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Original Article

Clinical and biomechanical studies on cemented hemiarthroplasty treatment of advanced-age comminuted intertrochanteric fractures

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Abstract: The clinical effectiveness and biomechanical reliability of cemented hemiarthroplasty treatment of comminuted unstable intertrochanteric fractures were assessed. A total of 77 patients with intertrochanteric fracture who received cemented hemiarthroplasty treatment were retrospectively followed up. Statistical analyses were conducted for various items of hospitalization data, Harris score, complication incidence, and mortality rate. A total of 18 lateral femoral specimens from nine human cadavers were used to simulate comminuted intertrochanteric fractures. After fixing the lesser trochanter with reduction wire and reconstructing the calcar femorale with bone cement, the prosthesis stem was fixed with bone cement, and the mechanical stability of the femoral prosthesis stem was tested with a universal testing machine. Conventional replacement was simultaneously conducted to serve as control. Mean follow-up time was about 39.2 months, and the mean age of patients was 80.6±6.0 years. At 1 wk postoperative, 89.6% patients could ambulate, Harris score was 75.6±12.0 points, complication incidence was 6.4%, and one-year mortality rate was 20.8%. After three groups of test articles completed the testing of cycle 10000 loads, no significant differences were observed in the axial displacement data among the three groups. Cemented hemiarthroplasty can effectively treat comminuted intertrochanteric fractures in the elderly, and cemented semi-hip replacement can provide adequate initial stability for prosthesis stem.

Keywords: Femoral intertrochanteric fracture, cemented hemiarthroplasty, harris score, biomechanics

Introduction

Hip fracture is common in the elderly and its incidence is increasing along with the aging social population. Approximately 700,000 people die of hip fracture annually worldwide [1], and the six-month mortality rate after injury reaches up to 17% to 27% [2-4]. In addition, 25% to 75% of patients are unable to regain pre-fracture function [5]. Intertrochanteric fracture accounts for 50% of hip fractures [6], and in most patients, intertrochanteric fracture is accompanied by internal diseases. A considerable number of patients die of complications or aggravated coexisting diseases before fracture healing. For the early and successful treatment of hip fracture, operation must be performed as early as possible to enable patients conduct functional exercise as early as possible, maximize the recovery of the affected limb, avoid the complications of long-term bed restriction, and significantly reduce the mortality rate [7-9].

The complication incidence of intramedullary fixation treatment for intertrochanteric fracture ranges from 12.8% to 25%, and reoperation rate is high [10-16], especially for comminuted unstable intertrochanteric fractures. Obtaining rigid fixation is difficult because of severe osteoporosis, posterior medial cortical collapse, and calcar femorale defects. Early weight bearing will readily cause serious complications, such as dissection, shift separation, hip screw outflow, fracture of femoral shaft, breakage of the intramedullary fixation, and other femoral shaft fractures [14, 17, 18]. To conduct physical activity and full weight bearing after operation as soon as possible, as well as to avoid high complication incidence and failure rate of intramedullary fixation treatment, for comminuted intertrochanteric fractures, some scholars believe that artificial hip joint replacement is preferred for hip fracture patients [19-21]. However, relevant clinical efficacy studies should be conducted. Necessary tests and evaluations should be performed, especially to determine whether such method complies with biomechanics requirements. The purpose of the present study is to assess the clinical effectiveness and biomechanical reliability of cemented hemiarthroplasty treatment of comminuted unstable intertrochanteric fractures. In the clinical study section, we retrospectively evaluated the efficacy of cemented hemiarthroplasty treatment in 77 patients with intertrochanteric fracture while receiving follow-up from March 2005 to November 2010. In the biomechanics section, the lesser trochanter was fixed with a reduction wire and calcar femorale was reconstructed with bone cement. Then, under the simulation conditions of femoral comminuted intertrochanteric fracture, the prosthesis stem was fixed with bone cement, and the mechanical stability of femoral prosthesis stem was tested with a universal testing machine. The present paper provides clinical and experimental bases for the use of artificial joint replacement treatment of femoral intertrochanteric fracture in clinics.

Methods

Clinical data

Patients with comminuted intertrochanteric fracture who received cemented hemiarthroplasty in the General Hospital of PLA from 2005 March to 2010 November, suffered from class III and IV fractures according to Jensen-Evans classification, and whose ages were over 70 years, were included in the present study. The patients were operated on by senior doctors. Patients who had pathological fractures or multiple injuries, without stepping ability, or had walking difficulties were excluded.

After the patients were hospitalized, skin traction was immediately conducted on the affected limbs to reduce pain. In addition, usual health situations, comorbidity types, and current treatment situations of each specific patient were considered. During treatment of the fractures, comorbidities were synchronously treated. For patients with coexisting cardiovascular disease, no acute onset was observed. For hypertensive patients, diastolic pressure was controlled at approximately 90 mm Hg. For diabetics, fasting blood-glucose was maintained below 10 mmol/L. Other systematic comorbidities were maintained at a relatively stable state. After assessment, the treatment operation was immediately performed for patients without absolute contraindication of operation. In the present study, the time interval from admission to operation ranged from about 1 d to 10 d, and the mean interval time was 4 d. Approximately 10% of patients received emergency operation after admission. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Chinese PLA General Hospital. Written informed consent was obtained from all participants.

