Primary versus secondary calcar replacement hip arthoplasty for treatment of unstable trochanteric fractures

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Background
Harris and Allen had modified and described a calcar replacement femoral component, which is necessary for the conventional femoral components, as a part of total hip replacement to address many problems related to proximal femoral deficiency. The aim of this study was to compare the clinical and radiological outcomes of a primary salvage calcar replacement hip arthroplasty with secondary salvage calcar replacement hip arthroplasty for treatment of new (group 1, prospective) or failed osteosynthesis or end prosthesis treatment (group 2, retrospective) of unstable trochanteric fractures.

Patients and methods
Fifteen patients were included in each group, with a mean age of 67.3 years for group 1 patients and 65.8 years for group 2 patients. The female-to-male ratio was 8 : 7 in group 1 and 10 : 5 in group 2. Incidence of preoperative comorbidities was 2.2 per patient in group 1 and 2.0 per patient in group 2. The mean time from the initial unstable trochanteric fracture to the time of calcar replacement hip arthroplasty was 4.2 days and 12.4 months in group 1 and group 2, respectively. The posterolateral approach using the posteriorKocher–Langenbeck proximally and the posterolateral approach distally for the proximal femur without trochanteric osteotomy. All patients were followed up clinically and radiologically, and at the end of the follow-up period (1–3 years) the Merle d'Aubigne and Postel score was used for functional evaluation.

Results
The mean operative time was 105 and 155 min, the mean amount of blood loss was 550 and 850 ml, and the mean period of hospital stay was 11 and 21 days for group 1 and group 2 patients, respectively. Two patients in group 2 had required postoperative ICU admission. Postoperative complication(s) were reported in one patient (6.6%) in group 1 and in five patients in group 2. Postoperative psychological problems and mortality during the first year were reported in three patients (20%). The Merle d'Aubigne and Postel functional outcome score by the end of the first year was found to be satisfactory (above 14 points) in 100 and 93.3% of patients in group 1 and group 2, respectively. After 3 years of follow-up it was satisfactory in 83.3 and 66.7% of patients in group 1 and group 2, respectively.

Conclusion
Primary cemented calcar replacement hip arthroplasty for treatment of unstable trochanteric fractures is associated with lesser pain, better walking ability without mortality or psychological problems, and with measurable better overall functional outcomes compared with salvage calcar replacement hip arthroplasty.

Keywords:
calcar replacement hip arthroplasty, failed osteosynthesis, unstable trochanteric fracture

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Introduction

Although a relative consensus exists about the treatment of femoral neck fractures in elderly patients, the optimal treatment for unstable trochanteric fractures is still under debate. The goals of surgical treatment for trochanteric fractures are immediate pain relief, rapid mobilization and ambulation, accelerated rehabilitation, and maintenance of independent living. The ideal implant for treatment of trochanteric fractures should have a low risk of complications and subsequent revision, and the patient should not be hampered by his or her treated hip fracture during their life time [1–3]. For several decades the treatment of choice for trochanteric fractures was osteosynthesis, with a reported 100% success rate for stable fractures and a 56% failure rate for fractures with severe comminutions, reversed obliquity, osteoporosis, inadequate reduction, and poor implant placement [4,5]. Failure of osteosynthesis results in nonunion, cutting

off, packing out, femoral head perforation with a profound risk of functional disability, and mortality. For the above reasons, hip hemiarthroplasty or unipolar or bipolar arthroplasty was introduced as a primary alternative to osteosynthesis or as a salvage secondary alternative for failed osteosynthesis in the treatment of unstable trochanteric fractures in elderly patients to allow early mobilization and weight bearing, as well as quicker return to preinjury level of activity, thus obviating the morbidity and mortality caused by immobilization, nonunion, and implant failure [6,7].

