Conversion Hip Arthroplasty Using Standard and Long Stems after Failed Internal Fixation of Intertrochanteric Fractures

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Abstract

**Background**: Failed internal fixation of intertrochanteric fractures is often treated by conversion hip arthroplasty (CHA). This study aimed to evaluate the results and complications of using long and standard femoral stems in this operation.

**Methods**: This retrospective, multi-center study enrolled 31 total hip arthroplasty (THA) and 23 hemiarthroplasty (HA) cases (30 women, 24 men; mean age 76 years) after FIF-ITF between 2012 and 2019, divided into 2 groups: standard stem group (n = 20) and long stem group (n = 34). The initial internal fixation includes 38 cases of proximal femoral nail anti-rotation (PFNA), 8 cases of the dynamic hip screw (DHS), and 8 cases of locking proximal femoral plate (LPFP). The indications for CHA included 38 cases of failure of fixation, 7 cases of nonunion, and 9 cases of avascular necrosis or posttraumatic osteoarthritis. Perioperative data and complications related to fracture and operation were collected, and preoperative and postoperative clinical and radiological data were analyzed.

**Results**: At an average of 5.6 years with a minimum of 2 years follow-up. A significant overall surgeon-related complication rate was detected (27.8% [15/54]), five cases had an intraoperative femur fracture, one case had a late periprosthetic femoral fracture, one case had a stem penetration, one case had a cement leakage, and two patients had an early postoperative dislocation, one infection and three cases of stem loosening or subsidence. Long stems had an increased risk of complication (13/34) compared to standard stems (2/20) (P= 0.031). The operation time and blood loss in the long stem group were higher than those in the standard stem group (P= 0.002;0.017). Harris Hip Score (HHS) and SF-36 significantly improved in both groups from preoperative to the final follow-up, and did not present significant differences at the final follow-up (P>0.05).

**Conclusion**: A high complication rate was detected in CHA following failed internal fixation of intertrochanteric fractures, and long stem arthroplasty should be approached with caution to the risks of complications, especially intraoperative femur fractures.

**Level of evidence**: III controlled cohort study

Introduction

The incidence of intertrochanteric fractures (ITF) has rapidly increased with the population ages, and most intertrochanteric fractures can be effectively treated with internal fixation\(^1,2\), nevertheless, a few patients experience nonunion or early fixation failure, previous studies have reported that the failure rate has reached up to 1.2–9.6% \(^3,4\).

Surgeons prefer a revision internal fixation with selected bone grafting for young patients with failed internal fixation of intertrochanteric fracture (FIF-ITF) \(^5\), in older patients with poor proximal bone quality and fail by implant cutout from the femoral head, conversion hip arthroplasty (CHA) is effective in the recovery of hip joint function with earlier walking and decreased complications \(^5,6\). However, hip
arthroplasty following such patients faces several challenges, including proximal femoral bone loss, proximal femur deformities, poor bone quality, possible gluteus medius muscle injury, and bone defects caused by residual screw holes. Complications such as periprosthetic fracture, dislocation, prosthesis subsidence, and even periprosthetic joint infection are significantly higher compared to primary hip arthroplasty. It's reported that hip arthroplasty for FIF-ITF is associated with higher blood loss, length of stay, and total costs compared to primary THA, necessitating a separate discussion from primary THA.

Previous studies have reported different types of the femoral prosthesis in CHA for FIF-ITF patients, as well as cemented, cementless, standard, calcar-replacement, modular, non-modular, revision stem, etc. Few studies have paid attention to the length of the femoral prosthesis, this study retrospectively included and analyzed the results, technical problems, and complications of CHA following FIF-ITF patients in multi-centers, and the clinical efficiency of standard and long stems were compared.