Anesthesia delivery included general anesthesia or epidural anesthesia plus nerve block, and most of anesthesia durations were controlled within 80 min. An incision was made at the posterolateral hip to cut off fascia superficialis and deep fascia. The gluteus maximus was separated bluntly, and the mesoglutaeus was retained. At sinus piriformis, the extortor short group and posterior capsula articularis were cut off to remove the caput femoris. Larger fracture blocks were retained on tuberosity, and the stump of the round ligament in acetabular fossa was cleaned. For partial patients with completer base of femoral neck, osteotomy at femoral neck to retain the complete calcar femorale was performed. The retained calcar femorale was fixed with the inserted artificial femoral stem through intramedullary fixation, the major trochanter was fixed with "∞"-type steel wire, the minor trochanter was fixed through double-strand wire cerclage, and calcar femorale was remolded with bone cement. Thus, the proximal femur was reconstructed. At hip and knee inflexion of 90°, the femoral anteversion angle was determined according to the mark of the femoral condyle parallel to the ground. On the femoral condyle plane, the anteversion angle of femoral prosthesis to be inserted was approximately 15°. The tightening wire was placed into the bone cement. After determination of the lengths of the two lower limbs, an appropriate prosthesis was selected and implanted. After reduction, if neutral position was in slight adduction flexion of 90° and extending positive was in extorsion of 90°, joint installation was considered appropriate. Subsequently, a negative pressure drainage tube was placed into the articular cavity, the posterior joint capsule was sutured, and the incision was closed layer by layer.

For postoperative treatment, appropriate broad-spectrum antibiotics with smallest influence on liver and kidney functions were used to prevent incision infection, and medication time was approximately 3 d. Continued treatment of comorbidities and supporting treatment were performed. If general conditions allowed, patients could ambulate under the protection of other people at 1 d postoperative, and the affected limb could conduct partial weight bearing and stand. At 2 d postoperative, patients could practice walker-assisted activities. At horizontal position, patients were urged to make isometric muscle contraction exercises of the affected limb and wear long-legged elastic stockings to prevent deep vein thrombosis.

After operation, recovery to the status before injury was considered excellent. When patients were able to ambulate via walker by themselves, the cases were considered to be good. When patients could ambulate via walker with the help of other people, the case was considered to be moderate. Patients who could not actively move were considered to be in bad status.

Femur specimens and prostheses

In this experiment, specimens from the femurs of freshly frozen adult cadavers were used. Both frontal and lateral radiographs were photographed for all femur specimens to exclude congenital deformity, fractures, or tumor lesions. A total of 18 lateral femoral specimens of nine human cadavers were obtained, including seven male and two female cadavers. The mean age was 81.6±6.0. The mean height was 171±5.5 cm. The mean bodyweight was 64.5±8.0 kg. The mean storage time was 2.6 months. Before the experiment, all femur specimens were thawed overnight at room temperature, and all attached soft tissues were removed.

All femur specimens were measured via the template for determining prosthesis model. SQK model artificial bipolar hemi-hip prosthesis (provided by Tianjin Zhengtian Medical Device Co., Ltd., Tianjin, China) was used and comprised femoral stem, ball head, plastic inner cup, and metal ring. The femoral stem was made of cobalt-chromium-molybdenum alloy material and designed as a straight stem with collar. The collodiaphysial angle was approximately 135°, and the stem was of standard length. Additionally, the stem was polished using abrazine. According to X-ray measurements of the femur specimens, femoral stems 0# to 3# were used. Caput femoris, which comprised a ball head with diameter of 24-8 matching with femoral stem, plastic inner cup made from ultra-high-molecular weight polyethylene, and metal ring made of titanium alloy, was matched with femoral stem and ball head. The appropriate prostheses were selected based on the size of the removed caput femoris measured during operation. A total of four specifications of caput femoris (46, 48, 50, and 52 mm) were used in the present study.

Test article preparation

Under the premise that the same femur specimen was not assigned to the same test group, 18 lateral femoral specimens of nine human cadavers were randomized into three test groups. In the conventional cemented hemiarthroplasty group, operations were conducted according to the artificial hip replacement standard. According to the angle of prosthesis shoulder support-stem, femoral neck osteotomy was conducted at 15 mm over the lesser trochanter, and the cavum medullare was expanded by the matched cavum medullare expander and cavum medullare file. Subsequently, the cavum medullare was washed clean. Bone cement (acrylic resin bone cement manufactured by Synthetic Materials Research Institute of Tianjin, Tianjin, China) was adjusted to the doughing stage and pressurized into the cavum medullare using a bone cement gun. Afterwards, the suitable model femoral prosthesis was implanted.

