3C stem for unstable intertrochanteric fractures, it is thought that the firm fixation of fractured trochanteric fragments is necessary, and for a reverse oblique fracture, it is better to use the 3B stem with a suitable length.

Background

Due to the increasing life expectancy and increasing physical activity of the elderly, the number of proximal femoral fractures worldwide is expected to rise from 1.6 to 6.3 million per year by the year 2050 [1]. Intertrochanteric femoral fractures are a common occurrence in the elderly and are often associated with high morbidity and mortality, owing to the associated comorbidities in this subset of patients [2]. For several decades, the treatment of choice for intertrochanteric fractures in elderly patients has been open reduction and internal fixation. However, primary bipolar hemiarthroplasty has been advocated as an alternative to osteosynthesis for unstable intertrochanteric fractures in the elderly, as it provides the advantages of permitting early full-weight bearing, avoiding the failures of osteosynthesis, and good

functional outcomes and fewer complications [3]. Recently, various cementless stems have been developed to improve clinical outcomes and promote firm fixation. Furthermore, the use of cementless femoral stems is increasing and various designs and surface coated methods have been used for unstable intertrochanteric fractures with good results [3–9]. However, information on mid- to long-term outcomes following the use of a cementless stem in unstable intertrochanteric fractures is limited. Moreover, the ideal femoral stem for the treatment of an unstable intertrochanteric femoral fracture is still a matter of discussion. The study aimed to analyze retrospectively and compare the clinical and radiological outcomes of the Wagner cone femoral stem (Zimmer-Biomet, Warsaw, IN) and a double-tapered rectangular cross-section stem (C2 stem, Lima Corporate, Udine, Italy) in hemiarthroplasty for unstable intertrochanteric femur fractures.

Materials And Methods

Participants

Of 1312 patients (1467 hip joints) who were admitted and treated for intertrochanteric femoral fracture between January 2004 and December 2013, 181 patients (183 hips) underwent primary bipolar hemiarthroplasty. The inclusion criteria for hemiarthroplasty were the following: three or more unstable intertrochanteric fractures with a loss of posteromedial cortical buttress, patients aged 70 years or more, and severe osteoporosis (T-score < 2.5), and patients could perform activities alone or use walking-assistance tools (cane, walker) without being helped by others (independent ambulator). From this cohort, 102 patients were excluded. Exclusion criteria included those treated using an alternative prosthesis (except Wagner cone and C2 stem), polytrauma, or minimum follow-up of less than five years, and bilateral fracture. Therefore, the 79 patients (79 hips) satisfying the above criteria of enrollment were divided into two groups and results were compared. Group A comprised patients who had been treated with a Wagner cone femoral stem, and Group B patients treated with the C2 stem. For Groups A (36 patients, hips) and B (43 patients, hips), the mean patient ages were 77.2 (70–83) years and 78.6 (70–84) years; male to female ratio, 12:24 and 16:27; mean follow-up period, 84.7 (60–108) months and 85.4 (60–96) months, respectively. We analyzed and compared both groups for bone mineral density before hemiarthroplasty for the assessment of bone quality. The degree of osteoporosis was assessed based on the bone mineral density (T-score) in the contralateral hip area, which did not differ significantly between the A and B groups (-2.9 ± 0.8 points vs. -2.7 ± 0.6 points; $p = 0.575$). Preoperative radiographs were evaluated for Dorr type using the contralateral side femur [10]. Preoperative femoral geometry was classified using the Dorr classification system (Group A: type A [n = 7], type B [n = 15], type C [n = 14], Group B: type A [n = 9], type B [n = 18], and type C [n = 16]). Patients were classified into two subgroups (Group A, 3/36; Group B, 3/43) according to the reverse obliquity, and the clinical and radiological results were compared (Table 1).

