

Failed proximal femur fracture fixation with Broken Cephalomedullary Nails: Outcomes of Conversion Total Hip Arthroplasty Using a Monoblock Tapered Fluted Revision Stem

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Abstract

Purpose

We evaluated the clinical and radiographic outcomes of a standardized reconstructive protocol in conversion total hip arthroplasty (cTHA) for failure of proximal femur fractures with cephalomedullary nail (CMN) breakage using a cementless monoblock tapered fluted revision stem.

Methods

We included 20 patients who underwent cTHA between 2021 and 2024 using the same revision stem after failed proximal femur fixation with a broken CMN, with a minimum follow-up of 24 months. The primary outcomes were femoral stem performance, assessed by stem revision for any cause, and radiographic outcomes. Secondary outcomes included complications, revision for any cause, and functional outcomes. Associations between functional outcomes and age, complications, and ASA grade were also evaluated.

Results

The mean follow-up was 31.3 months. No stem subsidence > 5 mm, aseptic loosening, or stem revisions occurred. Hip biomechanics was satisfactorily restored. Six complications occurred, including two perioperative events, three early dislocations (two requiring revision surgery), and one traumatic periprosthetic fracture. Sixty percent of patients achieved good or excellent Oxford Hip Score (OHS), the mean Parker Mobility Scale (PMS) was 6.5 ± 1.9 . Higher preoperative ASA grade was associated with worse postoperative OHS ($\rho = -0.589$, $p = 0.006$) and PMS ($\rho = -0.485$, $p = 0.030$).

Conclusions

Uncemented monoblock diaphyseal-engaging revision stems provide reliable femoral fixation in cTHA after failed CMN with nail breakage. Although complications were common, none involved stem failure. Functional outcomes are acceptable in most patients but remain associated with preoperative ASA status.

Levels of evidence IV

Introduction

Failed proximal femur fractures (PFF) with broken CMN represent a particularly challenging failure pattern, associated with difficult implant removal, additional bone loss, distorted proximal femoral anatomy, previous screw holes, soft-tissue contracture, and potential fracture nonunion. In elderly patients, conversion total hip arthroplasty (cTHA) is the recommended treatment. However, restoration of femoral version, leg length, and offset are challenging[1, 2]. Reported complication rates after cTHA

range from 7% to 30.7% [3–7], with intraoperative femoral fracture and dislocation among the most frequent[8–10].

Despite the increasing use of cTHA after failed CMN[9], cases involving nail breakage are generally few and pooled with other indications for conversion, limiting evidence specific to this failure pattern. In particular, the optimal femoral reconstructive strategy and stem design remain poorly defined.

The purpose of this study was to evaluate the radiographic and clinical outcomes of a standardized cTHA protocol for failed PFF fixation with CMN breakage using a single uncemented, monoblock, tapered revision stem. We hypothesized that this implant would provide reliable distal fixation and satisfactory restoration of hip biomechanics. The primary outcome was femoral stem performance. Secondary outcomes included complications, reoperations or revisions for causes other than aseptic loosening, and functional outcomes.

Materials and Methods

This retrospective consecutive case series included patients who underwent cTHA between 2021 and 2024 following failed proximal femur fracture fixation with rupture of CMN. Patients had an initial AO/OTA 31A1, 31A2, 31A3, or 31B3 fracture treated either at our institution or elsewhere.

Additional inclusion criteria were treatment with a cTHA using the same uncemented, non-modular, tapered fluted, revision stem (REDAPT Revision Femoral Stem, Smith & Nephew, Memphis, TN, USA) and any acetabular component and, any surgical approach, and a minimum clinical and radiographic follow-up of 24 months or until stem revision or death.

Exclusion criteria were septic nonunion, staged arthroplasty following interim surgical procedures, fixation of pathological fractures, metastatic disease, and incomplete clinical or radiographic follow-up.

All patients provided written informed consent. The study was approved by the institutional ethics committee with the reference number 30370_OSS and conducted in accordance with the Declaration of Helsinki.