End prosthetic replacement may not be an ideal option for elderly active people with more than 10-year life expectancy or with hip arthritis that may necessitate conversion to total hip replacement (THR), which seems to be a straightforward and ideal solution as a single-stage surgery for unstable trochanteric fractures to avoid secondary hospital admission with possible risks and extra costs. However, it must be traded off against the potential harm effects of prolonged and more invasive surgery, in addition to a number of intraoperative technical difficulties associated with salvage revision of failed osteosynthesis or end prosthesis [3,8].

The calcar replacement prosthesis gained its genesis with the work by Leinbach, who had treated peritrochanteric and comminuted proximal femoral fractures. Harris and Allen had modified and described a calcar replacement femoral component, which is necessary for the conventional femoral components, as a part of THR to address many problems related to proximal femoral deficiency [9,10].

Aim of the work

The aim of this prospective and retrospective study is to evaluate and compare the short-term clinical and radiological outcomes of using a primary calcar replacement hip arthroplasty for treatment of fresh unstable trochanteric fractures (group 1, prospective) and a secondary salvage calcar replacement hip arthroplasty for failed osteosynthesis or end prosthesis treatment of unstable trochanteric fractures (group 2, retrospective).

Patients and methods

Between December 2005 and December 2010, 30 patients were treated with calcar replacement hip arthroplasty for their unstable trochanteric fractures in the Orthopaedic Department, Mansoura University Hospital, Mansoura, Egypt. Fifteen patients were treated on primary basis as a prospective group (group 1) and another 15 were treated by a salvage operation for their failed osteosynthesis or end prosthesis treatment of their initial unstable trochanteric fractures as a controlled similar retrospective group (group 2).

All patients who were unable to walk before the incidence of the trochanteric fracture, those who were younger than 60 years of age, who had a stable fracture (A1 according to AO classification) with an intact lesser trochanter, and patients who were associated with other fractures were excluded from this study.

The mean age was 67.3 years (60–78 years) in group 1 and 65.8 years (60–75 years) in group 2. The female-to-male ratio was 8 : 7 in group 1 and 10 : 5 in group 2.

Fifteen preoperative comorbidities were found in seven patients in group 1 (2.2 per patient) and 12 comorbidities were found in six patients in group 2 (2.0 per patient). Six fractures were A2 and nine were A3 in group 1; eight fractures were A2 and seven were A3 in group 2. Primary calcar replacement hip arthroplasty was used in group 1 as early as possible after admission for unstable trochanteric fractures (Fig. 1). For group 2 patients the indications for salvage secondary calcar replacement hip arthroplasty were as follows: failed osteosynthesis in nine patients; nonunion with dynamic hip screw in two; implant failure with dynamic hip screw in four; implant failure with dynamic condylar screw in two; and implant failure with contoured plate and screws in one patient (Figs 2 and 3). Also, salvage secondary calcar replacement hip arthroplasty was carried out for failed end prosthetic treatment in another six patients (two failed Austin Moor's, two failed Thompson's, one failed unipolar, and one failed bipolar prosthesis). The mean time from the initial unstable trochanteric fracture to the time of calcar replacement hip arthroplasty was 4.2 days (range 2–10 days) for group 1 and 12.4 months (range 3–24 months) for group 2 patients.

Preoperatively, 53.3% of group 2 patients were able to walk with support and 46.7% were unable to walk because of failure of the primary treatment for their unstable trochanteric fractures, whereas all patients of group 1 were able to walk preoperatively (93.3% without support and 6.7% with support).