Table 1
Demographic data of Group A (Wagner cone femoral stem) and Group B (C2 stem)

		A group (n = 36)	B group (n = 43)	p value
Age (year)		77.2 (70–83)	78.6 (70–84)	0.877
Gender	Male	12	16	0.72
	Female	24	27	
Follow up (months)		84.7 (60–108)	85.4 (60–96)	0.713
BMD T score		-2.9 ± 0.8	-2.7 ± 0.6	0.575
Dorr type	A	7	9	0.881
	B	15	18	
	C	14	16	
Fx Type	A22	36	43	0.821
	A3	3	3	
Fx: fracture				
BMD: bone mineral density				

Evaluation Methods

1) Evaluation of intra-operative results

Retrospective analysis was performed and information regarding operating time, amount of bleeding, postoperative blood transfusion, and orthopedic complications during the procedure or immediately postoperatively, and additional treatments were obtained from the patients' medical records. The operation time was evaluated from the start to the end of anesthesia. The total amount of blood lost during the surgery was measured as the sum of the volume of the blood collected through the suction bottle and the volume of the blood soaked gauze.

2) Clinical evaluations

Pain, walking ability, and functional status were clinically evaluated pre-and at each postoperative follow-up. Pain was evaluated using a visual analogue scale (range, 0-100). Walking ability was evaluated as described below. The degree of capacity for activity at each follow-up was classified into three levels. Level 1 was defined by cases, where the patient could perform activities alone or use walking-assistance tools (cane, walker) without being helped by others (independent ambulator); level 2 were cases where the patient could perform activities only when helped by others (dependent ambulator); level 3 cases were those in which the patient could not conduct any activities other than moving in a wheelchair or resting in

bed (nonfunctional ambulator) [11]. In addition, we compared full weight bearing ambulation between Groups A and B, where possible. Meanwhile, functional status was evaluated using the Harris hip score (HHS) [12]. Complications including dislocation and periprosthetic fracture were recorded.

3) Radiological evaluations

For the radiographic evaluation, the anteroposterior and the cross-table lateral view of the hip joint was used, which included the entire stem length. At each follow-up, radiographic images were compared with the index image obtained immediately postoperatively. Radiographic evaluation was performed by two independent observers who did not participate in the index procedure. Subsidence of the femoral component was defined as the change in the distance from the superolateral edge at the shoulder of the prosthesis to the line indicating the lower margin of both teardrop lines on the anteroposterior radiograph of the hip. Osteolytic lesions were defined according the criteria of Engh et al. [13]. Cortical porosis was defined as a decrease in bone mineralization resulting in a homogeneous but somewhat sparse (washed-out) appearance of the remaining cortex [14]. In addition, we identified cases of endosteal cortical bone absorption around the femoral stem. We defined “endosteal cortical bone absorption as “divergent radiolucent lines greater than 1 mm” and performed additional analyses for these phenomena. Heterotopic ossification was classified according to the system of Brooker et al. [15] whenever present. We evaluated the union of fractured fragments of trochanteric areas, because we considered that the union of the trochanteric areas (proximal femur) could affect femoral stem fixation.

Statistics

Student's t test and Mann-Whitney's U test and Fisher's exact test were used to compare data between the groups and within each group, respectively. Two orthopedic residents who did not participate in the surgery assessed the results from the postoperative clinical and radiological studies. Kappa coefficient tests were applied for intra-rater (K1) and inter-rater (K2) reliability, and both categories were found to be at a reliable level (K1 = 0.88, K2 = 0.81). All statistical analyses were performed using R 3.5.1 (R Foundation for Statistical Computing, Vienna, Austria), and all statistical tests were two-sided. P-values < 0.05 were considered statistically significant.