Demographic and baseline clinical characteristics; intraoperative variables and perioperative complications (< 24 hours) were collected. Postoperative leg-length discrepancy (LLD) was clinically assessed because migration or malunion of the lesser trochanter precluded a reliable and reproducible radiographic reference point. It was measured using the anterior superior iliac spine to medial malleolus (ASIS–MM) method[11] and considered significant when greater than 5 mm or symptomatic. Postoperative outcomes included mortality and other complications, with particular attention to femoral stem revision. Functional outcomes were assessed at the latest follow up using the Oxford Hip Score (OHS), Parker Mobility Score (PMS). Associations between OHS and PMS and patient age at conversion, American Society of Anesthesiologists (ASA) physical status, and the occurrence of complications were evaluated.

Radiographic assessment

Radiographic evaluation included femoral stem subsidence, restoration of femoral offset, canal filling ratio (CFR), and secondary displacement of the greater trochanter.

Secondary displacement of the greater trochanter and femoral stem subsidence were assessed by comparing the immediate postoperative radiographs with those obtained at serial radiological follow-up. Greater trochanter displacement was considered significant when exceeding 5 mm, and stem subsidence when exceeding 5 mm. Femoral stem subsidence was assessed using the method described by Engh[12]. Changes in the distance between the two reference lines on serial radiographs were used to quantify vertical stem migration (Fig. 1a-b). Femoral offset difference was calculated as the postoperative femoral offset minus the native femoral offset of the contralateral hip. The canal filling ratio (CFR) was used to quantify canal occupancy within the femoral canal (Fig. 1c).

Surgical technique

An uncemented, monoblock tapered fluted revision stem was selected to bypass the mechanically incompetent proximal femur and provide stable fixation, as proximal metaphyseal bone support was considered inadequate, resulting in a defect analogous to a Paprosky type III femoral defect[13]. All procedures were performed by experienced hip arthroplasty surgeons. Residual greater trochanter instability or multifragmentary fractures were stabilized using figure-of-eight polymer cerclage cables (SuperCable®, Kinamed Inc., Camarillo, CA, USA)[14] (Fig. 2), or with a periprosthetic hook plate (EVOS Periprosthetic Hook Plate, Smith & Nephew, Memphis, TN, USA) [15]. Immediate mobilization and weight bearing as tolerated were permitted in all patients.

Data analysis

Statistical analyses were performed using RStudio (R Foundation, Vienna, Austria). Continuous variables are reported as mean $\pm$ SD or median (IQR), and categorical variables as frequencies and percentages. Associations between age, preoperative ASA, and postoperative functional outcomes (OHS and PMS) were assessed using Spearman's rank correlation coefficient. Functional outcomes were compared using the Mann–Whitney U test. Statistical significance was set at $p < 0.05$.

Results

Patient characteristics

Between 2021 and 2024, 68 consecutive cTHA following failed CMN fixation were identified. Of these, 27 had a nail breakage. Seven patients were excluded because a different implant was used, leaving 20 patients for the final analysis (Fig. 3).

The mean age at cTHA was 76.2 ± 9.6 years (range, 60–96)(Table 1). A 190-mm femoral stem was implanted in 11 patients (55%). Greater trochanter fixation was performed using polymer cerclage cables in 14 patients (70%) and a periprosthetic hook plate in 3 patients (15%). Thirteen patients (65%) required postoperative blood transfusion ($Hb < 8$ g/dl) (Table 2).

Table 1
Demographic data

Variable	Overall n = 20
Age at fracture, years	75.5 ± 9.9
Age at revision, years	76.2 ± 9.6
Sex	
Female	13 (65%)
Male	7 (35%)
BMI, kg/m ²	26.9 ± 7.7
ASA	
I	1 (5%)
II	7 (35%)
III	12 (60%)
Fracture characteristics	
AO classification	
31A1.3	1 (5%)
31A2.2	4 (20%)
31A2.3	2 (10%)
31A3.1	3 (15%)
31A3.3	8 (40%)
31B3	2 (10%)
Index fracture fixation	
Nail length	
Short	10 (50%)
Long	10 (50%)
Reduction (available cases, n = 12)	
Closed	8 (40%)
Open	3 (15%)
Time fixation to failure, days	197.0 (123.0–285.2)
Time failure to revision, days	8.0 (3.8–25.8)

