

# Poor outcomes for osteoporotic patients undergoing conversion total hip arthroplasty following prior failed dynamic hip screw fixation: a nationwide retrospective cohort study

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## Abstract

**Objectives:** This study was performed to compare the long-term clinical and radiological outcomes of conversion total hip arthroplasty (CTHA) following prior failed InterTan nail (IT) fixation or dynamic hip screw (DHS) fixation in Asian patients with osteoporotic intertrochanteric hip fractures (IHF) and to clarify which implant tends to be more favourable for CTHA.

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**Methods:** Records of consecutive Asian patients with osteoporosis who underwent conversion of failed primary unilateral IT or DHS fixation to THA from 2010 to 2013 were extracted from the comprehensive database of the China Pacific Insurance Company Ltd. All consecutive procedures were managed by high-volume surgeons. The primary endpoint was the clinical outcome. The secondary endpoint was the radiological outcome.

**Results:** In total, 447 Asian patients with osteoporotic IHFs (DHS,  $n = 223$ ; IT,  $n = 224$ ) were assessed during a median follow-up of 46 months (range, 39–53 months). The two groups showed a significant difference in the Harris hip score at final follow-up and in the orthopaedic complication rate (DHS, 20.2%; IT, 9.8%).

**Conclusion:** Conversion to THA following prior failed DHS fixation tends to be associated with poorer clinical and radiological outcomes in Asian patients with osteoporotic IHFs than that following prior failed IT fixation.

### Keywords

Intertrochanteric hip fracture, total hip arthroplasty, complication, InterTan nail, dynamic hip screw, conversion

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### Introduction

The performance of hip arthroplasty procedures after the development of intertrochanteric hip fractures (IHF) has become increasingly more common during the past two decades, with primary procedures increasing by >130% and revision procedures increasing by >10%.<sup>1–3</sup> In the recently published literature,<sup>4,5</sup> the need for conversion total hip arthroplasty (CTHA) following prior failed InterTan nail (IT) fixation or dynamic hip screw (DHS) fixation has increased and is expected to further increase given the expanded indications for primary procedures coupled with a progressively more active population. Furthermore, secondary hip dysfunction resulting in instability or decreased function after failed IT or DHS fixation frequently necessitates CTHA.<sup>6</sup> Despite its increasing use in the conversion setting, objective information regarding CTHA following prior failed IT or DHS fixation is still lacking.<sup>6,7</sup> The failure of prior IT or DHS fixation is largely associated with prosthesis

instability, cut-out, or aseptic loosening. Therefore, the intervention of CTHA, which may be used to re-establish a stable fulcrum to improve hip biomechanics and provide inherent stability, might be optimal for patients with a history of failed IT or DHS fixation.<sup>6,8</sup>

Despite its inferiority in the primary setting, THA has produced outstanding clinical outcomes in the prosthesis-revised setting in patients with severely deficient soft tissue and/or bone.<sup>9,10</sup> Although CTHA has the ability to provide enhanced dimensional stability of the components when setting the deficiencies of soft tissue constraints, this intensified restraint places greater stress on the acetabulum.<sup>11</sup> Reports of CTHA following prior failed IT or DHS fixation are insufficient and commonly consist of small samples.<sup>4,11,12</sup> Additionally, the clinical outcomes of most studies have been affected by either the prosthetic design or bearing materials.<sup>1,6,7,13</sup> The objective outcomes and factors

influencing these outcomes are difficult to appreciate without large, comprehensive series.<sup>14-16</sup>

The aim of this study was to compare the long-term clinical and radiological outcomes of CTHA following prior failed IT or DHS fixation in Asian patients with osteoporotic IHFs and to clarify which implant tends to be more favourable for CTHA.

