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## Original Research Article

## Calcar reconstruction in bipolar hemiarthroplasty for unstable intertrochanteric fractures

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## ABSTRACT

**Background:** The increasing popularity of primary bipolar hemiarthroplasty for comminuted and osteoporotic intertrochanteric femur fractures is well-documented. However, the absence of posteromedial calcar support due to fracture presents a unique challenge: implant instability and varus collapse. Existing solutions, relying on stem modifications or bone cement void filling, encounter limitations in cost-effectiveness and biomechanical performance.

**Materials and Methods:** This study evaluated the efficacy of posteromedial calcar reconstruction using autologous cortical grafts harvested from the extracted femoral head and neck in 30 patients with intertrochanteric femur fractures. Following strict inclusion and exclusion criteria, primary bipolar hemiarthroplasty was performed with meticulous graft implantation. Weight-bearing and range-of-motion exercises commenced on postoperative day 1. Functional and radiological outcomes were assessed at 12 months follow-up.

**Results:** The demographic distribution revealed a 50:50 split between patients above and below 75 years old. 73.33% (n=22) fractures were right-sided, and AO 31-A2.2 emerged as the most prevalent fracture pattern (46.67%, n=14). An acceptable functional and radiological outcome was achieved in 93.33% (n=28) patients. Two complications (superficial infection and implant breakage) resulted in unacceptable outcomes. Notably, the calcar grafts demonstrated robust healing in patients with favorable functional outcomes (Excellent and Good), as evidenced by a mean Harris Hip Score of 93.11 at 1 year follow-up.

**Conclusion:** This study demonstrates the potential of a well-shaped, wedged autologous cortical graft harvested from the femoral head and neck as an effective strategy for calcar reconstruction in intertrochanteric femur fractures. This technique facilitates graft union, prevents implant subsidence, and offers enhanced biomechanical stability with optimal stress distribution. Furthermore, it eliminates the need for allograft or donor site morbidity, leading to reduced costs and patient burden.

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## 1. Introduction

Intertrochanteric femur fractures represent a prevalent challenge in the aging population, with their incidence directly linked to the rising burden of osteoporosis.<sup>1</sup> These fractures are associated with significant morbidity and mortality,<sup>2</sup> necessitating a nuanced approach to management that considers fracture patterns, patient

characteristics, and surgical expertise.<sup>3</sup>

For stable fractures exhibiting adequate lateral wall thickness, sliding hip screw fixation proves effective. However, fractures characterized by comminution, deficient lateral wall, or posteromedial cortical instability necessitate intramedullary nailing.<sup>3</sup> Unfortunately, both sliding hip screw and intramedullary implants exhibit limitations in osteoporotic fractures or those with deficient lateral wall. For these cases, complications like implant cutout,

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medialization, varus collapse, and peri-implant fractures are frequently encountered.<sup>4,5</sup>

Prosthetic hip replacement emerges as a viable alternative for severely comminuted fractures, significant osteoporosis, salvage of failed implants, or pre-existing hip arthritis.<sup>6</sup> Early mobilization and rehabilitation, often difficult with internal fixation of these fractures, become readily achievable with prosthetic replacement.<sup>7</sup>

A critical concern in both internal fixation and arthroplasty for intertrochanteric fractures concerns the frequent void or comminution in the calcar region. Failure to address this structural deficit can lead to compromised surgical outcomes.<sup>8,9</sup> The posteromedial calcar plays a crucial role in the hip's stress distribution system, transforming bending and torsional forces while effectively redistributing stress throughout the joint.<sup>9</sup> Notably, the calcar exhibits remarkable resilience even in osteoporosis, serving as a key pathway for load transfer from the trabecular femoral head to the cortical femoral shaft.<sup>9,10</sup>

Various strategies have been employed to address calcar fractures, including screw/plate fixation, encirclage wiring for simple fractures during arthroplasty/fixation, and for severe cases, allograft reconstruction or void filling with bone cement.<sup>11,12</sup> However, neither allografts nor bone cement adequately replicate the calcar's inherent capacity to withstand bending and shear stresses. Additionally, implant modifications like longer diaphyseal fitting stems or modular stems offer limited solutions.<sup>13</sup>

A study by CJ Thakkar et al. proposed a novel approach utilizing a bone graft fashioned from the femoral head and neck, precisely fitted into the posteromedial void between the bone and stem.<sup>14</sup> This technique not only prevented varus and retroversion of the prosthesis but also facilitated limb length equalization. Building upon this innovative concept, the present study aims to comprehensively evaluate the functional and radiological outcomes of this autologous bone graft calcar reconstruction technique in the context of prosthetic replacement for osteoporotic, severely comminuted intertrochanteric femur fractures.

## 2. Materials and Methods

### 2.1. Participants

This prospective observational study enrolled 30 patients over 60 years old at a tertiary healthcare centre. Inclusion criteria included comminuted intertrochanteric fractures (AO types 2.1, 2.2, 2.3), severe osteoporosis (Singh's index < 3), informed consent, and willingness to attend follow-up visits. Excluded were patients:

1. Younger than 60 years with stable fractures and good bone stock.
2. With intact posteromedial cortex or open fractures.
3. Unfit for surgery or with severe comorbidities.