Table 2
Intraoperative data

Variable	Overall n = 20.
Surgical approach	
Anterior-Based Muscle Sparing	5 (25%)
Posterolateral	15 (75%)
Stem length, mm	
190	11 (55%)
240	8 (40%)
300	1 (5%)
Stem diameter, mm	
14	3 (15%)
15	3 (15%)
16	3 (15%)
17	3 (15%)
18	7 (35%)
20	1 (5%)
Trochanteric fixation	
Yes	17 (85%)
No	3 (15%)
Trochanteric fixation technique (n = 17)	
Figure-of-eight cerclage	14 (82%)
Periprosthetic hook plate	3 (18%)
Dual mobility cup	
No	11 (55%)
Yes	9 (45%)
Operative time, min	190.2 ± 49.9
Intraoperative complications n,%	1 (5%)

Implant performance

Mean follow-up was 31.3 months (range, 24.6 – 57.7). No deaths occurred during follow-up. No femoral stem revisions or cases of aseptic stem loosening were observed (Table 3). Radiographic evaluation demonstrated no femoral stem subsidence > 5 mm. The mean canal filling ratio was $80.8\% \pm 4.7\%$. Secondary greater trochanter displacement occurred in 4 patients (20%); however, in all cases displacement remained non-progressive and did not require reoperations. Mean femoral offset difference was -0.8 ± 4.8 mm. A clinically significant leg-length discrepancy was present in 5 patients (25%), all of whom were treated through a posterolateral approach.

Complications

Overall, complications occurred in six patients (30%). One intraoperative femoral fracture was recognized and managed during the index procedure. One patient developed a postoperative hematoma requiring transcatheter arterial embolization within 24 hours of surgery.

Three patients experienced a dislocation within 60 days after cTHA, all following a posterolateral approach and implantation of a dual motility cup. Two required revision surgery with implantation of a constrained liner (R3 Constrained Liner, Smith & Nephew, Memphis, TN, USA), whereas one was successfully treated with closed reduction without recurrence. One patient sustained a Vancouver type C periprosthetic distal femoral fracture 4.5 years after cTHA following direct trauma. None of the complications resulted in femoral stem revision or stem loosening during follow-up.

Functional outcomes

At the latest follow-up, the median OHS was 29 (range, 12–41). The mean PMS was 6.5 ± 1.9 . Patient age at cTHA was not associated with postoperative OHS ($\rho = -0.31$, $p = 0.184$) or PMS ($\rho = -0.26$, $p = 0.263$). In contrast, a higher preoperative ASA classification was significantly associated with worse postoperative OHS ($\rho = -0.589$, $p = 0.006$) and PMS ($\rho = -0.485$, $p = 0.030$) (Fig. 4). Functional outcomes did not differ between patients with and without intraoperative or postoperative complications (OHS: 32.0 [IQR, 30.2–33.8] vs. 31.5 [IQR, 19.8–36.8], $p = 0.836$; PMS: 6.67 ± 1.63 vs. 6.36 ± 2.06 , $p = 0.900$).

Table 3
Follow up

Variable	Overall n = 20
Blood transfusion	
No	7 (35%)
Yes	13 (65%)
Complications, n (%)	6 (30%)
Intraoperative	1 (5%)
early (< 24h)	1 (5%)
early (< 60 dd)	3 (15%)
late (> 60 d)	1 (5%)
Type of complication	
Dislocation	3 (15%)
Intraoperative fracture	1 (5%)
Late periprosthetic fracture	1 (5%)
Surgical hematoma	1 (5%)
Follow-up, months (mean, range)	31.3 (24.6–57.7)
Radiological follow up	
Greater trochanter secondary displacement	
No	16 (80%)
Yes	4 (20%)
Canal filling ratio, mean $\pm$ SD (%)	80.8 $\pm$ 4.7
Stem subsidence	
No	20 (100%)
Femoral offset difference vs. contralateral hip, mm	-0.8 $\pm$ 4.8
Clinical FU	
LLD > 5 mm (ASIS-MM), n,%	5 (25%)
Oxford Hip Score (0–48), median (IQR)	32.0 (21.5–36.5)
Oxford Hip Score category	
Very poor function (0–19)	5 (25%)