In two test groups of intertrochanteric fractures, femur specimens were used to simulate femoral intertrochanteric three-part fracture (class IV according to Jensen-Evans classifica-

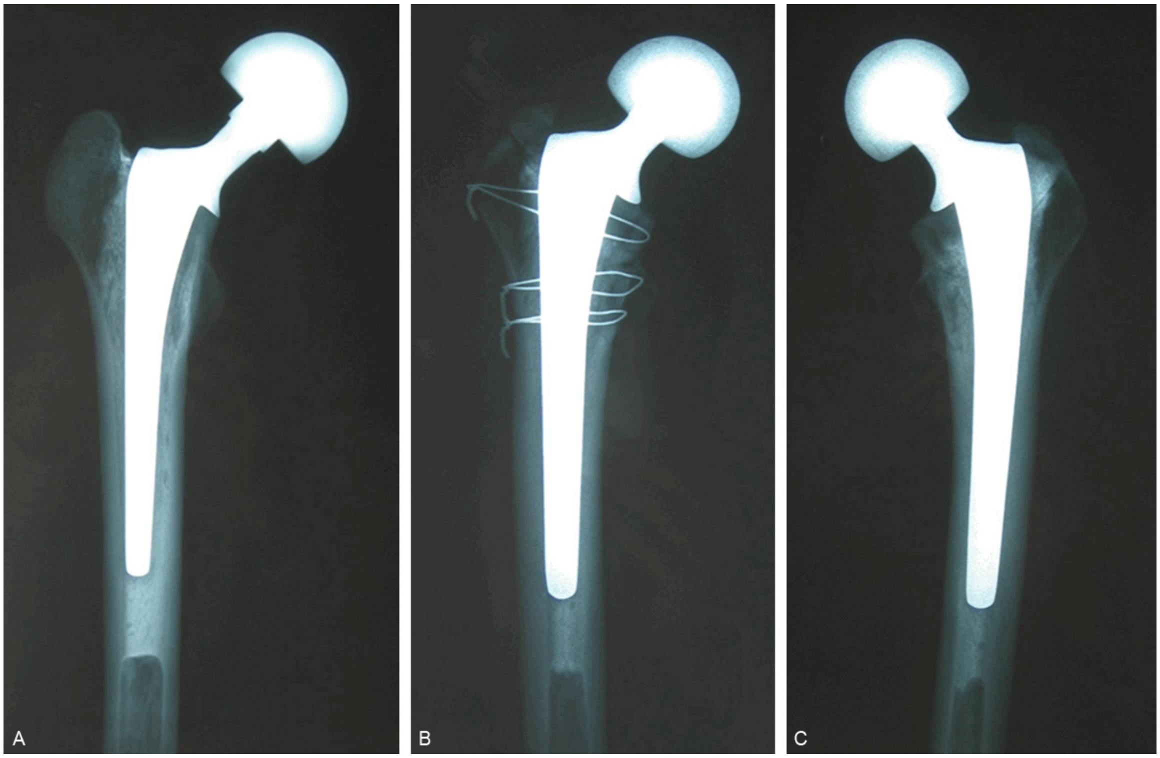

Figure 1. A: Test articles in the conventional replacement group; B: Test articles in the lesser trochanter fixation group; C: Test articles bone cement reconstruction group.

tion). Subsequently, according to the angle of prosthesis shoulder support-stem, femoral neck osteotomy was conducted, and the cavum medullare was expanded by the matched cavum medullare expander and cavum medullare file. Afterwards, the cavum medullare was washed clean. For the lesser trochanter fixation group, upper and lower parts of the lesser trochanter were drilled, and the lesser trochanter and calcar femorale fracture blocks were fixed with 1 mm wire through holes. Bone cement was then adjusted to the doughing stage and pressurized into the cavum medullare using a bone cement gun. During prosthesis implantation, the wire was tightened to compress the gap between fracture blocks, preventing the bone cement from entering the gap between fracture blocks. For specimens in the bone cement reconstruction group, after bone cement was pressurized into the cavum medullare, the prosthesis was implanted, and the calcar femorale was reconstructed using bone cement plasticity. Finally, the lesser trochanter bone blocks were stuck.

Radiographs were photographed for all femur specimens (**Figure 1**). All prostheses were ensured to be at neutral position, and no enstrophe or ecstrophy was observed. Moreover, all prostheses were mechanically tested after storage at room temperature for 24 h.