4. The study received prior approval from the Institutional Ethics Committee (IEC).

### 2.2. Surgical technique

Following anesthesia induction, patients were positioned in lateral decubitus. Standard surgical protocols for skin preparation and draping were followed.

1. **Transtrochanteric Approach:** Used for fractures involving the greater trochanter. The greater trochanter was either reflected or split coronally (open book) to expose the femoral head.
2. **Anterolateral Approach:** Employed for fractures with an intact greater trochanter. This minimized the risk of dislocation by preserving vital external rotators and abductors.

### 2.3. Posteromedial calcar reconstruction

The posteromedial region was meticulously inspected to assess bone deficiency. An autologous cortical bone graft, approximately 2.5 cm long and 1.5 cm wide, was harvested from the excised femoral head and neck. This graft encompassed the neck's calcar region, extending proximally to the head-neck junction. Careful preparation with an oscillating saw, bone cutter and nibbler ensured appropriate graft morphology.

The graft was then strategically wedged into the proximal femur's posteromedial region, half within the canal and half outside. Its proximal edge reached the level of the projected calcar cut used in conventional cases. With the graft in place, the broach was inserted to verify the prosthetic fit.

#### Fracture Stabilization and Prosthesis Insertion:

1. Fractured greater and lesser trochanters were stabilized with encirclage wiring if needed.
2. Following standard canal preparation, cement was inserted.
3. The posteromedial area was meticulously cleared of cement.
4. The prosthesis was partially inserted, and the cement at the intended graft site was removed.
5. The prepared graft was inserted, and the stem was impacted, ensuring appropriate length and anteversion.
6. Final tightening of the stainless steel wires secured the prosthesis.
7. Hip joint reduction and stability were verified.
8. The incision was closed in layers over a drain.

### 2.4. Post-operative care

Postoperatively, all patients were immobilized using an abduction bar, and rehabilitative measures were initiated, including bedside sitting and knee range of motion exercises. Weight-bearing, supported by a walker,



**Figure 1:** The graft is inserted in the calcar area and the stem impacted



**Figure 2:** Follow up at 12 months showing incorporation of graft and stable implant

commenced on the second day as tolerated. Drain removal occurred 48 hours postoperatively, with intravenous antibiotic discontinuation on the third postoperative day, and suture removal on the tenth postoperative day. Follow-up examinations were conducted at 1 month, 3 months, 6 months, and 1 year intervals. During each visit, the Harris Hip Score was calculated, and patients were categorized based on the scoring system: <70 (poor), 70-79 (fair), 80-89 (good), and 90-100 (excellent).<sup>15</sup> The Harris Hip Score at the 1-year mark was considered for analysis, with scores above 80 (excellent and good) indicative of an acceptable outcome. Anteroposterior and lateral radiographs were taken to evaluate implant stability and graft integration. Erosion of acetabular cartilage with bipolar cup migration >2 mm, and stem instability, defined as subsidence exceeding 3 mm, positional changes, or a radiolucent line wider than 2 mm at the bone-cement interface, were documented.<sup>16</sup>

### 3. Results

A cohort of 30 patients with intertrochanteric femur fractures underwent bipolar hemiarthroplasty with calcar reconstruction and was followed for one year. Observations include:

1. Age distribution: Fifty percent (n=15) of patients were aged between 70-75, while the remaining 50% (n=15) were above 75 years old.
2. Gender ratio: The male-to-female ratio was 2:3 (12:18).

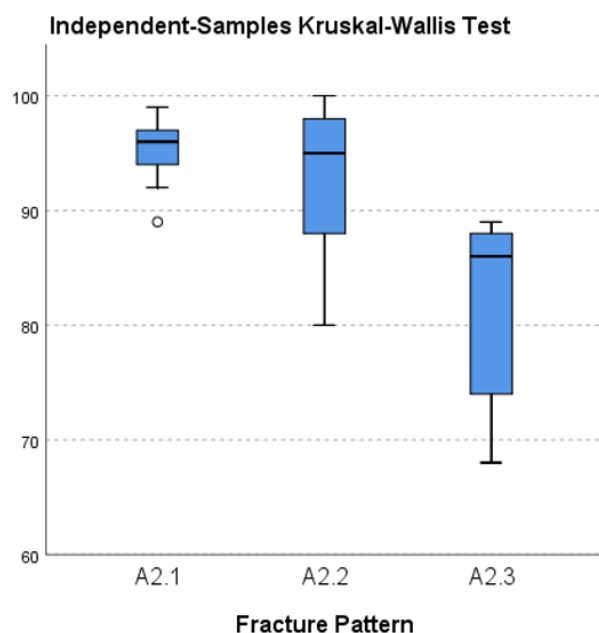
3. Fracture Side: The majority of fractures occurred on the right side (n=22, 73.33%).
4. Fracture classification: Nearly half of the fractures were classified as AO type A31 - 2.2 (46.67%, n=14), 33.33% (n=10) were A31 - 2.1, and 20% (n=8) were A31 - 2.3.
5. Functional outcome (Harris Hip Score): Sixty-three point three percent (63.33%) of patients achieved an excellent functional outcome with a mean Harris Hip Score of 96.26. Thirty percent (30%) had a good functional outcome with a mean Harris Hip Score of 86.44.
6. An independent samples Kruskal Wallis test between the fracture pattern and functional outcome revealed significance ( $p < 0.05$ ).