Variable	Overall n = 20
Poor function (20–29)	3 (15%)
Good function (30–39)	10 (50%)
Optimal function (40–48)	2 (10%)
Parker Mobility Score (0–9), mean $\pm$ SD	6.5 $\pm$ 1.9
very limited 0–3	2 (10%)
moderate limitation 4–6	8 (40%)
good/excellent motility 7–9	10 (50%)

Discussion

Primary Outcomes

The principal finding of this study was the absence of femoral stem-related failure during follow-up. No stem required revision, and no aseptic loosening or clinically relevant subsidence was observed despite immediate full weight bearing. Hip biomechanics were satisfactorily restored, with a mean femoral offset difference of -0.8 ± 4.8 mm and a mean canal filling ratio of $80.8\% \pm 4.7\%$. The cases of secondary displacement of the greater trochanter were non-progressive and did not require reoperation.

Although cTHA after failed proximal femoral fracture fixation has been widely studied, patients with broken CMN are rarely reported separately and are usually pooled with other failure modes and fixation methods. This limits the evidence available to guide femoral reconstruction in this particularly demanding setting. Failed CMN also appears to be associated with a greater complication burden than conversion after other fixation methods[2, 16]. By restricting our cohort to patients with broken CMN and applying a standardized surgical algorithm with a single monoblock, revision stem, we evaluated a specific reconstructive strategy in a homogeneous population.

The rationale for distal diaphyseal fixation is particularly relevant in broken CMN. Nail breakage is frequently associated with substantial proximal bone loss and an unreliable metaphyseal segment, with the proximal femur mechanically compromised after implant removal. Once stable distal press-fit fixation is achieved, we hypothesize that the combination of axial stability and rotational control provided may create a favorable mechanical environment for durable femoral reconstruction [17, 18].

We favored an uncemented revision stem also because optimal cementation after CMN removal may be technically difficult. Consistent with this concern, Selim[6] reported Barrack grade A[19] cementation in only 7.7% of conversions after CMN. Moreover, aseptic loosening has been reported as an important cause of revision in series using cemented stems. Li[20] reported a large series specifically including broken CMN, with 27 cases among 186 cTHAs. All patients received a cemented stem (Versys CT,

Zimmer Biomet, Warsaw, IN, USA). Despite 84% implant survival at 10 years, aseptic femoral loosening accounted for 13 of 28 revisions. Similarly, a series of 118 cTHAs after failed CMN reported 94% long-term implant survival, although nail breakage was not specified; stem revision for aseptic loosening occurred in 5.1% of cases [21].

Among the available literature, the series by Soundarrajan[22] is the most comparable in terms of femoral stem design, although the number broken CMN was not specified. Using an uncemented Wagner SL stem (Zimmer-Biomet, Warsaw, USA), they similarly achieved stable distal diaphyseal fixation without stem revision for aseptic loosening. Their higher rate of intraoperative femoral fractures (17.9% versus 5% in the present study) may be related to the lower use of short stems. More than half of our patients were successfully reconstructed using a 190-mm stem, compared with 30.7% in their cohort. The ability to achieve secure distal fixation with a shorter stem may reduce the risk of cortical perforation and intraoperative fracture. Whether these differences are related to stem geometry, instrumentation, or surgical technique remains speculative and warrants further investigation.

Comparable findings have also been reported with modular diaphyseal-engaging revision stems (MP Stem, Waldemar LINK®, Germany) [23], suggesting that stable distal fixation may be more important than specific stem design. Although modular stems provide greater intraoperative flexibility for restoring femoral version, offset, and leg length, they introduce an additional mechanical junction. Lack of proximal osseous support has been identified as a major risk factor for modular junction fracture[24, 25]. Because proximal metaphyseal bone loss and abductor insufficiency increase bending moments across the proximal femur, we favoured a monoblock stem to eliminate the modular junction while maintaining stable distal fixation and satisfactory restoration of hip biomechanics.

Successful reconstruction extends beyond femoral fixation alone. Greater trochanter fixation was required in 17 of 20 patients, reflecting the severity of proximal soft-tissue disruption, and should be considered an integral component of the reconstructive strategy rather than merely an adjunctive procedure[15].