Determination of femoral stem displacement

The lower end of the femur was fixed with dental base acrylic resin powder onto the foundation support using square box fixation mode. The force direction of weight bearing of the femur as single-foot standing was simulated, coronary plane presented an adduction of 25°, and the sagittal vertical position was fixed. The vertical height of all test articles was maintained at 25 cm to ensure precision in line with loading direction. According to the hip joint load curve for typical walking cycles by Davy *et al.* [22] assuming a body weight of 600 N, the peak and minimum axial loads of the femoral prosthesis in each walking cycle were 1500 and 150 N, respectively. A test article was assembled onto BOSE ELF 3330 testing machine (BOSE Corporation, Boston, USA), and the press plate was aligned to the center of the caput femoris. Sine wave loading from 150 N to 1500 N was used to simulate the load borne by

Figure 2. A: Testing of test articles in the conventional replacement group; B: Testing of test articles in the lesser trochanter fixation group; C: Testing of test articles bone cement reconstruction group.

the hip joint in walking cycles and cycled 10000 times at a frequency of 1 Hz (**Figure 2**). To ensure the repeatability of the test article in cycle testing and eliminate the effects of femoral relaxation creep, the test article was first preloaded with 100 times of cycle loads. Each test article was tested according to the same procedure. Micro displacement of femoral stem prosthesis in the axial direction was measured by the axial variable displacement sensor of testing machine (precision of 1 μm) and recorded by the software integrated in the testing machine.

Statistical analysis

Displacement data of each test article completing 1000 cycles were selected to calculate the mean displacement value of each test group in the corresponding number of cycles to plot the time-displacement curve, which represented the displacement trend presented by each test group with an increase in cycle number.

Statistical analyses were conducted for the displacement data of 10000 cycles of various test articles among the three test groups, and data were analyzed using SPSS18.0 statistical software. Data are expressed as means ± standard deviation, and ANOVA was used to compare the three groups of data. Statistically significant difference was considered at $P<0.05$.

Results

General data of patients

Clinical data of a total of 92 comminuted patients were retrospectively analyzed. Fifteen cases were excluded, including two cases of pathological fractures, six cases of multiple injuries, and six cases of patients without stepping ability or had walking difficulties. As a result, 77 cases of patients were included in this study. The mean age was 81.6±6.0 years. A total of 28 cases were males (36.4%), and 69 were females (63.6%). A significant difference in gender proportion (binomial test, $P=0.000$) was observed. Left-side intertrochanteric fracture accounted for 54.5%. All 77 patients suffered from fractures because of slipping themselves or falling from high altitude. Complete preoperative and postoperative X-ray films of all 77 cases were obtained and assessed. Patients with grade 4 and lower osteoporosis accounted for 77.9% of all cases, and singh index distributions are shown in **Figure 3**. According to the Jensen-Evans classification, ten cases belonged to class III, 23 cases belonged to class IV, and 44 cases belonged to class V. Class V four-part fracture accounted for 57.1% of all cases.

Patients without comorbidities accounted for 35.1%, patients with one to two kinds of comorbidities accounted for 50.7%, and some pati-

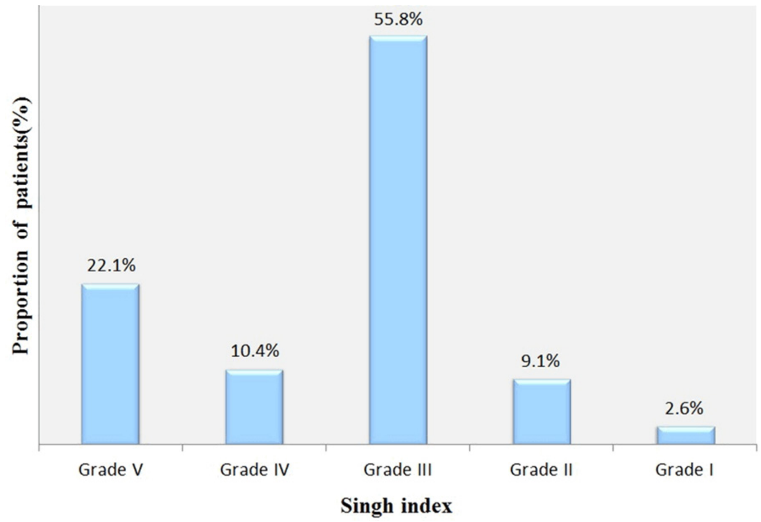

Figure 3. Singh index distributions.

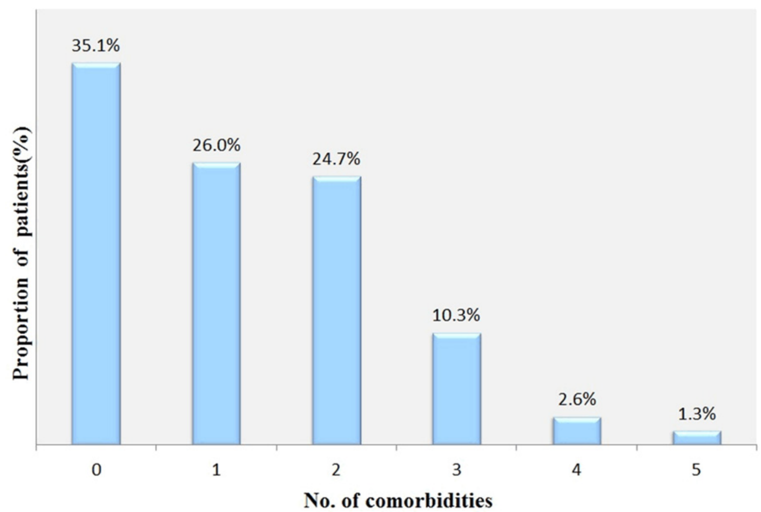

Figure 4. Kind number of internal comorbidities in patients.