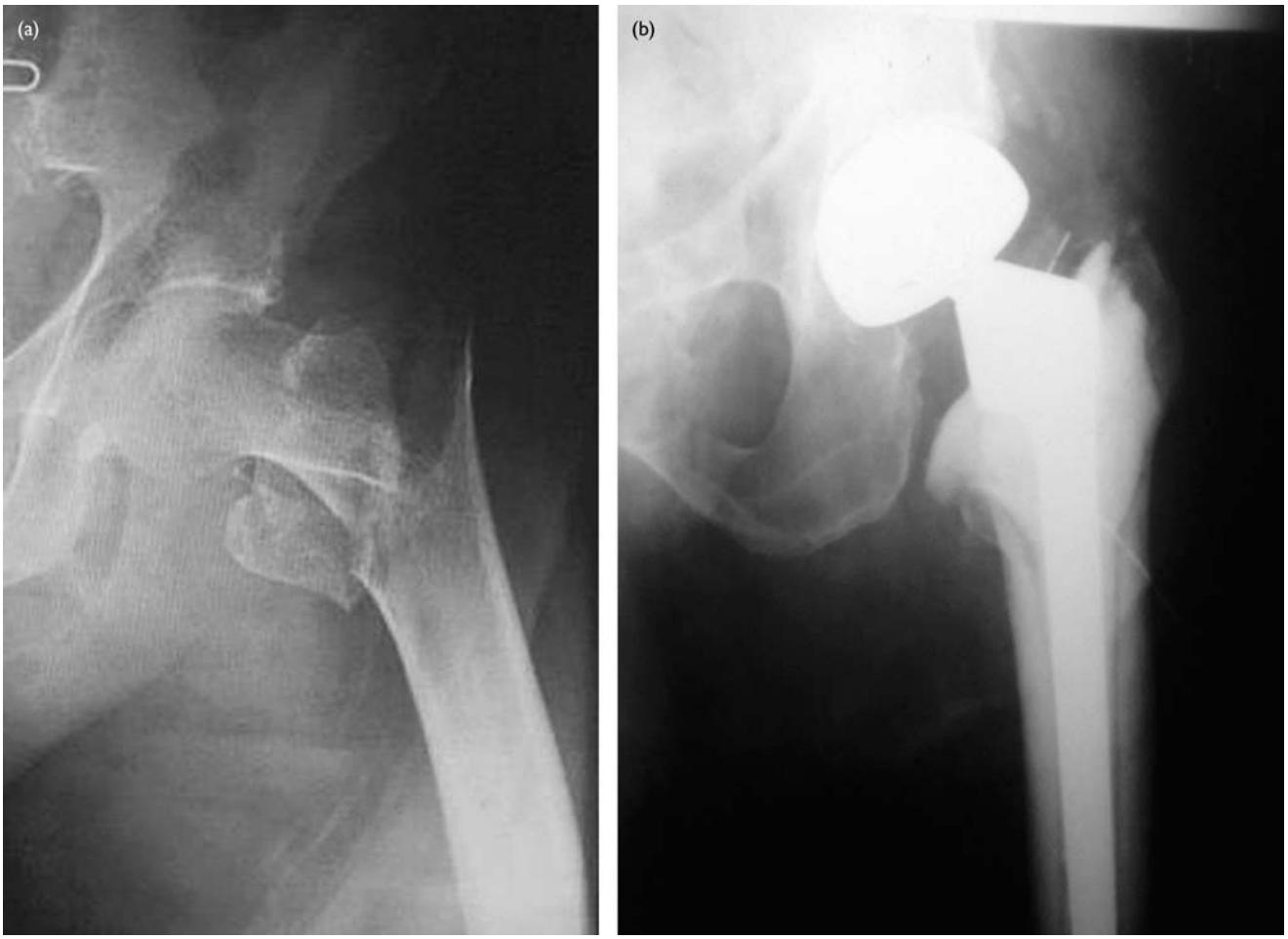
After detailed history taking and proper clinical examination, along with required medical consultation(s) with other subspecialties, a good laboratory and radiological checkup was carried out.

For group 2 patients, local examination of their old operative scar and analysis of complete blood cell count (total and differential white blood cell count), erythrocyte sedimentation rate, and C-reactive protein were carried out to exclude any hidden or subclinical infection associated with or causing the failure of the primary surgical treatment for unstable trochanteric fractures. Deep vein thromboprophylaxis was routinely used for both groups using Enoxaparin sodium (Clexan, Egypt). In addition, Ceftazidime (Fortum, Egypt) was used as a prophylactic antibiotic and no heterotopic ossification prophylaxis was used in our patients.

