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Outcomes of modular proximal femoral replacement in the treatment of complex proximal femoral fractures: A case series

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ABSTRACT

Background: The treatment of complex femur fractures poses a significant challenge. Even with current advancements and the various implements available for the fixation of femoral fractures, results are often disappointing. This study sought to identify problems associated with and examine results of modular proximal femoral replacement. Outcomes were evaluated in two groups of patients: those receiving primary modular proximal femoral replacement for fractures and those treated with salvage arthroplasty for failed internal fixation.

Methods: Twelve patients who had received modular proximal femoral replacement as primary treatment for proximal femoral fractures were evaluated along with nine patients treated with salvage proximal femoral replacement for failed internal fixation. After the surgical procedure, patients were evaluated at regular follow-up intervals and contacted by phone at the conclusion of this study. Patient functional results were evaluated using the Merle D'Aubigne hip rating scale, which measures pain, motion and ambulatory status. Routine radiographs were also obtained at each patient visit.

Results: On average, patients who received modular proximal femoral replacement as the primary surgery for their femoral fractures enjoyed a high-level functional result and had few complications. Subjects who received salvage femoral replacement had a less optimal outcome and experienced more complications. Nonetheless, final post-operative MDA score was significantly increased from pre-operative levels.

Conclusion: Modular proximal femoral replacement is a viable option in the primary fracture or revision setting, and has been shown to have a reasonable outcome, especially when the nature of initial injury is taken into account.

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1. Introduction

Despite the current advancements in biomechanics, and the vast array of implements available for internal fixation, the treatment of complex proximal femoral fractures is fraught

with difficulty and results are often disappointing.¹⁻¹² From the orthopaedist's standpoint post-surgical complications, such as loss of fixation, non-union and infection, are the main difficulty, while patients complain of persistent pain and limitations in activity.^{2-8,10-12} A review of the current

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literature demonstrates that moderate to severe complications occur in 10–45% of patients treated with complex femoral fractures.^{2,3,7,8} These difficulties can be minimized by achieving adequate reduction of the fractured hip and prompt fixation. The osteoporotic elderly, patients with multiple medical co-morbidities and severely injured trauma patients pose a significant challenge in this regard.

Patients who exhibit more pressing traumatic injuries, complex medical issues preventing prompt surgical intervention, or cognitive/physical co-morbidities that hinder early mobilization are further predisposed to developing severe complications in the post-operative period.¹² As a result, several investigators have proposed proximal femoral replacement as an effective treatment strategy for patients suffering significant proximal femoral bone loss.^{2-4,9,11-13} This intervention allows for a quicker return to function, advanced weight bearing status, elimination of the risk for osteonecrosis and non-union, as well as a decrease in complications resulting from prolonged bed rest and immobilization.^{2,3,9,12}

Prior research has explored the use of proximal femoral replacement for the salvage of failed total hip arthroplasty, oncologic processes, periprosthetic femur fractures and infectious problems.^{11,13-18} Some reports in the literature have addressed acute prosthetic replacement for unstable intertrochanteric fractures^{3,19-21} while others have published their findings regarding the use of salvage arthroplasty for failed osteosynthesis in unstable intertrochanteric and subtrochanteric fractures.^{1,4-6}

Currently, there are no studies in the orthopaedic literature evaluating the results of primary prosthetic replacement and outcomes in patients who receive modular femoral replacement as salvage for failed internal fixation. Furthermore, due to the small numbers of subjects and methodological disparities in previous studies, there is a lack of consensus in the literature regarding the efficacy and role of proximal femoral replacement in treating complex femoral injuries.

This study endeavored to evaluate functional results in patients who received modular proximal femoral replacement as the treatment for their proximal femur fractures as well as patients treated with similar prostheses as revision for failed internal fixation. The investigators hoped to demonstrate that proximal femoral replacement is a viable treatment option for orthopaedic surgeons dealing with complex proximal femoral fractures.