ents were accompanied with at least three kinds of comorbidities. The comorbidities with the corresponding percentages of patients were as follows: hypertension, 29.9%; coronary heart disease, 22.1%; diabetes, 15.9%; cerebrovascular disease, 13%; and chronic lung disease, 8.5% (**Figures 4** and **5**).

Operation and postoperative function

All 77 patients successfully completed the operations. Operation durations were 65.2±6.0 min. Intra-operative bleeding in 73 cases was 152.6±12.4 mL. Intra-operative bleeding was 273.2±32.6 mL. On average, the postoperative total drainage volume was 179.7 ±12.4 mL. Average hospitalization time was 14.1 days. Follow-up time ranged from 6 months to 98 months, and the mean follow-up time was 39.2 months. Within 3 d postoperative, 33 patients could ambulate. At 4 d to 7 d postoperative, 36 cases could ambulate. After 8 d postoperative, six cases could ambulate. During hospitalization, two patients were unable to ambulate. Harris score was 75.6±12.0. The number of cases with the corresponding levels of assessment was as follows: eight cases (10.4%), excellent; 16 cases (20.7%), better; 35 cases (45.5%), good; and 18 cases (23.4%), bad. Significant difference was observed in the Harris scores between males and females (79.9±8.8 vs. 74.4±12.5, P= 0.004 using t-test).

Complications and mortality rate

For postoperative complications, two cases of periprosthetic fractures caused by falling after discharge were recorded, and both cases were immediately treated by reoperation. In **Figure 6**, a 75-year-old male patient received hemiarthroplasty on February 25, 2007 and suffered from cerebral embolism at 14 months postoperative. In May 2009, the patient suffered from B_3-type periprosthetic fracture and was treated by long-stem prosthesis replacement combined with wire banding. His current Harris score was 74 points. Additionally, two cases of dislocations were recorded, one of who had dislocation at 3 d postoperative, and the other case occurred at 2 wk after discharge. After the dislocations were identified, closed reduction was immediately conducted. The reason of the dislocation was due to the flexion adduction of trouble sidebody. One case of unexplained pain was recorded. The incidence

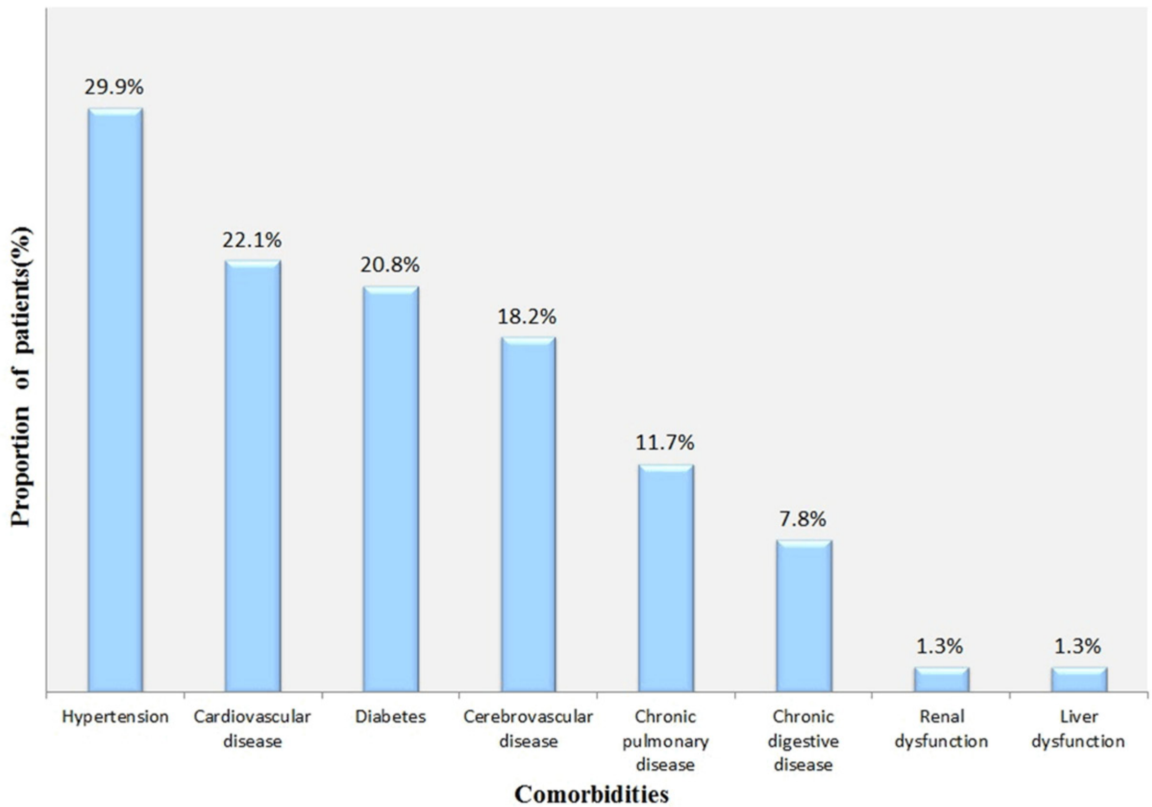

Figure 5. Percents of patients with variosu internal comorbidities.