Materials And Methods

This retrospective study was approved by the institutional review board, and a waiver for informed consent was obtained. FIF-ITF patients who received conversion hip arthroplasty at multi-centers from December 2012 to December 2019 were retrospectively analyzed. Inclusive criteria: patients received THA or HA for failed internal fixation of ITF (type AO/OTA 31.A) caused by previous trauma. Internal fixation failure was defined as any reason for required surgical intervention to replace the internal fixation. Exclusion criteria: incomplete data, or insufficient follow-up, hip dysfunction before fractures; rheumatoid arthritis or other inflammatory diseases; renal or other organ failures, serious infectious diseases, tumors, and mental disorders.

All preoperative clinical, laboratory, and radiographic data, the type of initial fracture, and the internal fixation performed were recorded, along with the cause of the fixation failure and the time between the fixation and its failure.

After excluding 12 patients who were lost to follow-up, and had insufficient data, 54 patients (30 women, 24 men) were eventually included (Table 1). The mean age at the time of the CHA was 75.64 ± 11.58 years. All fractures were unilateral (27 left cases and 27 right cases). The mean time from fixation to failure was 6.4 (range, 1-13.75) months. The mean interval between fracture and CHA was 6.4 (range, 1-13.75) months. The fracture type includes 19 cases of A1.2, 11 cases of A1.3, 8 cases of A2.2, 4 cases of A2.3, 5 cases of A3.1, 1 case of A3.2, and 6 cases of A3.3. For the initial fixation devices, proximal femoral nail anti-rotation (PFNA) was used in 38 cases, the dynamic hip screw (DHS) was used in 8 cases, and a locking proximal femoral plate (LPFP) was used in 8 cases. The indications for CHA were cut out in 38 cases of failure of fixation, 7 cases of nonunion, and 9 cases of avascular necrosis or posttraumatic osteoarthritis.
Operative Protocol

All patients received detailed clinical examination and evaluation for medical comorbidities on admission, and laboratory examinations including routine blood tests with a white cell count, C-reactive protein (CRP), and erythrocyte sedimentation rate.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard stem (n = 20)</th>
<th>Long stem (n = 34)</th>
<th>Total (n = 54)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>75.0 ± 13.9</td>
<td>75.6 ± 10.2</td>
<td>75.6 ± 11.6</td>
<td>.849a</td>
</tr>
<tr>
<td>Gender(M/F)</td>
<td>11/9</td>
<td>13/21</td>
<td>24/30</td>
<td>.269b</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>25.9 ± 5.7</td>
<td>26.5 ± 6.5</td>
<td>26.2 ± 5.9</td>
<td>.315a</td>
</tr>
<tr>
<td>BMD,T-score</td>
<td>-3.7 ± 0.6</td>
<td>-3.6 ± 0.6</td>
<td>-3.6 ± 0.7</td>
<td>.264a</td>
</tr>
<tr>
<td>Diabetes</td>
<td>5</td>
<td>8</td>
<td>13</td>
<td>.576b</td>
</tr>
<tr>
<td>Smoking</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>.619b</td>
</tr>
<tr>
<td>Side, R/L</td>
<td>12/8</td>
<td>15/19</td>
<td>27/27</td>
<td>.579b</td>
</tr>
<tr>
<td>Singh index &gt; 4</td>
<td>7</td>
<td>14</td>
<td>20</td>
<td>.802b</td>
</tr>
<tr>
<td>ASA physical status, N(%)</td>
<td></td>
<td></td>
<td></td>
<td>.910c</td>
</tr>
<tr>
<td>I</td>
<td>12(60.0)</td>
<td>21(61.8)</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>5(25.0)</td>
<td>8(23.5)</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>3(15.0)</td>
<td>5(14.7)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>AO/OTA fracture type, N(%)</td>
<td></td>
<td></td>
<td></td>
<td>.101c</td>
</tr>
<tr>
<td>31A1</td>
<td>15(75.0)</td>
<td>15(44.1)</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>31A2</td>
<td>3(15.0)</td>
<td>9(26.5)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>31A3</td>
<td>2(10.0)</td>
<td>10(29.4)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Time to failure (months):</td>
<td>14.6 ± 17.2</td>
<td>10.4 ± 12.5</td>
<td>11.6 ± 14.4</td>
<td>.095a</td>
</tr>
<tr>
<td>Failure type, N(%)</td>
<td></td>
<td></td>
<td></td>
<td>.511c</td>
</tr>
<tr>
<td>Cut out</td>
<td>13(75.0)</td>
<td>25(73.5)</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Nonunion</td>
<td>3(15.0)</td>
<td>4(11.8)</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Variables | Standard stem (n = 20) | Long stem (n = 34) | Total (n = 54) | P-value |
---|---|---|---|---|
Posttraumatic osteoarthritis or Avascular necrosis | 4(20.0) | 5(14.7) | 9 | .284<sup>c</sup> |
Primary internal fixation, N(%) | 12(60.0) | 26(76.5) | 38 | |
PFNA | 5(25.0) | 3(8.8) | 8 | |
DHS | 3(15.0) | 5(14.7) | 8 | |
Mean follow-up time (m) | 55.2 ± 32.1 | 50.1 ± 23.6 | 51.9 ± 26.9 | .111<sup>a</sup> |