The posterolateral approach using the posterior Kocher–Langenbeck proximally and the posterolateral approach distally for the proximal femur without trochanteric osteotomy.

For group 2 patients tissue cultures were obtained as there was no facility for obtaining frozen sections, and the hip was dislocated first before implant removal to avoid

Figure 1



(a) Preoperative anteroposterior view of the left hip showing an unstable trochanteric fracture. (b) Postoperative anteroposterior view of the left hip showing primary calcar replacement hip arthroplasty after 36 months of follow-up.

an iatrogenic fracture. Cemented primary (group 1) and secondary (group 2) modular calcar replacement long femoral stems were used. There was no intraoperative iatrogenic complication during femoral stem preparation or insertion; however, there were some intraoperative difficulties in ensuring proper limb length and rotation, as in many cases the lesser trochanter was either avulsed or deficient, in addition to the difficulties encountered in implant removal for group 2 patients.

Second-generation cementing techniques using a cement gun and a femoral plug were used with rapping or blocking the screw holes with a glove filled with saline or with gauze towels to avoid cement leakage for group 2 patients. The acetabulum was replaced (THR) in seven patients in group 1 and in 10 patients in group 2. Bipolar hip arthroplasty without acetabular replacement was performed in eight patients in group 1 and in five patients in group 2.

Trochanteric fixation to restore the abductor mechanism was required for two patients in group 2 because of a nonunited avulsed trochanteric fracture in one patient and proximally displaced avulsion fracture in the other. Two patients in group 2 developed intraoperative complications in the form of lung atelectasis, hypotension, and desaturation in one patient and arrhythmia in the other. The time needed for the operation, the amount of blood loss, and any postoperative ICU admission and complications were also reported (Table 1).

Postoperatively, early passive and active hip and knee range of motion exercises were started, and weight-bearing mobilization as tolerable was also encouraged. All patients were followed up clinically and radiologically every 6 weeks for the first 6 months and then every 3 months until the end of the follow-up period, which should be 12 months or more. The Merle d'Aubigne and Postel scores were used for clinical evaluation with a satisfactory score above 14 points [11]. Radiological assessment included the following: initial femoral stem fixation using the grading system by Harris *et al*. [12] and adequacy of the femoral stem cementing technique using the grading system by Barrack *et al*. [13] from the initial postoperative radiographs. Femoral stem alignment and subsidence was performed using the criteria suggested by Hwang *et al*. [14] and Kawamura *et al*. [15] by comparing the initial and final radiographs, and finally femoral stem stability was assessed using the grading system of Engh *et al*. [16,17] and the criteria of Gruen *et al*. [18] from the final follow-up radiographs.

Figure 2

(a) Preoperative anteroposterior view of the left hip showing an unstable trochanteric fracture. (b, c) Postoperative final anteroposterior and lateral views of the left hip showing failed plate and screw osteosynthesis as a mode of primary treatment. (d, e) Postoperative anteroposterior view of the left hip showing secondary salvage calcar replacement hip arthroplasty after 15 and 28 months of follow-up.