Figure 6. B_3 type periprosthetic fractures occurred and long-stem prostheis replacement was conducted. A: Postoperative 3 days; B: Postoperative 27 months; C: Postoperative 28 months.

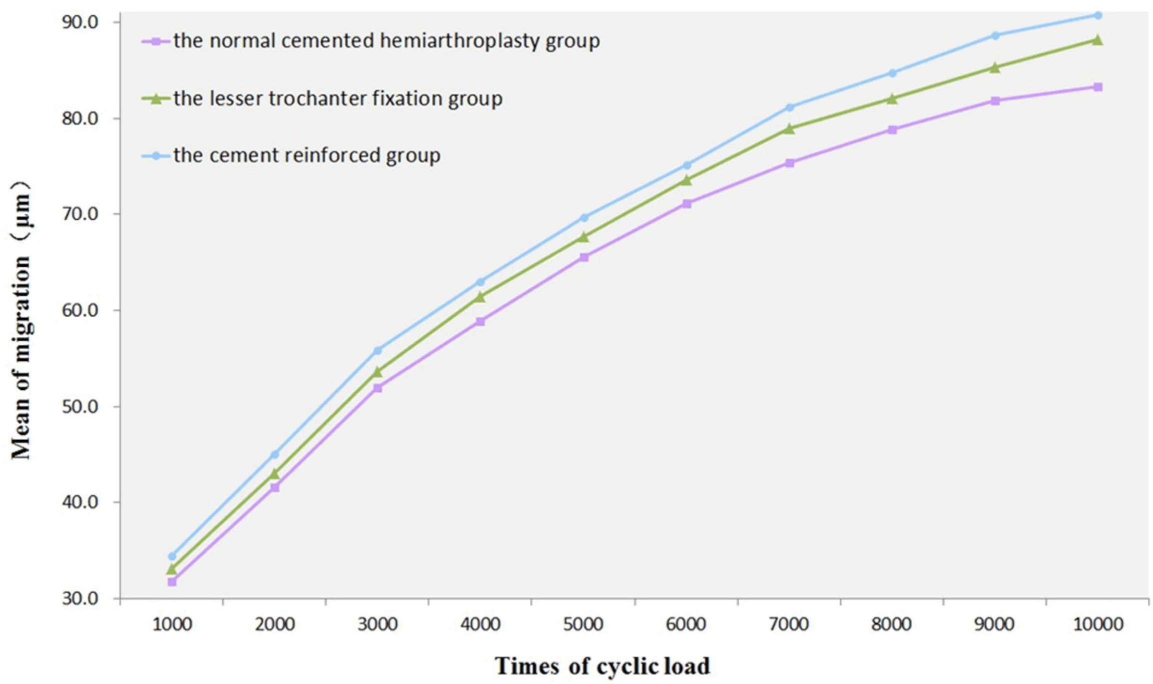

Figure 7. Cycle-displacement curves of three experiment groups.

of complications was 6.4%. Among 77 cases of patients, 24 cases died within the follow-up period. One-month, six-month, and one-year mortality rates were 3.9%, 11.7%, and 20.8%, respectively. The total mortality rate was 31.2%.

Biomechanical test

All test articles successfully completed the cycle load test, and fixing devices were firm and without looseness and deformation. The different groups of femur specimens showed no fracture, rupture, or deformation, the loading plane was stable, and load transmission was uniform.

According to the cycle-displacement curves in the various test groups (**Figure 7**), displacement increased with the number of cycles in the three test groups. The conventional replacement group showed the minimum mean displacement value at the end of every 1000 times of cycle loads, contrary to bone cement reconstruction group which showed the maximum corresponding value. For all test groups, displacement amplitude initially increased and then gradually decreased in the latter stages of the cycle. Increase in displacement amplitude in every 1000 times in the last 3000 times in the conventional replacement group was less than 3 μm. The basic curve suggests that the increase in displacement amplitude of prosthesis in all test groups was higher during the initial stage of the cycle, and increase in displacement amplitude became smaller with increasing number of cycles. In the conventional replacement group, the resulting trend was more obvious because of the complete proximal femur structure.