Results

Perioperative data

The mean operation time was 70 ± 16 minutes (Group A: 68 ± 28 minutes, Group B: 71 ± 20 minutes; $p = 0.521$). Intraoperative blood loss was 755.5 (Group A: 375–1400 mL, Group B: 380–1550 mL; $p = 0.715$). Twenty-one patients (Group A: 9, Group B: 12; $p = 0.771$) required postoperative blood transfusion; the mean number of transfused blood (packed RBC) units during hospital admission was 2.8 ± 1.3 in Group A and 2.9 ± 1.7 in Group B. There were no significant differences in operation time, intraoperative blood loss, or transfusion requirement between the two groups. One case of acute immediate deep periprosthetic infection occurred in Group A. At 25 days after the operation, the patient was treated with a one-stage operation. After the exploration, extensive debridement and irrigation was performed. The head and bipolar cup were replaced, and deep periprosthetic infections improved. One femoral shaft fracture

related to intraoperative procedure occurred during the insertion of the femoral stem in Group A. This fracture was fixed with wires, which healed completely without any additional operation. One case in Group B required revision surgery for hematoma. The drain was drawn on the day of surgery by patient under delirium, and the surgical site became tight and tensioned. Three days after the operation, the drain was re-inserted and the hematoma improved. There was no incidence of dislocation or differences of lower limb lengths above 1 cm in either group (Table 2).

Table 2
Perioperative results and complications of Group A and Group B

		A group (n = 36)	B group (n = 43)	p value
op time (minute)		68 ± 28	71 ± 20	0.521
bleeding (ml)		762.9 (375–1400)	748.1 (380–1550)	0.715
transfusion patients		9	12	0.771
transfusion pRBC		2.8 ± 1.3	2.9 ± 1.7	0.885
immediate complication	Deep infection	1	0	0.271
	hematoma	0	1	0.357
	Intraop Fx.	1	0	0.271
Op: operation				
pRBC: packed red blood cells				
Fx: fracture				
Intraop: intraoperatively				

Clinical Results

Full weight bearing was achieved similarly in both groups (Group A: 23.0 ± 1.6 days, Group B: 23.7 ± 1.2 days; p = 0.211). Six weeks postoperatively, the pain level was decreased in both groups compared to the pre-and postoperative status with no significant differences found in both groups regarding pain levels up to 24 months. However, there were significant differences in both groups from the postoperative 36-month evaluation (p = 0.032). Group A revealed higher evaluation of pain than Group B from 36 months postoperatively to the last follow-up. The evaluation of walking ability divided by the three grades did not significant differ between the two groups until the last follow-up. Among the patients in Group A, despite the capacity for activity was maintained at final follow-up in 25 patients, this declined by one level in eight patients, and declined by two levels in three patients. In Group B, 43 patients survived for at least five years after intertrochanteric fracture, while the capacity for activity was maintained at final follow-up in 21, declined by one level in 13 patients, and declined by two levels in nine patients (p = 0.051), approaching an acceptable significance level (Fig. 1) [11]. Postoperatively, there was no significant

difference in the HHS for both groups until 36 months. However significant differences in both groups were found from postoperative 48 months ($p = 0.034$). Group A showed a higher HHS than Group B postoperatively at 48 months to the last follow-up. The mean HHS was 83.7 ± 15.1 (Group A) and 77.6 ± 11.8 (Group B) at postoperative 60 months ($p = 0.023$) [12] (Fig. 1) (Table 3).

Table 3
Clinical results of Group A and Group B

			A group (n = 36)	B group (n = 43)	p value
FWB (day)			23 ± 1.6	23.7 ± 1.2	0.211
Pain (VAS score)	Pre-op		88.8 (71–97)	90.1 (75–97)	0.546
	Post-op		77.1 (59–89)	79.3 (50–91)	0.607
	6 weeks		37.6 (11–47)	35.5 (15–47)	0.708
	6 months		21.7 (7–35)	19.2 (6–38)	0.436
	1 year		18.2 (4–37)	16.4 (5–49)	0.332
	2 year		15.9 (5–42)	14.1 (4–51)	0.174
	3 year		9.5 (0–10)	11.7 (1–21)	0.032
	4 year		4.2 (0–8)	14.8 (0–26)	0.025
	5 year		4.8(0–9)	16.9 (0–26)	0.041
walking ability		level 1	36	43	
	pre-op	level 2	0	0	
		level 3	0	0	
		level 1	28	32	
	1 years	level 2	7	9	0.711
		level 3	1	2	
		level 1	25	31	
	2 years	level 2	9	9	0.848
		level 3	2	3	
		level 1	25	24	
	3 years	level 2	9	13	0.173
		level 3	2	6	
		level 1	25	22	
	4 years	level 2	9	12	0.057
FWB: full weight bearing					
VAS: visual analog scale					