(ESR) were performed. If an infection was suspected, joint punctures were performed preoperatively to obtain synovial fluid, followed by cell counting and bacterial culture. X-rays and CT were taken for all patients to access bone quality, proximal and distal femoral defects, the condition of the greater trochanter, and the evaluation of limb length.

A posterolateral approach was used in all patients, prior scar was used and extended. The surgeon decided to perform total hip arthroplasty (THA) or hemiarthroplasty (HA) according to the degree of acetabular cartilage injury and the life expectancy of patients. To minimize the risk of iatrogenic fracture, failed fixation devices were removed after dislocation of the hip, and then the femoral head was removed and the femoral canal was reamed. The type (cemented or cementless) and length (standard or long) of the femoral stem used were based on bone quality, the geometry of the femoral medullary canal, and the stability of the proximal femur. The relation between the tip of the stem and the distal screw hole was not considered. An elastic system of cerclage wires was indicated for intraoperative bone-cracking, metaphyseal comminution, and cerclage wires, tension band wiring, or articulated hook plate were used for the reconstruction of a nonunion greater trochanter, depending on the surgeon’s preference.

A suction drainage tube was placed after flushing and closure of the incision and was removed within 24 hours. Frozen sections were routinely performed. The operation time, total blood loss, intraoperative technical problems, and complications were recorded. Prophylactic antibiotics and anticoagulation therapy with low molecular weight heparin were routinely used.

**Implantations**

Thirty-one patients underwent THA due to acetabular cartilage wear or injury, and the remaining twenty-three received HA. On the acetabular side, a cementless cup was used on all hips. Feyen et al. defined
standard and long stems based on stem length, the level of the osteotomy of the femoral neck, and the intended site of primary stability (Fig. 1). Based on that, patients were divided into 2 groups: standard-stem group (n = 20) using standard length femoral stems including 14 cemented stems and 6 cementless stems, and long-stem group (n = 34) using long length femoral stems including 4 cemented stems and 30 cementless stems.

**Clinical evaluation**

Follow-up occurred at 1, 6, and 12 months after CHA and annually thereafter. X-ray films were taken to assess the prosthesis survival condition during the follow-up. Harris hip score (HHS) and SF-36 Health Questionnaire scores were used to evaluate the recovery of hip joint function and limb recovery.

**Radiographic analysis**

The zone of osteolysis was recorded at the acetabulum by that described by DeLee and Charnley and at the femoral component as described by Gruen. Definite loosening of the acetabular component was diagnosed when a continuous radiolucent line > 2 mm could be observed, and a change in the angle of at least 4 or > 3 mm of migration was observed. The mode of fixation of the femoral component was classified as bone ingrown, fibrous stable, or unstable according to the system of Engh. The subsidence of the femoral stem was measured by Callaghan, and subsidence of more than 10 mm was considered to be of clinical significance. The fixation of the cemented femoral stem was judged by the criteria of Barrack. Heterotopic ossification was classified according to the method of Brooker.