Secondary outcomes - Complications

Recent systematic reviews have reported complication rates of 10–15% and revision rates of 3.8–6.7% after cTHA following failed proximal femoral fracture fixation[8, 10, 16]. Instability and periprosthetic fractures consistently are among the most frequent complications, particularly after failed CMN [3, 5, 7, 8, 26, 27]. In our cohort instability remained the predominant complication, whereas no patient underwent stem revision for aseptic loosening. Only one femoral fracture was procedure-related; the second occurred 4.5 years postoperatively after trauma and was unrelated to failure of the index reconstruction.

The severity of proximal soft-tissue disruption may be a leading cause of instability. In both patients' requiring revision surgery, the greater trochanter had healed in a posteriorly displaced position, causing impingement and loss of abductor tension despite stable femoral fixation. This concept is further

supported by studies using modular revision stems where instability remained the leading complication[23]. Likewise, an analysis of the American Joint Replacement Registry found no advantage of modular stems in preventing instability, with monoblock stems showing a lower risk of re-revision for dislocation[26]. Together, these findings suggest that optimizing implant geometry alone cannot fully compensate for severe abductor deficiency.

Functional outcomes

Consistent with previous studies, cTHA provided pain relief and improved function [16, 27–29]. No patient died during follow-up while in previous cTHA series mortality was 4–19% [3, 5, 6]. Functional recovery was associated with preoperative ASA score, but not with age or postoperative complications, suggesting that physiological reserve rather than chronological age is the principal determinant of outcome. Importantly, no stem-related failures occurred regardless of ASA grade.

Limitations

This study has several limitations. It is a retrospective case series with a limited sample size and no control group, and limited follow-up preclude conclusions regarding long-term implant survivorship. The principal strength is the homogeneity of the cohort: all patients underwent cTHA for failed CMN with nail breakage, using the same surgical algorithm and femoral reconstruction strategy. Because broken nails are usually underrepresented in larger cTHA series, this focused cohort provides a more consistent assessment of a specific reconstructive approach.

Conclusions

In patients undergoing conversion THA after cephalomedullary nail breakage, a monoblock uncemented tapered fluted revision stem provided reliable femoral reconstruction and fixation, and satisfactory restoration of hip biomechanics. Despite the complexity of these cases, no stem-related failures occurred. Functional outcomes were acceptable in most patients but were influenced by preoperative ASA status.

Declarations

No funding was obtained for this study

Author Contribution

DS: conceptualization, methodology, formal analysis, writing original draft FM: investigation, data curation, writing review & editing FC, FL: investigation, validation, MI, RC: conceptualization, supervision MI: conceptualization, writing review & editing, supervision

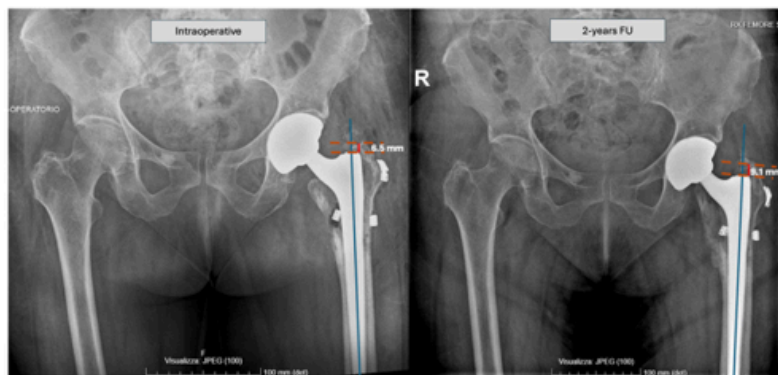
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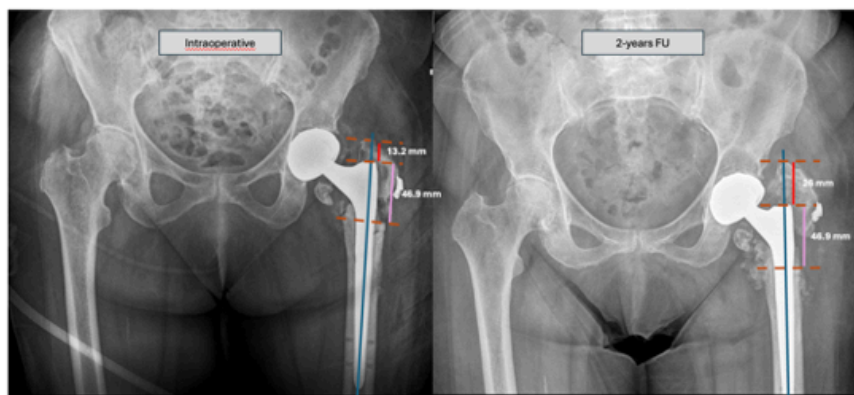
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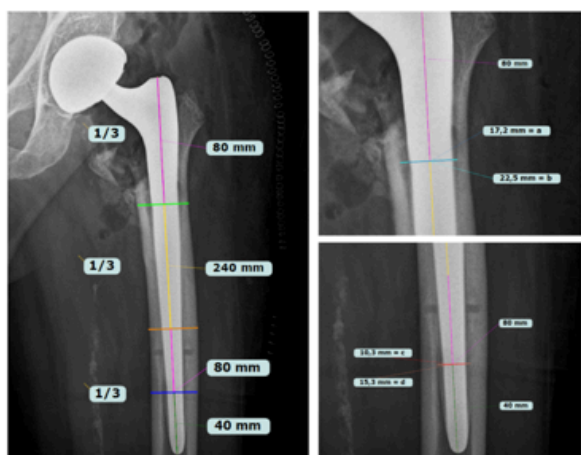
Figures