		A group (n = 36)	B group (n = 43)	p value
	level 3	2	9	0.051
	level 1	25	21	
	5 years level 2	8	13	
	level 3	3	9	
Harris hip score	Pre-op	97.8 ± 17.4	96.2 ± 19.8	0.824
	1 year	84.6 ± 16.1	85.9 ± 22.5	0.671
	2 year	83.3 ± 17.2	84.5 ± 15.6	0.545
	3 year	85.8 ± 10.9	80.5 ± 13.7	0.291
	4 year	82.9 ± 14.5	77.4 ± 14.4	0.034
	5 year	83.7 ± 15.1	77.6 ± 11.8	0.023
FWB: full weight bearing				
VAS: visual analog scale				

Radiological Results

A subsidence of 5 mm of the femoral stem was observed in one case in Group A at the six-week postoperative radiograph, which was not progressive on later radiographs. None of the stems showed radiographic signs of osteolysis. Cortical porosis was observed around the stem in 14 cases in Group B (four cases in Group A) from postoperative 12 months to 24 months (Fig. 2). Among the cortical porosis cases, endosteal cortical bone absorption (divergent radiolucent lines > 1 mm) surrounding the stem was observed in five cases in Group B from postoperative 36 months to 60 months (no cases occurred in Group A) (Fig. 3). Trochanteric nonunion occurred in seven cases in Group A (reverse oblique fracture: one case) and 12 cases (reverse oblique fracture: three cases) in Group B (Table 4) (Fig. 4), and of the latter four cases showed endosteal cortical bone absorption (reverse oblique fracture: three cases). According to the Brooker classification system, heterotopic Grade I ossifications were observed in one case in Group A and in one case in Group B. Cortical bone porosis statistically significantly occurred in group 2 ($p = 0.046$), and endosteal cortical bone absorption occurred in five cases of group B, which only approached an acceptable significance level ($p = 0.059$). Finally, endosteal cortical bone absorption occurred in cases of cortical bone porosis (odds ratio: 34.16), nonunion of trochanteric fracture fragments (odds ratio: 10.76), and reverse oblique fracture (odds ratio: 107.8) (Table 4).

Table 4
Radiological results and complications of Group A and Group B

		A group (n = 36)	B group (n = 43)	p value
subcidence (> 5 mm)		1	0	0.271
cortical porosis		4	14	0.024
endosteal cortical bone absorption		0	5	0.035
trochanter nonunion		7	12	0.381
heterotrophic ossification		1	1	0.899
late complications	postop infection	1	0	0.271
	periprosthetic fracture	0	2	0.19

Table 5
Risk factors of endosteal cortical bone absorption

risk factor	endosteal cortical bone absorption						Odds ratio	low_CI	up_CI	p value
	exist			nonexist						
CP	exist	5	9	non exist	0	29	34.16	1.72	676.51	0.002
TFN		4	8		1	30	10.76	1.46	79.39	0.017
ROF		3	0		2	38	107.8	4.27	2718.38	0.001
CP: cortical porosis										
TFN: trochanteric fracture nonunion										
ROF: reverse oblique fracture										
CI: confidence interval										

Complications

One stem was revised due to periprosthetic infection at postoperative 6 months in Group A. Periprosthetic fractures in two patients occurred because of slip-down in Group B. One patient was treated by open reduction and internal fixation with wiring and plate. The other patient was treated with conservative treatment due to stable periprosthetic fracture (Vancouver classification Type AG fracture located at the proximal metaphysis, and involved the greater trochanter). None of the other stems required revision during the follow-up period (Table 4).