**Statistical analysis**

SPSS 21.0 was used to conduct the statistical analysis. Normally distributed data are expressed as the mean ± SD, while skewed distribution data are expressed as the median and interquartile range (IQR). Measurement data were compared between groups. Comparisons of variables between groups were performed using 2-sample t-tests for continuous normally distributed data, Wilcoxon rank-sum tests for continuous nonnormally distributed data, and Chi-square or Fisher exact tests for categorical variables. Differences were considered statistically significant when P values were less than 0.05 (P < 0.05).

**Results**

The mean follow-up time was 51.98 ± 26.91 months (25–134 months), except two patients died of causes unrelated to the operation (one died of cerebral apoplexy and one died of myocardial infarction within 2 years after the operation, there were no patients lost to follow-up during the study period.

The operation time and total blood loss of the long stem-group were significantly higher than those of the standard stem group (137.13 ± 43.63 vs. 113.75 ± 28.61 min, P = 0.002; 79 ± 374.38 vs. 436.00 ± 299.43 ml, P = 0.017, respectively). The mean length of stay was not significantly different between groups, with a mean of 7.3 ± 3.5 days in the standard- stem group, and 8.8 ± 4.4 days in the Long- stem group (P = 0.222) (Table 2).
Clinical outcome

All patients had different degrees of hip pain and movement limitations before the operation, and most patients had different degrees of limb shortening and coxa varus deformity. After the conversion, most patients reported remarkable pain relief and functional recovery. The average HHS, SF-36 PF, SF-36 BP was significantly improved in both groups (Table 3), suggesting significantly pain relief, function recovery, and improvement in overall health-related quality of life. No significant difference was found in HHS, SF-36 PF, and SF-36 BP between the standard-stem group and the long-stem group at the last follow-up (P > 0.05).

Complications

Table 2 shows the orthopedic and general complications of patients after CHA. There were 13 (24.07%) patients who had surgical complications related to the operation. A total of 5 cases (11.32%) had intraoperative femur fractures during the operation, three cases had proximal femoral cracks that occurred during intramedullary reaming and implantation of the stem, which were treated with cerclage wires and healed without additional complications. Two patients had distal femoral screw hole fractures during intraoperative reaming, and then the planned femoral stems were changed to lengthened uncemented revision stem to bypass the screw hole.