## **Materials and methods**

### *Study population*

Ethical approval (SYU 710231) was obtained from the Institutional Review Board and Ethical Review Board of Sun Yat-sen University. Informed consent was obtained from all patients prior to their inclusion in the study. The data validated for this nationwide retrospective cohort study were extracted from the comprehensive database of the China Pacific Insurance Company Ltd. (CPIC) based on the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10 S72.101) and were complemented by data from the hospitals that provided the primary surgical treatment. Asian patients with osteoporotic IHF and adequate homogeneity in the surgical aspects of standardised IT or DHS fixation were identified in the CPIC database. Severe pain and stiffness were the chief complaints and main criteria for conversion. Patients included in the study were followed until death or until 30 September 2017. The inclusion criteria were an age of 50 to 70 years; conversion of failed primary unilateral IT or DHS fixation following IHF (AO/OTA 31. A1) to THA from 2010 to 2013; a bone mineral density (BMD) T-score of less than  $-2.5$  as quantified with dual-energy X-ray absorptiometry at the non-dominant proximal femoral neck; performance of all surgical procedures at tertiary care centres with

preoperative, immediate postoperative, and 6-month postoperative radiographs available for review; ability to walk independently before fracture; and eligibility to undergo treatment with a standard CTHA device (Standard-device; Stryker, Mahwah, NJ, USA). The exclusion criteria were pain with loss of function; pathological fractures; metastatic diseases; clinical, radiological, or haematological evidence of active infection; non-healing; planned surgery; signs of loosening; instability of the implant; neoplasia; arthritis; incomplete medical records; refusal to participate; cardio-cerebrovascular diseases; thrombotic episode within 6 months; an American Society of Anesthesiologists score of IV or V; ipsilateral lower limb surgery; contralateral hip fractures or other revision procedures; co-occurring mental illness; cognitive dysfunction; interruption of follow-up; life expectancy of  $<2$  years; uncontrolled diabetes mellitus or hypertension; and non-response to the self-report questionnaire. Before CTHA, each patient's preoperative, intraoperative, and postoperative data of were collected, including those from the electronic medical records, operative notes, and a self-report questionnaire that had been mailed to each patient.

### *Indications for revision surgery*

The main indications for CTHA were component loosening, periprosthetic fracture, cut-out, non-union, implant malpositioning, locally destructive adverse tissue reactions, infection, and avascular necrosis. These imaging features were accompanied by relevant clinical symptoms that seriously affected the patient's quality of life. Preoperative imaging data strongly suggested that retention of the IT or DHS was infeasible, predominantly because of instability following deficient bone stock, even when the addition of bone grafts was considered.

### *Implant systems and surgical methods*

All patients underwent CTHA by high-volume surgeons following failed fixation with either an IT (lag screw, 11-mm diameter; compression screw, 7-mm diameter; composite screw, 15.5-mm diameter; normal length; 2 proximal screws, 1 distal screw; Smith & Nephew, Memphis, TN, USA) or a DHS (standard screw/blade; Synthes, West Chester, PA, USA) for treatment of IHFs (AO/OTA Type 3.1A1). A modular cementless femoral stem combined with a grit-blasted surface (CLS; Sulzer, Winterthur, Switzerland), a modular cup combined with a titanium shell and a polyethylene insert using a Metasul inlay (both Fitek; Sulzer), and a 28-mm Metasul head (Fitek; Sulzer) were used for all CTHA procedures. All consecutive CTHA procedures were managed by high-volume surgeons who adopted a direct anterior approach, as previously described.<sup>17,18</sup> All surgeries were performed under general anaesthesia. The prior IT or DHS equipment was removed through the direct anterior approach. The patient was placed in the supine position on a modern fracture table, with both feet in boots for proper positioning. A 12- to 14-cm anterior incision was performed from 3 cm lateral to the anterior superior iliac spine, distal to the vastus ridge. Soft tissue undermining was performed, an acetabular retractor was placed, and reaming of the acetabulum commenced. The cup inclination and version angles were calculated from the anteroposterior pelvis film using a validated computer-assisted Martell Hip Analysis Suite, version 8.0.4.1 (University of Chicago, Chicago, IL, USA).<sup>19,20</sup> All surgical procedures were performed under direct visualisation with C-arm confirmation for positioning.

### *Clinical and radiographic assessment*

The primary endpoint was the clinical outcome as determined by the Harris hip score