a)



b)



c)

Figure 1

A-C. Radiographic assessment of stem subsidence, greater trochanteric displacement, and canal filling ratio (CFR). A, Stem subsidence measured according to the method described by Engh et al. A line was drawn along the longitudinal axis of the femoral stem, with perpendicular reference lines at the stem shoulder and greater trochanteric apex. B, Modified Engh method in cases of greater trochanteric displacement. A fixed point on the lateral femoral cortex, specifically the cortical spicule immediately

distal to the fracture site, was used as the femoral reference. Greater trochanteric displacement was calculated as the change in the stem shoulder–greater trochanter distance between serial radiographs, corrected for measured stem subsidence. C, Canal filling ratio measured at the junction of the proximal and middle thirds and at the midpoint of the distal third of the femoral stem. The reported CFR was the mean of the 2 measurements.

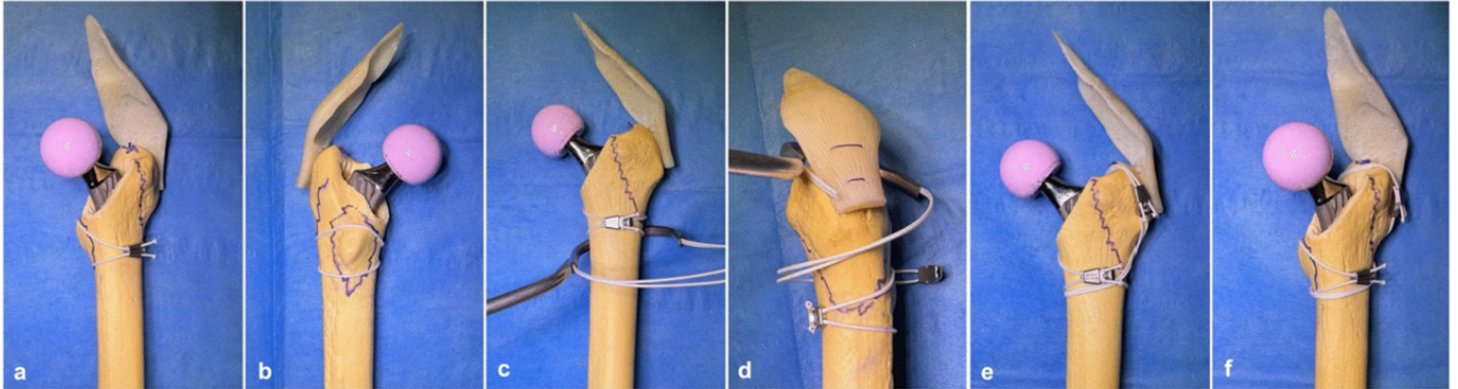


Figure 2

The figure was reproduced without modification from: [A novel figure-of-eight polymeric cerclage wiring technique for greater trochanter fixation in revision arthroplasty and conversion of failed proximal femur fracture fixations to total hip arthroplasty](#), Leggieri et al Journal of Orthopaedics and Traumatology 2026. Configuration in case of lesser trochanter detachment or fracture with feasible fixation. Greater and lesser trochanter fractures were marked with blue ink. **a** Sling fixation technique, anterior view. **b** Sling fixation technique, medial view. **c** The cable was passed around the proximal third of the femur just below the lesser trochanter as in the classic configuration. **d** The longer cerclage end was passed from lateral to medial in a loop around the gluteus medius as in the classic configuration. **e** Anterior view of the final aspect of the cerclage configuration: the cable of the sling fixation of the lesser trochanter acts as an anchor for the cable which passes below it. **f** Medial view of the final aspect of the cerclage configuration. The image is licensed under a Creative Commons Attribution 4.0 International License.