Statistical analysis on displacement data of various test articles completing the final 10000th cycle indicated no significant difference in axial displacement data among the three groups (P=0.052). Minimum mean displacement and degree of variation of data were found in the conventional replacement group. Mean displacement and degree of variation in the bone cement reconstruction group were higher than those in the lesser trochanter fixation group (**Table 1**).

Discussion

Intertrochanteric fracture is a prevalent disease in the elderly. If osteoporosis is more serious, the fracture becomes increasingly unstable and comminuted. In advanced-age patients, complications induced by bedridden status

Table 1. Statistical results of axial displacement under cycle loads in various experiment groups

Number of cycles	Conventional replacement group	Lesser trochanter fixation group	Bone cement reconstruction group	F value	*P* value
Mean displacement (μm, mean ± SD)					
1000	31.8±1.9	33.1±1.6	34.5±1.6	3.507	0.056
2000	41.6±2.8	43.1±2.6	45.1±2.6	2.5	0.116
3000	52.0±2.9	53.6±2.3	55.9±2.4	3.655	0.051
4000	58.9±3.1	61.5±2.1	63.0±2.6	3.543	0.055
5000	65.6±3.1	67.7±3.2	69.7±3.3	2.485	0.117
6000	71.1±3.2	73.6±3.9	75.2±4.2	1.803	0.199
7000	75.4±3.8	78.9±4.4	81.2±4.7	2.675	0.101
8000	78.8±4.3	82.1±4.7	84.8±5.0	2.547	0.112
9000	81.8±4.5	85.3±4.9	88.7±5.1	3.18	0.071
10000	83.3±4.8	88.2±4.9	90.8±5.1	3.612	0.052

caused by fracture and rapid deterioration of comorbidities result in high mortality rates. For osteoporotic comminuted fracture, achieving a reliable fixation is usually difficult, and the risk of failure is high. Cemented hemiarthroplasty for such fractures can avoid internal-fixation relevant complications, allow rapid recovery of the patient's locomotor ability, and prevent systemic complications induced by bedridden status. Previously conducted mechanics experiments also confirmed that prosthesis stem provides enough initial stability and is reliable in biomechanics.

Numerous researchers have reported on the efficacy of artificial hip replacement for intertrochanteric fracture. Abdelkhalek *et al*. [19] reported an 85% satisfactory rate of semi-hip replacement. Sinno *et al*. [20] thought that cemented hemiarthroplasty is superior to intramedullary fixation in terms of full weight bearing time, postoperative function, and complications. Faldini *et al*. [23] treated 54 patients with unstable intertrochanteric fracture by semi-hip or total-hip replacement and indicated that patients receiving hip replacement could earlier bear full weight and more easily cared for than patients receiving intramedullary fixation. In the current study, the mean age of patients was 81.6±6.0 years. Patients with one to two comorbidities accounted for 50.7%, and several patients were accompanied by three comorbidities. Patients with cerebrovascular disease and patients with lung disease accounted for 73.5%. Patients with singh index grade 4 and lower steoporosis accounted for 77.9%. Most fractures were comminuted fractures, and class V four-part fracture accounted for 57.1%. Within 3 d postoperative after cemented hemiarthroplasty, 33 patients (42.9%) could ambulate. On 4 d to 7 d postoperative, 36 cases (46.7%) could ambulate. After 8 d postoperative, six patients (7.8%) could ambulate. During hospitalization, two cases (2.6%) could not ambulate. No systemic complications induced by bedridden status were observed, and the effectiveness of facilitating early recovery of activity function in patients and reducing complications was successful.

For comminuted unstable intertrochanteric fractures, the proximal femoral structure integrity has been severely damaged, and its operation difficulty is more complex than conventional total hip replacement. Various techniques are used to treat proximal fracture blocks. Some scholars have used calcar femorale-substituting prostheses to treat 58 cases of old patients with osteoporotic comminuted intertrochanteric fracture. Among them, 88% patients regained walking ability within 1 wk postoperative, and 91% of patients regained walking ability before discharge [24]. Good results were also obtained after using standard femoral prosthesis via bone structure reconstruction of the proximal femur. Grimsrud *et al*. [25] used a novel cerclage to fix intertrochanteric fracture fragments and retain calcar femorale. Loosening and sinking of the femoral prosthesis did not occur during the one year follow-up. In the current study, large bone blocks were restored and fixed tightly to reconstruct structural integrity of proximal femur. For extremely comminuted bone blocks in which structual integrity could not be restored by fixation or for cases with short life expectancy, implantation of prosthesis after using bone cement to remold calcar femorale was performed. Loosening and sinking of femoral prosthesis did not occur during the follow-up period. Our mechanics experiments also proved that the prosthesis could similarly obtain the initial stability after filling bone cement into the bone defect and reconstructing calcar femorale. The calcar femorale-substituting prosthesis might present some problems, such as trochanteric nonunion, inequality of lower limbs, and weakness of peripheral soft tissues. Thus, this type of prosthesis is more suitable for pathological fractures. Graft reconstruction of bone defect is advantageous in restoring the integrity of anatomical structures, and a patient's tolerance to operation should be considered to make an appropriate application.