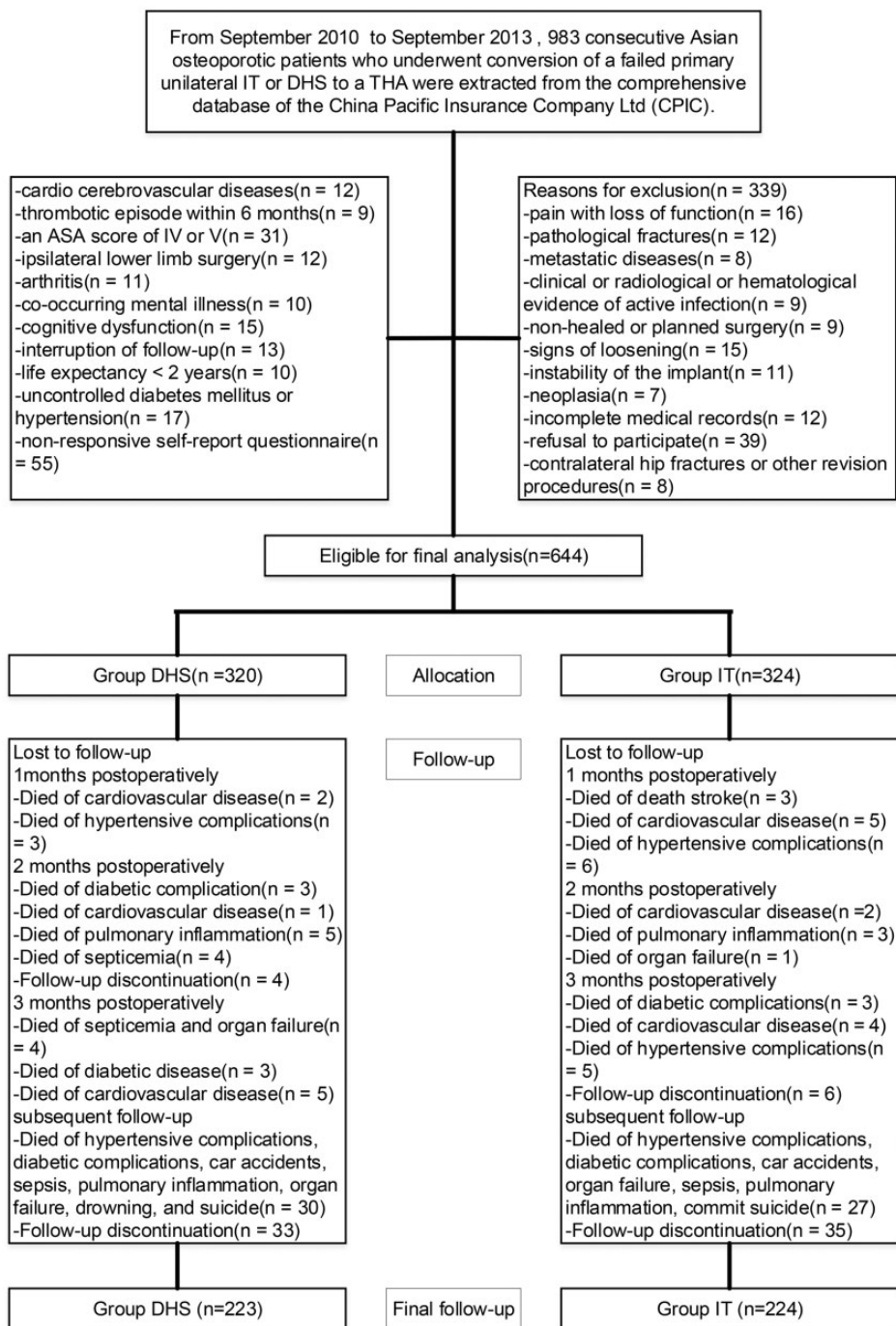
(HHS), which was determined within 72 hours preoperatively; 1, 3, 6, 9, and 12 months postoperatively; and every year thereafter. The secondary endpoint was the radiological outcome.

### *Statistical analysis*

Registry data were managed using the REDCap electronic data capture system (Vanderbilt University, Nashville, TN, USA) and were exported for statistical analysis using SPSS software, version 24.0 (IBM Corp., Armonk, NY, USA). Standard descriptive statistics were used to summarise baseline and follow-up parameters. Categorical variables are presented as frequency and proportion. Continuous numeric variables are expressed as mean  $\pm$  standard deviation. Pearson's chi-squared test of independence was applied for categorical variables, whereas Student's t-test and the Wilcoxon test were used for parametric and nonparametric continuous variables, respectively. Fisher's exact test was used when appropriate. The significance level was set at 0.05.