One patient suddenly developed hip pain badly during walking four months after CHA and sustained Vancouver type B1 periprosthetic femoral fracture at the previous screw hole (Fig. 2). The prosthesis was retained, and the fracture was successfully
<table>
<thead>
<tr>
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<th>Total (n = 54)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of arthroplasty, N(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total hip arthroplasty</td>
<td>11(55)</td>
<td>20(58.8)</td>
<td>31</td>
<td>.784b</td>
</tr>
<tr>
<td>Hemiarthroplasty</td>
<td>9(45)</td>
<td>14(41.2)</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Operation time (min)</td>
<td>113.8 ± 28.6</td>
<td>137.1 ± 43.6</td>
<td>133.9 ± 43.6</td>
<td>.002a*</td>
</tr>
<tr>
<td>Intraoperative blood loss (mL)</td>
<td>436.0 ± 299.4</td>
<td>678.8 ± 374.4</td>
<td>587.2 ± 364.9</td>
<td>.017a*</td>
</tr>
<tr>
<td>Hospital stay (d)</td>
<td>7.3 ± 3.5</td>
<td>8.8 ± 4.4</td>
<td>8.2 ± 4.1</td>
<td>.222a</td>
</tr>
<tr>
<td>Overall complications, N(%)</td>
<td>10</td>
<td>14</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Orthopaedic complication</td>
<td>2(10.0)</td>
<td>13(38.2)</td>
<td>15(27.8)</td>
<td>.031b*</td>
</tr>
<tr>
<td>Intraoperative femur fracture</td>
<td>0</td>
<td>5(14.7)</td>
<td>5(93)</td>
<td>.145b</td>
</tr>
<tr>
<td>Postoperative periprosthetic fracture</td>
<td>1(5.0)</td>
<td>0</td>
<td>1(1.9)</td>
<td>.370b</td>
</tr>
<tr>
<td>Stem penetrate</td>
<td>0</td>
<td>2(5.9)</td>
<td>2(3.7)</td>
<td>.525b</td>
</tr>
<tr>
<td>dislocation</td>
<td>0</td>
<td>2(5.9)</td>
<td>2(3.7)</td>
<td>.525b</td>
</tr>
<tr>
<td>Cement leakage</td>
<td>0</td>
<td>1(2.9)</td>
<td>1(1.9)</td>
<td>1.000b</td>
</tr>
<tr>
<td>Stem loosening or subsidence</td>
<td>1(5.0)</td>
<td>2(5.9)</td>
<td>3(5.6)</td>
<td>1.000b</td>
</tr>
<tr>
<td>Infection</td>
<td>0</td>
<td>1(2.9)</td>
<td>1(1.9)</td>
<td>1.000b</td>
</tr>
<tr>
<td>General complication</td>
<td>7(35.0)</td>
<td>8(23.5)</td>
<td>11(20.4)</td>
<td></td>
</tr>
<tr>
<td>Patients affected, N(%)</td>
<td>5(25.0)</td>
<td>4(11.8)</td>
<td>9(16.7)</td>
<td>.266b</td>
</tr>
<tr>
<td>Acute deep vein thrombosis</td>
<td>1(5.0)</td>
<td>2(5.9)</td>
<td>3(5.6)</td>
<td>1.000b</td>
</tr>
<tr>
<td>Delirium</td>
<td>2(10.0)</td>
<td>0</td>
<td>2(3.7)</td>
<td>.133b</td>
</tr>
</tbody>
</table>

*: Statistically significant values; a: Analysed using the independent-samples t-test. b: Analysed using the chi-square test.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard stem (n = 20)</th>
<th>Long stem (n = 34)</th>
<th>Total (n = 54)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestive heart failure</td>
<td>0</td>
<td>1(2.9)</td>
<td>1(1.9)</td>
<td>1.000\textsuperscript{b}</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>1(5.0)</td>
<td>1(2.9)</td>
<td>2(3.7)</td>
<td>1.000\textsuperscript{b}</td>
</tr>
<tr>
<td>Hypostatic pneumonia</td>
<td>1(5.0)</td>
<td>2(5.9)</td>
<td>3(5.6)</td>
<td>1.000\textsuperscript{b}</td>
</tr>
<tr>
<td>Reoperation for any reason</td>
<td>1(5.0)</td>
<td>0</td>
<td>1(1.9)</td>
<td>.370\textsuperscript{b}</td>
</tr>
</tbody>
</table>

\*: Statistically significant values; \textsuperscript{a}: Analysed using the independent-samples t-test. \textsuperscript{b}: Analysed using the chi-square test.