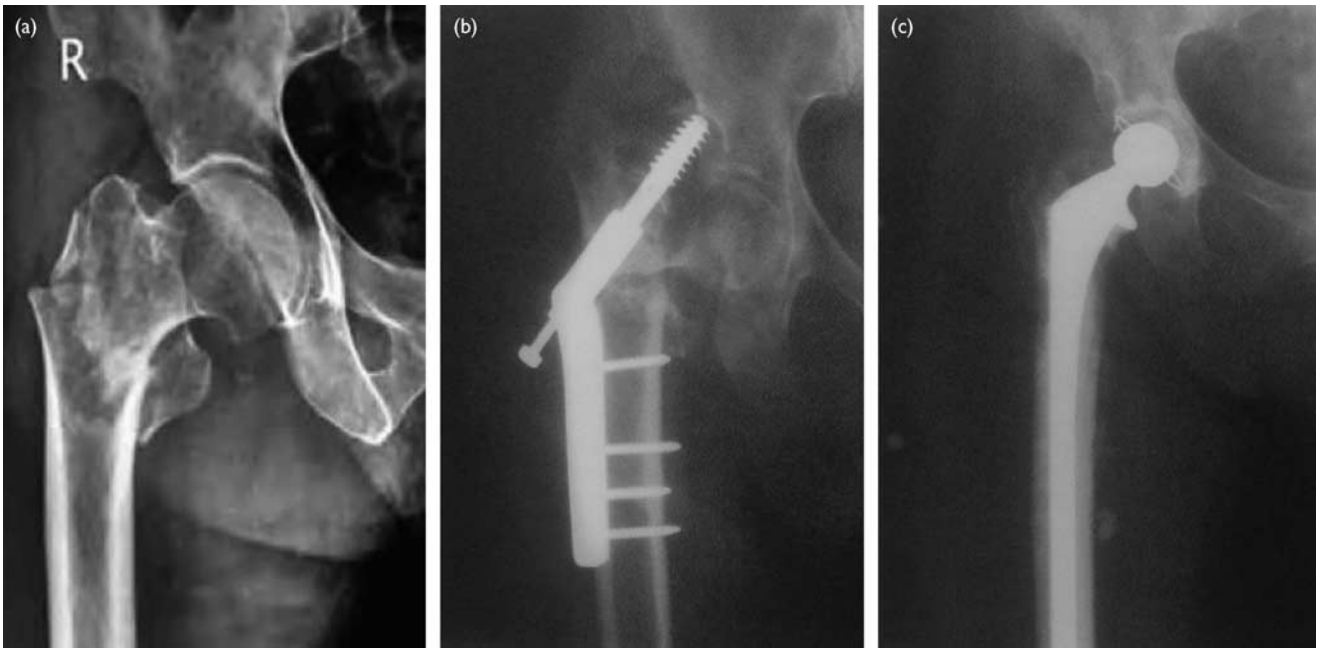
All the data of both groups were statistically analyzed using the Statistical Package of Social Science software for Windows 12.0 (SPSS Inc., USA). One-way analysis of variance (ANOVA) and Fisher's exact test were used for comparing both groups. *P*-value was set at 0.05 or less.

Results

The mean follow-up period was 28 months (12–36 months) for group 1 and 31 months (1–40 months) for group 2. The mean operative time was 105 min (80–145 min) for group 1 and 155 min (120–195 min) for group 2. The mean amount of blood loss was 550 ml (260–800 ml) for group 1 and 850 ml (400–1300 ml) for group 2. The mean period of hospital stay was 11 days (7–18 days) for group 1 and 21 days (14–38 days) for group 2 (Table 1).

Two patients in group 2 required postoperative ICU admission. Postoperative complications were reported in one patient (6.6%) in group 1 and in five patients (33.3%) in group 2 (Table 1).

Figure 3



(a) Preoperative anteroposterior view of the right hip showing an unstable trochanteric fracture. (b) Postoperative final anteroposterior of the right hip showing a failed dynamic hip screw osteosynthesis as a mode of primary treatment. (c) Postoperative anteroposterior view of the right hip showing secondary salvage calcar replacement hip arthroplasty after 36 months of follow-up.

Postoperative psychological problems in the form of delirium, dementia, and depression were reported in three patients (20%) in group 2. These psychological problems made postoperative mobilization and rehabilitation very difficult (Table 1). Two of these three patients in group 2 died within the first 3 months postoperatively: one from pulmonary embolism and the other from pneumonia, urinary tract infection, and finally multisystem organ failure resulting from chronic cirrhosis and long-standing diabetes. Another patient in group 2 died before the end of the first year from massive upper gastrointestinal bleeding as a complication of portal hypertension resulting from chronic liver cell failure.