### **Results**

From September 2010 to September 2013, 983 Asian patients were assessed for study eligibility. Of these 983 patients, 644 met the inclusion criteria. Of these 644 patients, 197 (30.6%) ineligible patients died of unrelated causes or had a follow-up interruption, and no information was available regarding treatment failure or revision surgery before their death or after the follow-up interruption. Consequently, the remaining 447 surviving patients met the inclusion criteria and were enrolled to compare the long-term clinical and radiological outcomes of CTHA following prior failed IT or DHS fixation, as presented in Figure 1. The DHS group comprised 223 patients with a median age of  $59.4 \pm 9.41$



**Figure 1.** Flow diagram demonstrating methods for the identification of studies to compare the long-term clinical and radiological outcomes of conversion THA following prior failed IT or DHS fixation and to clarify which implant tends to be more favourable for conversion THA using the clinical outcome as the primary endpoint in consecutive Asian patients with osteoporosis who underwent conversion of failed primary unilateral IT or DHS fixation to THA. THA, total hip arthroplasty; IT, Inter-Tan nail; DHS, dynamic hip screw; ASA, American Society of Anesthesiologists.

**Table 1.** Patient demographics between the two study groups.

Variable	DHS (n = 223)	IT (n = 224)	P value
Age at onset, years	59.4 ± 9.41	59.7 ± 9.56	0.102 <sup>a</sup>
Sex, male:female	120:103	117:107	0.738 <sup>b</sup>
BMI, kg/m <sup>2</sup>	24.5 ± 1.76	24.6 ± 1.58	0.315 <sup>a</sup>
BMD, T-score	-3.8 ± 0.73	-3.9 ± 0.37	0.836 <sup>a</sup>
Side, left/right	116/107	113/111	0.740 <sup>b</sup>
Injury mechanism			0.500 <sup>c</sup>
Low-energy trauma	69	72	
Vehicular accident	96	102	
Fall from height	58	50	
AO/OTA fracture type			0.748 <sup>c</sup>
31A1.1	56	52	
31A1.2	106	110	
31A1.3	61	62	
Paprosky classification of femoral bone loss <sup>§</sup>			0.916 <sup>c</sup>
Type I	103	98	
Type II	56	64	
Type IIIA	33	37	
Type IIIB	21	17	
Type IV	10	8	
BMI <sup>#</sup>			0.444 <sup>c</sup>
Underweight	43	41	
Normal	65	58	
Overweight	47	53	
Obese class I	43	41	
Obese class II	14	17	
Obese class III	11	14	
ASA physical status			0.949 <sup>c</sup>
I	76	71	
II	98	109	
III	49	44	
Length of follow-up, mos	36.3 ± 7.22	36.6 ± 6.14	0.237 <sup>a</sup>

Data are presented as mean ± standard deviation or number of patients.

<sup>a</sup>Analysed using the independent-samples t-test. <sup>b</sup>Analysed using the chi-square test. <sup>c</sup>Analysed using the Mann-Whitney test. <sup>§</sup>Based on the description by Grisez et al.<sup>20</sup> <sup>#</sup>Categorised according to the World Health Organization as follows: underweight (<18.5 kg/m<sup>2</sup>), normal (18–25 kg/m<sup>2</sup>), overweight (25–30 kg/m<sup>2</sup>), obese class I (30–35 kg/m<sup>2</sup>), obese class II (35–40 kg/m<sup>2</sup>), or obese class III (>40 kg/m<sup>2</sup>). DHS: dynamic hip screw; IT: InterTan nail; BMD: bone mineral density; BMI: body mass index; ASA: American Society of Anesthesiologists.

years, and the IT group comprised 224 patients with a median age of 59.7 ± 9.56 years. Of the 447 patients, 237 (52.9%) were male and 210 (47.1%) were female, with a median age at the time of CTHA of 59 years (range, 50–69 years) and a median clinical follow-up period of 46 months (range, 39–53 months). The most common IHF type was 31A1.2, as shown in Table 1.

### Clinical outcomes

Outcome scores were available for 447 of the 644 patients (69.4%). Both groups showed improvement of the HHS with a median follow-up of 46 months. The HHS in the IT group improved from 46.78 ± 4.17 to 78.40 ± 3.29, and that in the DHS group improved from 46.62 ± 4.67 to 77.71 ± 3.53.