treated with open reduction and internal fixation with a plate and screws. Two patients suffered early postoperative dislocation due to improper exercise and were given closed reduction and both had no recurrent dislocations. There was one acute infected case that was managed with debridement and retention of the prosthesis 3 weeks postoperatively. One case had bone cement leakage from a previous screw hole that did not affect the stem stability, surgical intervention was not required.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Standard stem (n = 20)</th>
<th>Long stem (n = 34)</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>HHS</td>
<td>38.5 ± 4.2</td>
<td>41.1 ± 4.6</td>
<td>.215a</td>
</tr>
<tr>
<td>Preop</td>
<td>79.7 ± 5.4</td>
<td>81.8 ± 6.2</td>
<td>.271a</td>
</tr>
<tr>
<td>Final</td>
<td>79.7 ± 5.4</td>
<td>81.8 ± 6.2</td>
<td>.271a</td>
</tr>
<tr>
<td>P</td>
<td>.001b</td>
<td>.001b</td>
<td></td>
</tr>
<tr>
<td>SF-36 PF</td>
<td>29.1 ± 4.2</td>
<td>28.9 ± 3.6</td>
<td>.292a</td>
</tr>
<tr>
<td>Preop</td>
<td>75.8 ± 16.8</td>
<td>76.2 ± 13.8</td>
<td>.197a</td>
</tr>
<tr>
<td>Final</td>
<td>75.8 ± 16.8</td>
<td>76.2 ± 13.8</td>
<td>.197a</td>
</tr>
<tr>
<td>P</td>
<td>.001b</td>
<td>.001b</td>
<td></td>
</tr>
<tr>
<td>SF-36 BP</td>
<td>28.6 ± 3.7</td>
<td>30.8 ± 4.8</td>
<td>.269a</td>
</tr>
<tr>
<td>Preop</td>
<td>78.1 ± 12.7</td>
<td>80.3 ± 15.7</td>
<td>.123a</td>
</tr>
<tr>
<td>Final</td>
<td>78.1 ± 12.7</td>
<td>80.3 ± 15.7</td>
<td>.123a</td>
</tr>
<tr>
<td>P</td>
<td>.001b</td>
<td>0.001b</td>
<td></td>
</tr>
</tbody>
</table>

Harris hip score: HHS; a: Analyzed using the independent-samples t-test. b: Analyzed using the paired samples t-tests.

The major general complications were hypostatic pneumonia in 3 patients, acute deep vein thrombosis in 3, delirium in two, and congestive heart failure in one.

**Radiographic evaluation**

Radiographs were available for all patients at the last follow-up. According to the preoperative X-ray Singh index measurement grading, only 20 patients had grades > 4, suggesting that most patients had different degrees of osteoporosis. Successful bony union of the fracture and previous screw holes was achieved in all patients. All stems had stable bony ingrowth except 3 cases (5.6%) of stem loosening or subsidence. One case with cemented femoral stem had probable femoral loosening at ten years, 2 cases had stem subsidence occurred within the first year after the operation and there was no progressive subsidence, the patients had minimal discomfort, none of them need revision surgery. There were 5 cases (9.3%) of ectopic ossication on imaging, including 2 cases of Brooker type-1 heterotopic bone and 3 cases of Brooker type-1 heterotopic bone, which did not affect function.
Discussio

Conversion hip arthroplasty following FIF-ITF faces several challenging technical problems, including removal of previous failed internal fixation devices, management of nonunion or mal-union great trochanteric, residual screw holes, possible intraoperative femur fracture, and reliable fixation of the femoral stem, and different results have been reported \(^{11,34-36}\). In this study, we retrospectively analyzed 54 CHA following FIF-ITF, and the results showed a satisfactory curative effect, which for most patients relieved their pain and restored good joint function, however, a significant rate of orthopedic complications (13/54[24.07%]) was detected.

Compared with primary hip arthroplasty, CHA following FIF-ITF has a higher risk of early complications and poor hip function \(^{8,37-39}\) and requires a high level of surgical skills \(^{7,40}\). In the present study, not surprisingly, the average operation time and the average intraoperative blood loss were high (137.13 min; 587.17 ml), which was similar to previously reported results \(^{24,41}\). One of the possible reasons for the lengthy operation time is the need to remove the previous internal fixators, such as broken screws and plates, and the use of special instruments for removing broken screws could help simplify the process. The fractured fragments of the head and neck are often in positions of deformation and rotation, which must be reset before resection, this process requires great care to avoid damaging the adjacent important blood vessels, nerves, and tendons, which often leads to an increase in operation time and blood loss.