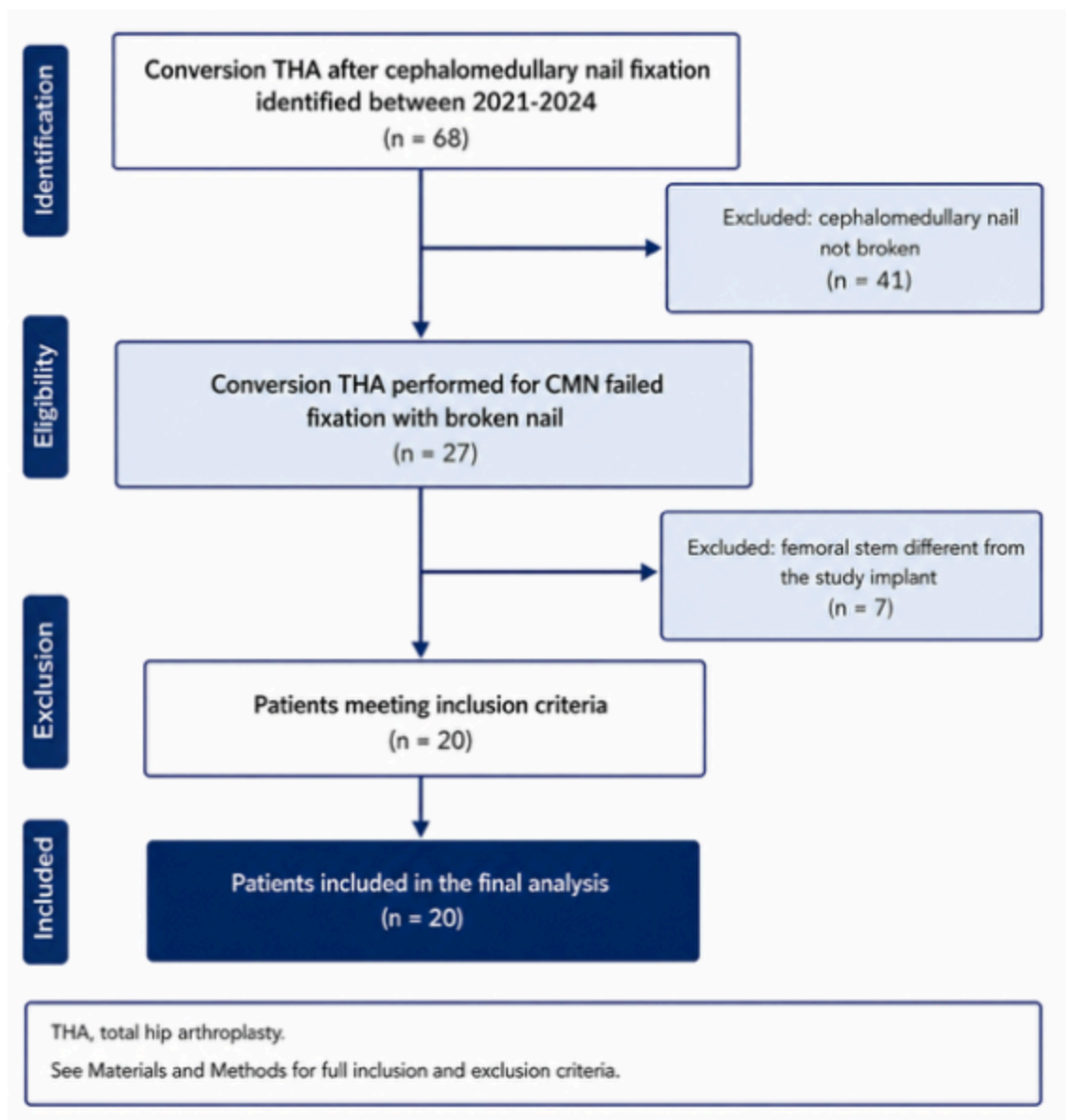


Figure 3

Flowchart illustrating patient identification, eligibility, exclusions, and final inclusion of patients undergoing conversion total hip arthroplasty after failed cephalomedullary nailing with nail breakage.

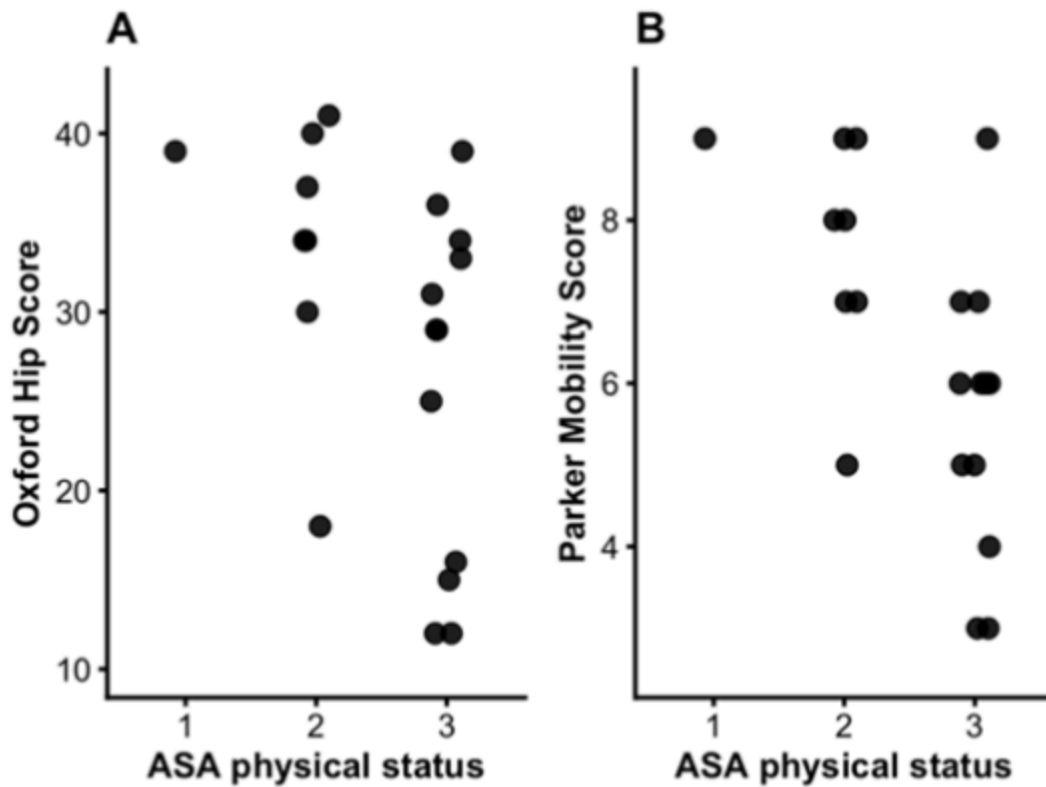


Figure 4

a-b. Association between preoperative American Society of Anesthesiologists (ASA) physical status and postoperative functional outcomes. **(A)** Oxford Hip Score (OHS). **(B)** Parker Mobility Score (PMS). Each point represents one patient. Higher preoperative ASA grade was associated with worse postoperative OHS (Spearman $\rho = -0.589$, $p = 0.006$) and PMS (Spearman $\rho = -0.485$, $p = 0.030$).