**Table 2.** Comparison of Harris hip score between the two study groups.

	DHS (n = 223)	IT (n = 224)	P value
72 hours preoperatively	46.62 ± 4.67	46.78 ± 4.17	0.217 <sup>a</sup>
1 month postoperatively	77.71 ± 3.53	78.40 ± 3.29	0.364 <sup>a</sup>
3 months postoperatively	83.85 ± 3.12	84.20 ± 2.02	0.113 <sup>a</sup>
6 months postoperatively	85.04 ± 4.26	87.21 ± 3.94	0.026 <sup>*,a</sup>
9 months postoperatively	87.75 ± 5.32	87.43 ± 4.76	0.326 <sup>a</sup>
12 months postoperatively	88.21 ± 2.16	87.73 ± 4.53	0.147 <sup>a</sup>
15 months postoperatively	89.57 ± 3.64	89.76 ± 3.66	0.531 <sup>a</sup>
18 months postoperatively	87.23 ± 5.38	87.03 ± 6.57	0.435 <sup>a</sup>
21 months postoperatively	86.74 ± 7.05	87.42 ± 8.36	0.103 <sup>a</sup>
24 months postoperatively	86.23 ± 10.34	87.31 ± 9.28	0.134 <sup>a</sup>
27 months postoperatively	84.45 ± 9.51	86.56 ± 9.83	0.022 <sup>*,a</sup>
30 months postoperatively	80.01 ± 9.34	84.54 ± 9.97	0.038 <sup>*,a</sup>
Final follow-up	76.14 ± 11.12	82.97 ± 1.96	0.014 <sup>*,a</sup>

Data are presented as mean ± standard deviation.

\*Statistically significant. <sup>a</sup>Analysed using the independent-samples t-test. DHS: dynamic hip screw; IT: InterTan nail.

**Table 3.** Main radiological outcomes between the two study groups.

Variable	DHS (n = 223)	IT (n = 224)	P value
Perioperative complications	47	42	
Patients affected	38 (17.0)	35 (15.6)	0.686 <sup>a</sup>
Medical complications	26	24	
Patients affected	21 (9.4)	22 (9.8)	0.885 <sup>a</sup>
Urinary tract infection	19	16	
Pulmonary embolism	2	2	
Atrial fibrillation	4	3	
Acute renal failure	1	3	
Orthopaedic complications	83	40	
Patients affected	45 (20.2)	22 (9.8)	0.002 <sup>*,a</sup>
Glenoid loosening	17	5	
Acetabular abrasion	4	2	
Periprosthetic fracture	13	6	
Dislocation	12	9	
Abductor tendon deficiency	4	3	
Periprosthetic infection	4	1	
Heterotopic ossification	16	7	
Nerve injury	4	4	
Femoral loosening	9	3	

Data are presented as n or n (%).

\*Statistically significant. <sup>a</sup>Analysed using the chi-square test. DHS: dynamic hip screw; IT: InterTan nail.

The HHS at the final follow-up was significantly different between the two groups ( $P = 0.014$ ) (Table 2). There were no significant differences in the rate of medical complications between the IT and DHS groups (9.8% vs. 9.4%, respectively).

### Radiographic outcomes

The orthopaedic complication rate tended to be higher in the DHS group (45/223 patients, 20.2%) than in the IT group (22/224 patients, 9.8%), as shown in Table 3.

Of the 45 (20.2%) patients in the DHS group who had orthopaedic complications, 18 required repeated revision intervention due to component loosening, nerve impingement, or instability; these patients' radiographic complications included acetabular component disassembly ( $n=5$ ), femoral component loosening ( $n=3$ ), instability ( $n=1$ ), nerve injury ( $n=1$ ), Brooker class 6 heterotopic ossification ( $n=2$ ), acetabular abrasion ( $n=3$ ), periprosthetic fractures ( $n=1$ ), and infection ( $n=2$ ). The mean interval to CTHA was 11.5 months (range, 0.6–23 months) in the DHS group. Of the 22 (9.8%) patients in the IT group who had orthopaedic complications, 12 required repeated revision intervention due to component loosening or instability; these patients' radiographic complications included acetabular component disassembly ( $n=1$ ), femoral component loosening ( $n=2$ ), instability ( $n=2$ ), nerve injury ( $n=2$ ), Brooker class 6 heterotopic ossification ( $n=1$ ), acetabular abrasion ( $n=1$ ), periprosthetic fractures ( $n=2$ ), and infection ( $n=1$ ). The mean interval to CTHA was 7.5 months (range, 0.6–19 months) in the IT group.