Discussion

Recently, the cementless stem has been widely used for hip arthroplasty and there have been many studies reporting good results for unstable intertrochanteric fractures [3–9]. However, studies evaluating the long-term outcomes patients who have survived for over five years or femoral stems applied using different fixation methods according to each design have been small studies. With recent advances in medical technology, the mortality rate after hip fractures has decreased significantly [16, 17]. Therefore, patients subjected to surgical treatment for intertrochanteric fractures are more likely to survive for more than five years after hip fracture. Thus, the choice of surgical method (osteosynthesis or arthroplasty) is critical, and the choice to treat with arthroplasty or the selection of implants considering survival of over five years is important.

The cone stem applied in Group A was type 3B [18], and featured a conical design with a distal taper. Since its proximal portion is a relatively rounded cone, it can provide rotation in wide femoral metaphysis, and is mostly fixed in the distal regions [19]. Long-term survival of 91.5% at a mean of 11.5 years using these stems has been reported [20]. There have been several studies indicating good results for treatment of intertrochanteric fractures in elderly patients with osteoporosis using stem fixation on diaphysis [5]. Kayali et al. reported that good outcomes following the application of the type 3B cementless stem for 42 intertrochanteric fracture patients [6]. There are several studies about the results of using the type 3B stem for proximal femoral bone loss and osteotomy surgery, which are associated with a loss of continuity of the proximal femur, e.g., unstable intertrochanteric fractures. Robert et al. suggested that the Wagner stem has superior initial fixation stability over fully porous-coated cylindrical stems, in the setting of severe proximal femur bone loss, with only 3 cm of intact femoral diaphysis [21]. Zhu et al, reported that stable fixation by bone ingrowth was defined as no subsidence or radiolucent lines around the prosthesis for 21 Crowe type IV dysplastic hip patients using a type 3B cementless stem combined with transverse subtrochanteric femoral osteotomy [22]. Likewise, we present similar results, whereby type 3B cementless stems were stable in the early stage and had good mid- to long-term survival in patients with unstable intertrochanteric fractures. Although there were seven cases of fracture nonunion (with one case of reverse oblique fracture) and four cases of cortical osteoporosis, none progressed to endosteal cortical bone absorption. Cortical osteoporosis was identified in three cases of trochanter fragment nonunion cases and in one case of the union cases.

The C2 stem of Group B was a type 3C [18], which features a rectangular cross-section that obtains three-point fixation in the metaphyseal diaphyseal junction of the femur below the lesser trochanter and its cross-section provides four-point rotational support [23]. The clinical experience with type 3C stem has been very good, with excellent results; the survival rate of the stems after ten years was 96%, and the complication rate was very low [24]. However, poor bone ongrowth has been reported in the proximal region when using the type 3C stem in long-term follow-up [25]. Specifically, if the type 3C stem is used for intertrochanteric fractures in which the proximal region is fractured, the bone ongrowth of the proximal region may be poorer because the fixation force is mainly obtained in the diaphysis and stable three-point fixation cannot be achieved. Some studies have reported good results with type 3C stems for unstable intertrochanteric fractures [3, 7]. However, studies that report excellent results using these type 3C stems have been mostly short-term. Lee et al. reported unstable intertrochanteric fractures using type