The causes of fair functional outcome after the third year in one patient in group 1 was moderate hip pain and inability to walk, associating the complications of preexisting chronic renal failure with renal osteodystrophy, hypertension, and hyperparathyroidism.

The causes of fair and poor functional outcome after the first year in group 2 patients were as follows: refusal to walk and hip pain associated with depression in the first patient and moderate hip pain and diabetic neuropathy in the second. After 3 years the causes of fair functional outcome were as follows: severe hip pain following periprosthetic femoral fracture in one patient and respiratory failure due to chronic obstructive pulmonary disease. Further, in group 2, the causes of poor and bad functional outcome in the other two patients were liver cell failure in one patient and midfoot amputation as a result of a diabetic foot in another.

After 1 and 3 years of follow-up, moderate and severe hip pain was found in 6.7 and 13.3% of patients in group 1 in comparison with 16.7 and 25% of patients in group 2. This relationship was found to be statistically significant using one-way ANOVA (Table 2).

After the secondary salvage operation for group 2 patients, 50% of patients were able to walk without support, 33.3% were able to walk with support, and 16.7% were unable to walk by the end of the first year, from 46.7% of patients who were unable to walk and 53.3% who were able to walk with support preoperatively. The difference in walking ability for each group and both groups preoperatively and postoperatively after 1 and 3 years was found to be statistically significant using one-way ANOVA (Table 2).

The Merle d'Aubigne and Postel functional outcome score [11] by the end of the first year was found to be satisfactory (>14 points) in 100 and 93.3% of patients in group 1 and group 2, respectively. After 3 years of follow-up it was satisfactory in 83.3 and 66.7% of patients in group 1 and 2, respectively. The functional outcome score for both groups at 1 and 3 years was found to be statistically insignificant for group 1 and significant for group 2 using Fisher's exact test.

The radiological results of both groups were nearly similar, except for the occurrence of less than 3° varus alignment of one femoral stem in group 2. The radiological results of both groups were found to be statistically insignificant for initial femoral stem fixation, for the initial adequacy of the femoral stem cementing technique, and for the final femoral stem stability and were significant for the final femoral stem alignment using one-way ANOVA (Table 3).

Table 1 Distribution of the baseline variables within treatment groups

	Group 1 ($n=15$)	Group 2 ($n=15$)
Age (years)	62.3 (55.78)	60.8 (50–75)
Sex (male/female)	7–8	5–10
Comorbidities	15 in 7 patients (2.2/patient)	12 in 6 patients (2.0/patient)
Diabetes mellitus	3	2
Hypertension	3	3
Angina	0	1
Arrhythmia	1	0
COPD	0	1
Bronchial asthma	0	1
CRF	1	0
Cerebral stroke	1	0
Liver cirrhosis	4	3
Osteoporosis	2	1
None	8	9
Original fractures type (AO classification)		
A2	6	8
A3	9	7
Indications for calcar replacement hip arthroplasty		
Fresh unstable trochanteric fracture	15	0
Failed DHS	0	7
Failed DCS	0	2
Failed Austin Moor	0	2
Failed Thompson	0	2
Failed unibipolar replacement	0	2
Timing of calcar replacement hip arthroplasty surgery from the time of trochanteric fracture (days–months)	4.2 days (2–10)	12.4 months (3–24)
Anesthesia time (min)	120 (90–165)	180 (135–205)
Operative time (min)	105 (80–145)	155 (120–195)
Blood loss (ml)	550 (260–800)	850 (400–1300)
Intraoperative complication(s)	0	Atelectasis, hypotension, desaturation Arrhythmias
Postoperative ICU admission	0	2
Postoperative complication(s)	2 in 1 patient	8 in 5 patients
Excessive prolonged drainage	1	0
Pneumonia	1	1
Superficial wound infection	0	1
Deep vein thrombosis	0	1
Pulmonary embolism	0	1
Urinary tract infection	0	1
Psychological problems	0	3
Hospital stay (days)	12 (7–18)	21 (14–38)
Postoperative mortality		
First year	0	3 (20%)
Second year	0	0
Third year	0	0

COPD, chronic obstructive pulmonary disease; CRF, chronic rental failure; DCS, dynamic condylar screw; DHS, dynamic hip screw.