There is still much controversy over many issues related to the use of a femoral stem, and there is no compelling evidence to support the selection of either a standard or a long femoral stem. Enocson et al. \(^{42}\) showed that the risk of reoperation for a standard length femoral stem (11/47) was higher than that of a long stem (3/41), but there was no statistical significance in this difference (HR = 4, 95% CI: 1.0–13; P = 0.06). As a result, these studies propose using a long stem to improve the medullary cavity contact area, span the distal screw hole, bridge the bone cortical defect, uniformly distribute stress, and prevent periprosthetic fracture caused by stress concentration. However, to preserve more bone mass, reduce cost and possible revision surgery in the future, systematic use of long stems is not recommended and should be reserved for severe osteoporotic cases, Zhang et al. \(^{14}\) retrospectively analyzed 19 patients treated with cemented standard femoral stems, and no stress fracture occurred after an average of 7.4 years of follow-up. Also, Moris et al. \(^{43}\) reported 99% implant survivorship with a standard cemented stem in 107 patients after aseptic failed fixation of ITF, and no patients had late periprosthetic femur fracture or implant loosening at an average follow-up of 7.4 years.

In this study, 20 standard stems and 33 long stems were used and the results showed that there was no significant difference in HHS, SF-36 PF, SF-36 BP between the two groups (P > 0.05), while the average operation time and intraoperative blood loss in the long group were higher than in the standard group [137.1 ± 43.6 min vs. 113.8 ± 28.6 min, P = 0.002; 678.79 ± 374.4 ml vs. 436.0 ± 299.4 ml, P = 0.017], while the length of hospital stay was not significantly different (P > 0.05). Significantly, the long stem group had a higher incidence of orthopedic complications compared to the standard stem group (P = 0.031), and the incidence of intraoperative femur fracture in the long stem group (5/34) was also higher than that of a
standard stem (0/20), but this was not statistically significant, although the cases in this study are from multiple centers, and the skill and experience of surgeons are inconsistent, such a high incidence of intraoperative fractures still cannot be ignored.

It is inappropriate to simply generalize that the use of long or standard stem for FIF-ITF patients is sufficient, the integrity of the proximal femoral structure, the degree of osteoporosis, the previous fracture, as well as the size of diaphyseal bone defect, must guide the selection of femoral stem. The use of long stems is not necessary in all cases, such as cases of avascular necrosis or posttraumatic osteoarthritis, in which the previous fracture has healed and a standard metaphyseal locking stem could provide rigid stability. It is important to note that the surgeon should avoid situations where the tip of the stem is just located in the area of the screw holes, stress riser at the tips may cause periprosthetic fracture (Fig. 1). In fact, some authors suggested using standard stems as long as the holes are closed with bone cement. For cases with a meta-diaphyseal mismatch, massive bone defect, or lower limb discrepancy, which is frequently seen in FIF-ITF patients, a standard stem may not be suitable, several studies reported good results of the use of a modular, distally fixed cementless stem in the management of failed intertrochanteric fractures.

Fractures often occur during the dislocation, reduction, cement removal, reaming cavity, and prosthesis implantation. It is advisable to remove the previous failed internal fixation after a dislocation. During dislocation, the surrounding soft tissue should be released repeatedly, and scar and ectopic bone should be removed from the ossified bone. For uncemented femoral stems, the incidence of periprosthetic fracture of an uncemented femoral stem is 14 times higher than that of a cemented femoral stem, preoperative template measurement is very important to avoid fracture caused by a mismatch between the prosthesis and medullary cavity. The surgical operation should be gentle and avoid reaming in a varus position, for the increased risk of diaphyseal fractures in previous ITF, a prophylactic cable in the region of screw holes to minimize the impact of these stress risers is suggested.