### 4. Discussion

This study evaluates the effectiveness of calcar reconstruction using the technique described by C.J. Thakkar et al. for managing posteromedial deficits in hemiarthroplasty for intertrochanteric femur fractures.

#### 4.1. Importance of calcar reconstruction

Numerous studies have underscored the crucial role of calcar reconstruction in achieving optimal functional outcomes after hemiarthroplasty. It contributes to implant stability<sup>7</sup> by distributing weight-bearing stresses evenly.<sup>8,9</sup> While diaphyseal fitting stems offer shorter operative times and reduced blood loss in cases without calcar



**Figure 3:** Harris Hip Scores at 1 year correlated with fracture pattern

reconstruction, their higher cost and limited availability necessitate alternative approaches.<sup>17</sup>

#### 4.2. Existing calcar reconstruction methods

Various methods have been explored for calcar reconstruction, each with advantages and limitations:

1. Encirclage wiring: Not feasible in osteoporotic cases with bone loss or comminution.<sup>16</sup>
2. Bone cement: Poor tolerance to tensile stress and fracture risk.<sup>10</sup>
3. Femoral head graft with encirclage wiring: Requires more skill and fixation, with moderate success rates (50%).

#### 4.3. Thakkar's technique and comparison

Thakkar's method demonstrated promising results, with 76.5% of patients achieving acceptable Harris Hip Scores (HHS) above 80.<sup>12</sup> A subsequent review by Sivabalan et al. reported similar outcomes (71% acceptable HHS). Both studies emphasized good graft uptake without fixation, making it a simpler and potentially superior technique.

#### 4.4. Our findings

Our study, involving 30 patients, yielded even higher success rates, with 93.33% achieving acceptable functional outcomes at one year. All cases showcased satisfactory graft incorporation on serial radiographs. Interestingly, a

correlation was observed between fracture pattern and HHS, with increasing comminution associated with lower scores. While no fair or poor outcomes were observed in A2.1 and A2.2 fracture patterns, A2.3 exhibited a decline in excellent outcomes and an increase in fair and poor outcomes. This association was statistically significant ( $p < 0.05$ ).

While primary prosthetic replacement for intertrochanteric fractures remains controversial, it offers advantages in specific scenarios. In contrast to neck of femur fractures with preserved abductor function and strong calcar support, intertrochanteric fractures pose challenges due to potential complications associated with internal fixation, particularly in patients with severe comminution and osteoporosis. These complications, including varus collapse, screw cutout, and poor fracture healing, often necessitate reoperation, further compromising limb function and increasing morbidity and mortality.

Primary arthroplasty offers faster rehabilitation and avoids complications related to prolonged supine positioning. However, it presents its own challenges, including reconstructing functional abductor mechanisms and addressing posteromedial support deficits. Additionally, assessing rotation and limb length can be difficult due to fractured trochanters, and cementing poses risk of leaks.

#### 4.5. Benefits of Thakkar's technique

Using a wedged bone graft to address calcar deficiency offers several advantages:

1. Fills the void of posteromedial comminution.
2. Facilitates rotation assessment and proper stem placement.
3. Prevents varus stem placement through the wedge mechanism.
4. Restores limb length and abductor tension.
5. Avoids calcar cementing and its associated complications.

Given the limitations of internal fixation, the potential benefits of primary arthroplasty, and the technical challenges it presents, the author advocates for Thakkar's technique in select patients. This simple autograft procedure offers potentially superior functional and radiological outcomes without requiring additional donor site morbidity or fixation.

#### 5. Limitations and Future Directions

This study has limitations:

1. The limited sample size necessitates a larger study to confirm the statistical significance of the observed association between fracture pattern and functional outcome.

2. Employing alternative modalities like computed tomography or MRI could provide a more accurate assessment of graft uptake status.

Future research should focus on larger, multicenter studies to further validate the effectiveness of Thakkar's technique and explore optimization strategies for enhanced functional outcomes in patients with intertrochanteric femur fractures undergoing hemiarthroplasty.

## 6. Author Contribution

1. Dr. Sanjay Barnwal - Supervision, Conceptualization.
2. Dr. Sanjay Gaikwad - Methodology, Writing - Review & Editing Visualization, Project administration.
3. Dr. Kamal Jain - Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft.

## 7. Source of Funding

None.

## 8. Conflict of Interest

None.

## 9. Ethical Standard Statement


This article doesn't contain any studies with animal participants performed by any authors. Informed consent – Formal consent taken from the patients, after approval of the consent from the ethics committee.


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