## Discussion

The most important finding of this study is that CTHA intervention following prior failed DHS fixation had a significantly higher-than-expected risk for additional radiographic complications than that following prior failed IT fixation. Although CTHA has been regarded as an unconventional therapeutic regimen following IHFs, CTHA for the management of IHFs following prior failed DHS or IT fixation has become an indispensable strategy that has reached a consensus during the last decade.<sup>11,21</sup>

Our result is in line with the finding of Zeng et al.,<sup>11</sup> who showed that the radiographic complication rate following

conversion after prior failed DHS fixation was significantly higher than that after prior failed intramedullary nail fixation and that there was no significant between-group difference in the functional outcome. In the present study, the rate of radiographic complications following CTHA revision surgery after prior failed DHS fixation was high (20.2%) and consistent with that reported by Zeng et al.<sup>11</sup> Given the possibility of compromised femoral bone quality in the CTHA intervention setting, the primary consideration tended to be the need for femoral bone grafting.<sup>22</sup> In accordance with the findings reported by Oshima et al.,<sup>23</sup> patients who underwent morselised allograft bone grafting, which decreases the risk of implant-related failure in the CTHA setting, had a satisfactorily low rate of prosthetic loosening. In addition, these patients had reliable pain alleviation and restoration of hip function.

An osteoporotic femoral or acetabular component tends produce prosthesis loosening.<sup>24</sup> Additionally, prior DHS fixation may further worsen osteoporosis in the lateral wall of the femur.<sup>25</sup> However, few studies have been performed to assess the proximal femoral bone density at the time of the CTHA intervention, particularly when orthopaedic-related complications occur.<sup>4,11,25</sup> Consequently, we used BMD as the measurement parameter after prior failed DHS or IT fixation in all patients of the present study. As proven by previous biomechanical tests,<sup>26</sup> patients with osteoporotic IHFs who undergo DHS fixation are prone to develop poor BMD, which might partly explain the destruction and/or atrophy of the proximal femur.

Limited data on CTHA following prior failed IT for IHFs have been reported to date. Lee et al.<sup>27</sup> performed a multicentre study involving 33 patients treated by IT fixation and 33 patients treated by DHS fixation. The authors found that after the two groups of patients were converted to CTHA



due to prior failed DHS or IT fixation, the postoperative implant-related complication rate was 30.3% (10/33) in the DHS group and 9.1% (3/33) in the IT group ( $P=0.016$ );<sup>27</sup> this is basically in line with our finding. The role of CTHA in saving these prior failed DHS- or IT-treated IHFs is complex and dependent on many factors. However, emerging data suggest that although revision surgery is critical for early functional recovery and avoidance of complications associated with limiting patient activity, such operations must be carefully performed according to the surgical indications, mainly because CTHA-related postoperative complications are not negligible in patients with osteoporosis, particularly those who have previously undergone DHS fixation.<sup>11,25</sup> Gwam et al.<sup>28</sup> studied the impact of CTHA performed after different treatment strategies for IHFs and concluded that BMD, not other factors, could influence survival independently and that CTHA is more suitable for patients who have previously undergone failed DHS fixation. In parallel with these findings, the present study showed that patients with osteoporotic IHFs who underwent CTHA following primary failed DHS fixation had a higher complication rate, indicating a more negative prognosis when conversion was accompanied by a precipitous decrease in the HHS, referred to as “secondary failure.” Regardless of the BMD variable, patients previously treated with DHS fixation had a low HHS and high implant-related complication rate, which indirectly supports previous findings.<sup>11,25</sup>

This study has two main limitations. First, the retrospective nature of the study, which itself is associated with patient recall bias, limits the level of evidence of our conclusion. Second, patient- and surgeon-related confounders may have existed. Nevertheless, the well-matched groups allowed us to conclude that the between-group differences were unrelated to the

baseline characteristics. Despite these limitations, this study provides long-term follow-up results and is the first assessment of covariates that may have an impact on the clinical results of patients with osteoporotic IHFs treated with CTHA following prior failed DHS fixation.

In conclusion, CTHA following prior failed DHS fixation tended to be associated with a considerably higher risk of poor clinical and radiological outcomes in Asian patients with osteoporosis, and the most common causes of these poor outcomes were the time to failure, instability, hardware removal, acetabular loosening, and early periprosthetic fracture. This finding might have dynamic clinical reference value because of the increased incidence of IHFs.

### Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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