3C stems (average follow-up: 36 months) and they found that the occurrence of cortical porosis around the femoral component in 30% of patients. These phenomena might provide some explanations for the observed porosis, and could represent stress shielding following the use of a cementless stem, and/or cortical thinning due to aging [8]. In terms of stability, Ha et al. reported that the cortical porosis did not threaten the stability of the stems for 2–6 years postoperatively [9]. However, Lee et al. reported that the cortical porosis did not threaten the stability of the femoral components for a minimum of 2 years postoperatively, whether this type of bone loss will eventually threaten implant stability is unknown. Thus, the authors suggested that a longer follow-up is necessary to assess the effects of the porosis on the longevity of implants, and this stem design should be used with caution in young active patients with a long life expectancy [8]. We also identified cortical porosis in 14 of 43 patients in Group B (32.6%) and in four of 36 patients in Group A (11.1%). This phenomenon appeared 12 months after surgery. Nine of 14 patients in Group B had no progression without improvement, but five progressed and showed endosteal cortical bone absorption combined with radiolucent lines between the femur stem and cortex. For the cementless femoral stem, proximal bone contact is widely recognized as necessary to decrease micromotion and facilitate osseointegration at the implant bone interface [26, 27]. Therefore, the lack of fixation in the proximal region could lead to high clinical failure rates [28]. The proximal portion of the femur is very important in order for the type 3C stem to achieve three-point fixation. If this portion is unstable, it may affect fixation or long-term stability of the stem. Sophia et al. used a type 3C stem for femurs with proximal femoral bone loss and tested the resulting micromotion [29]. Their study showed medial-lateral and anterior-posterior migrations in the nonfractured group, with significantly smaller migrations compared with the fractured group, with anterior-posterior migrations larger than medial-lateral migrations. By design, the type 3 stem has a dual tapered design intended to enable the stem to fill the femoral canal in the coronal plane, without any regard to the sagittal plane filling [30, 31]. Therefore, one would expect anterior-posterior motions to be higher than the medial-lateral motions. This may affect the increase in the micromotion of the stem fixed to the femur.

Kang et al. performed hip arthroplasty using a type 3C stem and reported radiological results after more than five years [32]. Of the 112 cases followed up, 15 cases (13.4%) showed a radiolucent line, and there were significant cases of lack of calcar filling ($p = 0.033$), which may occur when the calcar fill is insufficient, as the proximal femoral region is wide in the case of a Dorr A type femur. The fine motion of the femoral stem causes bone resorption, and the fibrous membrane fills the gap between the femoral stem and inner cortex, which appears radiolucent on plain radiography [32]. Furthermore, Lutz et al, performed hip arthroplasty using a type 3C stem and analyzed the clinical and radiological outcomes determined by CT-assisted osteodensitometry of bone mineral density and bone mineral changes of the femoral cortical and cancellous bone [33]. At six years postoperatively, the cortical and cancellous bones of diaphysis around the stem tip showed a small decrease in bone density, but the cortical and cancellous bones of the metaphysis showed a significant decrease in bone density.

Although the threshold for ingrowth has been debated in the literature, several studies have reported that acceptable micromotions between 28–40 micrometers for bony ingrowth and up to 150 micrometers for fibrous ingrowth [26, 27]. Thus, in the case of unstable intertrochanteric fractures, which are estimated to

have more than 150 micrometers of micromotion in the proximal femoral cavity, motion beyond this range is possible even if the proximal fracture is firmly fixed. If the fractured proximal femur is a delayed union or does not achieve a complete union, the micromotion is expected to increase and other effects such as stress shielding may lead to radiolucent lines and endosteal cortical bone absorption. We identified 12 cases of trochanter fracture nonunion and 14 cases of cortical osteoporosis. Four cases that showed a fracture nonunion (three cases of reverse oblique fracture) and cortical osteoporosis, progressed to endosteal cortical bone absorption, and pain and function was significantly different from that of Group A from 36 months and 48 months after operation. However, the relationship could not be precisely defined; thus, additional cases are needed for long-term studies. We propose that this phenomenon occurred because the traditional fixation concept of type 3C stems was not achieved in intertrochanteric fractures (fixed to meta-diaphysis but mainly fixed to diaphysis). Although the fractured proximal portion was firmly fixed, a stable three-point fixation was not obtained. This may be a reason for the increased micromotion of the femoral stems on the femur and the progression to insufficient fixation, while insufficient contact area may have led to incomplete bone ongrowth. We suggest that these factors influenced the changes in cortex of the proximal femur.