For postoperative functions, randomized clinical trials conducted by Shin-Yoon compared the efficacy of long-stem prosthesis replacement with intramedullary fixation in A2-type fractures, and the results showed no significant differences in postoperative functions between the two techniques [26]. Andreas reported no significant difference in complication incidence, hip joint function, and life quality between semi-hip replacement and intramedullary fixation [16]. Diwanji et al. [27] observed the situations of life quality improvement of patients after replacement by means of SF-36 and found that semi-hip replacement could meet the basic needs of daily life, but no advantage was found in terms of function in short term. In the current study, patients were older, with severe osteoporosis, and low average postoperative Harris scores. The primary reason why patients receive caput femoris replacement was lack of exercise, which decreases muscle strength and aggravates osteoporosis, thereby decreasing patient function.

Postoperative complications are mainly related to hip replacement. In the current study, postoperative complications included two cases of periprosthetic fractures, two cases of dislocations, and one case of postoperative hip pain. Prosthesis loosening and deep infection were not observed, and the complication incidence was 6.4%. Periprosthetic fracture is one of the serious complications that occur after joint replacement. Bethea found potential lossening of prosthesis stem in 75% of patients with periprosthetic fracture [28]. However, we found that in advanced-age patients with periprosthetic fracture, falling after replacement was a direct reason for periprosthetic fracture. No related manifestiations were observed before falling, and severe osteoporosis was the inherent reason for refracture. Hip joint dislocation usually occurs within 4 wk to 5 wk postoperative, and late dislocation has an obvious pathological process and often appears several years after prosthesis implantation. Hip joint dislocation is related to prosthesis implantation site and operative approach. In addition, muscle atrophy around the hip joint, joint capsule relaxation, and multiple operations result in a number of scar tissues around the joint and may reduce hip stability and easily induce dislocation. Additionally, postoperative inappropriate placement of the lower limb will also cause dislocation. In the current study, two cases of patients presented postoperative dislocations. After the dislocations were identified, closed reduction was immediately conducted, after which dislocation occurred again. Early postoperative pain is often thought of as a protective mechanism, while late chronic pain is mainly caused by the prosthesis itself or by extra articular lesions. For cemented hemiarthroplasty, acetabulum abrasion is possibly the main reason for late pain and mostly occurs in patients with a good activity ability.

Both clinical efficacy and prosthesis stability of artificial hip joint replacement treatment for caput femoris necrosis and hip osteoarthritis have been widely recognized, while proximal femur bone structure damage after intertrochanteric fracture is a negative factor for stem stability. Results from our mechanics experiment suggest no significant difference in axial displacement data of test articles completing the final 10000th time cycle among the three groups. According to the cycle-displacement curve, mean displacement values at various time points in the conventional replacement group are minimum because of the complete proximal femur bone structure. For two intertrochanteric fracture groups, the increase in displacement amplitude of the lesser trochanter fixation group is less than that of the bone cement reconstruction group, which may be related to that of the case of bone cement reconstruction of calcar femorale bone defect. The proximal femur could not provide support to the whole anatomical structure and thereby infuenced the strength of bone cement shell under low-pressure conditions. Theoretically, posteromedial bone blocks of proximal femur provide the contact of metaphysis with the greater trochanter, and retained lesser trochanter and calcar femorale bone blocks can promote trochanter healing to recover the integrity of proximal femur anatomic mechanics, thereby ensuring the stability of the implanted prosthesis. For extremely comminuted intertrochanteric fractures, trochanter reconstruction will increase operation duration and risk. After filling bone cement into the bone defect and reconstructing calcar femorale, the implanted prosthesis can similarly obtain the initial stability.

Clinical data in the present study are obtained from a single center, the sample size is smaller, and postoperative follow-up time is shorter. For evaluations on long-term functional recovery, prosthesis stability and mortality rate, conducting multiple-center and large-sample size studies are still required. For in vitro model used in the mechanics test, simulating the exact traction situation of fracture blocks caused by muscles around hip joint in body environment and assessing the displacement situations of fracture blocks after long-term activites are impossible. Additionally, conducting further testing and explorations on whether hip joint function is influenced are necessary.

Conclusion

For patients with unstable intertrochanteric fractures, especially advanced-age patients with severe osteoporotic intertrochanteric fractures, cemented hemiarthroplasty is a safe and effective treatment method. Cemented semi-hip replacement can provide adequate initial stability for prosthesis stem. After operation, patients can ambulate and bear weight, conduct physical activities, and obtain function recovery as soon as possible, while avoiding the occurrence of fracture complications (especially systemic complications). However, compared with intramedullary fixation, hip replacement has no advantage in function recovery, and problems such as prosthesis replacement-relevant complications are encountered.

Acknowledgements

This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Chinese PLA General Hospital. Written informed consent was obtained from all participants.

Disclosure of conflict of interest

None.

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