There were no complications related to the acetabular component, with cemented or uncemented cups, and with the bipolar acetabular component.

Discussion

Primary calcar replacement hip arthroplasty for treatment of unstable trochanteric fractures is associated with better clinical and functional results compared with secondary salvage calcar replacement hip arthroplasty following failed osteosynthesis or end prosthetic treatment of unstable trochanteric fractures. Whereas primary arthroplasty is a standard procedure for femoral neck fractures, little experience exists for trochanteric fractures and it was mainly used as a salvage operation after failure of its primary treatment [5–8,19–21].

Although there is no clear indication of using arthroplasty as a primary treatment for trochanteric fractures, it eliminates the risk of nonunion, implant failure, and vascular necrosis and at the same time allows early mobilization and weight bearing [22–24].

For complex primary and salvage hip arthroplasty in unstable trochanteric fractures, many intraoperative technical challenges should be expected as the proximal femur may be deficient or mechanically incompetent [25].

Calcar replacement femoral stem is an ideal implant for use in this difficult situation and it resulted in satisfactory functional results in all group 1 patients and in 93.3% of group 2 patients after 1-year follow-up. On the basis of our results we believe that early postoperative ambulation and rehabilitation should be considered while a decision is taken to treat fresh unstable trochanteric fractures in elderly independent patients.

This paper agrees with the conclusions of many other authors in that primary hip arthroplasty is considered one of the most effective primary treatment methods for unstable trochanteric fractures in elderly patients to decrease the morbidity and mortality of osteosynthesis [26–30]. Stern and Angerman [10] reported 94% excellent and good results and Rosenfeld *et al.* [30] reported 86% satisfactory results. Chan *et al.* [29] reported a 31.5% mortality rate after primary standard cemented hip arthroplasty within 1 year in contrast to our group 1 patients in whom no mortality was reported in contrast to 20% mortality in group 2 patients.

It was clear from this study that the preoperative mobility state had a direct effect on the final clinical and functional outcomes, as hip pain, dependent or nonwalking ability, psychological problems, and mortality were more common in group 2 patients as it was aggravated by their preoperative disabled state following their failed primary treatment. This observation was also reported by many authors and others had added the effect of preoperative comorbidities as a risk factor [2,5,23,29,30–32].

Haentjens *et al.* [33] had compared calcar replacement hip arthroplasty with internal fixation and Kim *et al.* [34] had compared it with intramedullary fixation in fresh trochanteric fractures with no difference in the mortality rate but with better functional outcomes in the arthroplasty group because of early ambulation and weight bearing.

A higher dislocation rate up to 12% was reported after primary hip arthroplasty in the treatment for trochanteric fractures in comparison with the rate after osteoarthritis and rheumatoid arthritis [20,30–33]. This higher dislocation

Table 2 Clinical and functional results

	Group 1 ($n=15$)		Group 2 ($n=15$)	
	1 year ($n=15$)	3 years ($n=15$)	1 year ($n=12$)	3 years ($n=12$)
Postcalcar replacement hip pain [*n* (%)]				
No pain and mild pain	14 (93.3)	13 (86.7)	10 (83.3)	9 (75)
Moderate and severe pain	1 (6.7)	2 (13.3)	2 (16.7)	3 (25)
Postcalcar replacement walking ability [*n* (%)]				
Without support	11 (73.4)	9 (60)	6 (50)	4 (33.3)
With support	4 (26.6)	5 (33.3)	4 (33.3)	5 (41.7)
Unable to work	0 (0)	1 (6.7)	2 (16.7)	3 (25)
Merle d'Aubigne and Postel score [*n* (%)] [11]				
Excellent (18 points)	9 (60)	6 (40)	4 (33.3)	2 (16.7)
Very good (17 points)	4 (26.6)	4 (26.6)	2 (16.7)	2 (16.7)
Good (15–16 points)	2 (13.4)	4 (26.6)	4 (33.3)	4 (33.3)
Fair (13–14 points)	0 (0)	1 (6.7)	1 (8.3)	2 (16.7)
Poor (9–12 points)	0 (0)	0 (0)	1 (8.3)	1 (8.3)
Bad (<9 points)	0 (0)	0 (0)	0 (0)	1 (8.3)