A nonunion or separated greater trochanter could cause pain, limb shortening, and even affect abductor function of the hip joint and the stability of the prosthesis. Therefore, the healing of the greater trochanter should be evaluated during the operation. Several methods for the reconstruction of the greater trochanter have been reported, including contoured plating, tension band wiring, and trochanter claw plating with wiring. Hsu et al. reported 16 cases of FIF-ITF patients who received surgery with HA and the cable-grip system, and 15/16 patients were observed to have a solid union of the greater trochanter postoperatively by 24 weeks, and no dislocation occurred during the follow-up. In this study, the greater trochanter was reconstructed with cable cerclage in eight patients, and two patients was fixed with a steel plate and cable (Fig. 3).

Our study was limited by a small sample size, which may have an impact on our conclusions. Although we collected cases from multiple centers in this region, the number of cases in this study reached or exceeded previous similar studies because of the rarity of this disease. As a multicenter retrospective cohort study, patient selection bias exists. Incomplete data collection of some patients, lack of
preoperative relevant scores, diversity of prostheses, and operations not performed by the same surgeon may also have some impact on the results of the study. Large-scale prospective randomized controlled trials and related biomechanical experiments are still needed to confirm our results.

In conclusion, our study for conversion hip arthroplasty following FIF-ITF showed a successful mid-term clinical cure effect, and surgeons using long stem in this surgery should be aware of the risks of complications, especially intraoperative femur fractures.

**Abbreviations**

ITF: intertrochanteric fracture; FIF-ITF: failed internal fixation of intertrochanteric fracture; CHA: conversion hip arthroplasty; THA: total hip arthroplasty; HA: hemiarthroplasty; HHS: the Harris hip score

**Declarations**

**Ethics approval and consent to participate**

This study was approved by the Ethical Committee of The First Affiliated Hospital of Fujian Medical University, and an exemption from informed consent was obtained from the board. All procedures were performed in accordance with relevant guidelines.

**Consent for publication**

Not applicable.

**Conflict of Interest**

The authors declare that they have no competing interests.

**Availability of Data and Materials**

The data utilized are accessible from the corresponding author upon reasonable request.

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**Authors' contributions**

TB S, XY F, WM Z developed the study idea, designed the study, and interpreted the data. TB S also obtained and refined data collection, planned and performed the statistical analysis, and graphical presentation, and drafted the paper. ZD H, WM L, RJ Y, C X provided data access, interpreted data, and revised the paper. Critical revision of work and final approval of manuscript: all authors.
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References


**Figures**
Figure 1

d: distance between tip of greater trochanter and base of lesser trochanter. Standard stem: total length greater than twice distance from tip of GT to base of LT vertical distance, the tip of stem locates in the region of B; Long stem: total length greater than twice distance from tip of GT to base of LT vertical distance, the tip of stem locates in the region of C.
Figure 2

A 93-year-old female with failed internal fixation with PFNA for left intertrochanteric fracture underwent cemented HA 7 months after initial surgery, the tip of the stem was just at the position of the distal screw hole. A, B: PFNA was performed for the left ITF; C, D: The spiral blade cutting out from the femoral head was observed 7 months after the operation, and multiple locking holes could be seen in the femur; E: She underwent a conversion HA, and a standard cemented stem was selected, and the tip of the stem was just at the position of the distal screw hole; F: Severe pain occurred in the affected thigh 4 months after HA without trauma and sustained Vancouver type B1 periprosthetic femoral fracture; G, H: The fracture was treated with open reduction and internal fixation with a blade plate and cannulated screws, placement of a Cortical Bone Plates Allografts was successfully performed.
Figure 3

A 70-year-old man with right comminuted intertrochanteric fracture was treated with PFNA, and received THA after failed internal fixation. A, B: Right comminuted intertrochanteric fracture treated with PFNA; C: At 13 months post-surgery the patient exhibited nonunion and the medial and lateral walls were incomplete; D: A successful THA reconstruction using Corail Revision femoral stem (DePuy Orthopaedics Inc.) and hook cable plate.