The present study has the following limitations. It is not a large-scale prospective study using femoral stems with various designs and surface coatings. In the future, a long-term study by many institutions is needed. In particular, considering the fractured proximal bone fragments in addition to the design of the stem, a comparative study comparing the surface coating of the stem is necessary to evaluate bone ingrowth and ongrowth better. Although not significant for walking evaluation, walking ability decreased in Group B from 48 months postoperatively. Our study also has a retrospective design, which has inherent limitations. In the future, it is necessary to score the evaluation of walking ability or to increase the grade to three or more for further evaluation prospectively. Lastly, investigation of whether cortical bone porosis, nonunion of trochanteric fracture fragments, and endosteal cortical bone absorption affected the reduction of ambulation capacity was not performed because of the lack of statistical value due to the small number of cases. Again, we believe that large-scale multicenter studies with more cases will be needed in the future.

Conclusions

Hip hemiarthroplasty using a cementless femoral stem for unstable intertrochanteric fractures can be used selectively in elderly patients and those with osteoporosis, considering early ambulation and low rate of complications. However, careful femoral stem selection regarding the design is needed considering the remaining life of the patient, and if a 3C stem is used, surgeons have to ensure firm fixation of the fractured trochanteric fragments in order to obtain sufficient three-point fixation in the proximal femur. Additionally, as with a reverse oblique fracture, when using a 3C stem or when it is difficult to achieve stable and firm fixation of the fracture fragments, it is better to use a stem with a suitable length and design that can be fixed in diaphysis mostly.

Abbreviations

HHS

Harris hip score

Declarations

Ethics approval and consent to participate

The design and protocol of this retrospective study were approved by the institutional review board of the First Author's Hospital (GJVH-IRB No. 2019-6-2). All patients were informed that their medical data could be used in a scientific study and provided their consent.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no potential conflicts of interest to disclose.

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Not applicable.

Authors' contributions

HMC conceived and coordinated the study. HMC, SDK, and JP designed the ethical issues. HMC and SDK acquired the data. HMC and SDK reviewed the data. YL and HMC performed the statistical analysis. HMC, JP, and KK prepared the manuscript. SDK, JP, and KK provided administrative, technical, or material support. All authors approved the manuscript.

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Consent for publication

Written informed consent was obtained from all patients.

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Figures

(A) Harris hip score

(B) Walking ability

Figure 1

Changes in hip function and walking grades. There is a significant decrease in hip function from 48 months postoperatively in Group B, and walking grades 2 and 3 in Group B increase from 48 months postoperatively.

Figure 2

Representative case in Group A. A) A2-type intertrochanteric fracture in an 81-year-old female patient. B) Postoperative radiograph of a 3C stem. C) Follow-up at 12 months showing stable fixation of the femoral stem without any cortical porosis and radiolucent lines. D) Follow-up at 24 months showing cortical porosis around the femoral stem with stable fixation. E) Follow-up at 60 months showing stable fixation of the femoral stem and persistent cortical porosis without radiolucent lines.

Figure 3

Representative case in Group B. A) A2-type intertrochanteric fracture in a 79-year-old female patient. B) Postoperative radiograph of a 3C stem. C) Follow-up at 12 months showing some cortical porosis around

the femoral stem with stable fixation and a united greater trochanter. D) Follow-up at 60 months showing a radiolucent line at the bone-stem interface with a united greater trochanter.

Figure 4

Representative patient with trochanteric nonunion. A) A3-type intertrochanteric fracture in an 82-year-old female patient. B) Postoperative radiograph of a 3B stem. C) Follow-up at 36 months showing stable fixation of the femoral stem. D) Follow-up at 60 months showing stable fixation of the femoral stem and a non-united greater trochanter without any cortical porosis and radiolucent lines.