Table 3 Radiological results

	Group 1 ($n=15$)		Group 2 ($n=15$)	
Variables	1 year ($n=15$)	3 years ($n=15$)	1 year ($n=12$)	3 years ($n=12$)
Initial femoral stem fixation (Harris *et al.*'s criteria) [12]				
Definite	14	93.3	13	86.6
Probable	1	6.7	2	13.4
Possible	0	0	0	0
Non	0	0	0	0
Initial adequacy of the femoral stem cementing technique (Barrack *et al.*'s cement grade) [13]				
A	13	86.7	11	73.3
B	1	6.7	3	20.0
C	1	6.7	1	6.7
D	0	0	0	0
Final femoral stem alignment and subsidence changes (Hwang *et al.*'s and Kawamura *et al.*'s criteria) [14,15]				
$\geq 3^{\circ}$ varus	0	0	1	8.3
$\geq 3^{\circ}$ valgus	0	0	0	0
≥ 5 mm longitudinal changes	0	0	0	0
Final femoral stem stability (Engh *et al.*'s and Gruen *et al.*'s criteria) [16–18]				
Bony in growth	13	86.7	10	83.3
Stable fibrous	2	13.3	2	16.6
Unstable	0	0	0	0

rate had forced Geiger *et al.* [31] to change their treatment policy from THR to bipolar arthroplasty with 0% dislocation rate, and they had limited its use for salvage of failed osteosynthesis in elderly patients with adequate bone quality and in patients with hip osteoarthritis.

In this study, hip dislocation was not reported in either group, nor were there problems related to the greater trochanter. In the literature, diverse results have been reported after salvage hip arthroplasty to treat failed primary treatment for trochanteric fractures. Secondary salvage calcar replacement hip arthroplasty used to treat group 2 patients markedly alleviated pain, improving the walking ability in most patients. Also, it allowed most patients to regain their lost function [5,7,22,23,26,34–38].

The strength of this study is that it included only those patients who were treated by calcar replacement hip arthroplasty for unstable trochanteric fractures with the single experience of the senior author. The weaknesses of this study, which we do not believe undermine its conclusions, include the following: the subjectivity of the choices made by the senior author between THR and bipolar arthroplasty, the limited number of patients, short-term follow-up, and the prospective–retrospective nature of this study.

We did not observe any differences in short-term outcomes between our cases treated with THR and those with bipolar arthroplasty with respect to the quality of pain, walking ability, mortality, and survival of patients from the implant in agreement with Haidukewych and Berry [22] and in disagreement with Geiger *et al.* [31]. A long-term follow-up study will be conducted to ascertain how much the functional and radiological outcomes will deteriorate and also for how long the calcar replacement hip prosthesis will survive.

Conclusion

Cemented calcar replacement femoral stems can overcome all the intraoperative challenges associated with

unstable trochanteric fractures without serious intraoperative complications.

Primary cemented long stem calcar replacement hip arthroplasty is a viable and effective option for treatment of unstable trochanteric fractures in dependent elderly patients. Also, it is the only available viable and effective option for salvage of failed osteosynthesis or end prosthesis treatment of unstable trochanteric fractures.

Primary cemented long stem calcar replacement hip arthroplasty for treatment of unstable trochanteric fractures is associated with lesser pain and better walking ability without mortality or psychological problems, and with measurable better overall functional outcomes compared with salvage calcar replacement hip arthroplasty.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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