2. Methods and materials

Between 1991 and 2004, 21 patients received 22 proximal femoral replacements as treatment for their complex proximal femoral injuries at Akron General Medical Center. Twelve patients received 13 modular proximal femoral replacements as primary treatment for their proximal femoral injuries (Figs. 1–3). These injuries occurred as a result of falls in 10 cases while motor vehicle accidents were responsible for the other 2 fractures. Eleven patients were female. Ten patients sustained intertrochanteric fractures (OTA class 31A2.2 or A2.3), while 3 had femoral neck fractures. Severe comminution and/or bone loss was present in every instance. Decision to use a megaprosthesis was based on a balanced assessment of



Fig. 1 – Radiographic image of a 66-year-old female patient treated with a primary proximal femoral replacement for comminuted intertrochanteric fracture. Pre-operative anteroposterior radiograph of the proximal femur demonstrating severe comminution and displacement of an intertrochanteric fracture.

the patient's fracture pattern, bone stock, co-morbidities and other associated injuries, with osteoporosis and comminuted/complex fracture pattern (OTA 31-A2.2 or .3) being considered most important. Average age at the time of fracture



Fig. 2 – Pre-operative computed tomographic scan of the proximal femur showing degree of bone loss in the same patient as Fig. 1.



Fig. 3 – Final post-operative anteroposterior radiograph of the same patient as Figs. 1 and 2, 3 years after injury. The patient experienced no residual pain in her left hip, had full active range of motion and could ambulate independently.

was 76 years (range 62–90 years). Average time to surgery from time of fracture was 2.15 days (range 1–6 days). Surgeries were performed through a posterior approach to the hip and all components were cemented at the time of surgery. Of the prostheses in the primary replacement group, 10 were manufactured by Howmedica™ (Allendale, NJ) and 2 were Biomet™ (Warsaw, IN) prostheses. A cable grip with wires was used to fix the greater trochanter and abductor musculature to the prosthesis in every instance. All patients were treated by one or both surgeons (MCL, GAV) involved in this study.

Of the patients treated, 1 died intra-operatively, 1 was lost to follow-up after 2 months and the rest completed a satisfactory post-operative course. The patient who suffered an immediate post-operative demise was excluded from consideration in the study. The mean time of follow-up was 44 months (range 2 months to 11 years). All patients received post-operative physical exams and roentgenographic evaluations that demonstrated adequate fixation of their prostheses. Patients were also assessed for their level of pain, ability to perform daily activities and ambulate without assistance. Post-operative complications and co-morbidities were recorded and level of satisfaction was obtained. Each patient's overall functional assessment was compiled into a Merle D'Aubigne (MDA) score²² based on performance in three separate categories: hip pain, joint range of motion and walking

ability. Summation of the three scores allowed for determination of an overall final functional result, which was rated as excellent, very good, good, fair, poor or bad.

A similar protocol was developed to evaluate the outcomes of patients treated with modular proximal femoral replacements as salvage for failed internal fixation of proximal femoral fractures. Between 1991 and 2004, 9 patients were treated by one or both surgeons in this study with 9 proximal femoral prostheses for failed osteosynthesis of hip fractures (Figs. 4 and 5). Seven of the patients in this group were female. Eight of the initial injuries occurred as a result of a fall while 1 fracture occurred in a motorcycle accident. Seven of these fractures were intertrochanteric, while 2 were subtrochanteric. Six fractures had initially been treated with a sliding hip screw and 3 initially received cephalo-medullary constructs. The average time to failure was 6.2 months (range 1–16 months). All patients received their modular proximal femoral replacement as the first procedure following failed internal fixation. Surgeries were performed in an identical manner to that described for the primary replacement group, with all patients in the revision group receiving Howmedica™ prostheses. The average age at the time of revision to megaprosthesis was 72.5 years (range 54–85 years).

One patient passed away 2 months after surgery, while the rest completed a satisfactory post-operative course. The average follow-up in this group was 37.5 months (range 2 months



Fig. 4 – Radiographic image of a 79-year-old female treated with a proximal femoral replacement as revision for failed internal fixation with a sliding hip screw. Pre-operative anteroposterior radiograph of the proximal femur showing collapse at the fracture site and hardware failure.



Fig. 5 – Post-operative anteroposterior radiograph of the same patient as Fig. 4, 14 months after proximal femoral replacement. This patient was found to have a pain free hip with full active range of motion. She required a walker for ambulatory assistance.

to 14 years). Post-operative evaluations were identical to those described for the primary replacement group. Patients in this group had pre-operative and final functional performance compiled into MDA scores for the purposes of comparison.

One author (A.J.S.) was responsible for reviewing hospital charts, office notes and post-operative function data sheets to evaluate functional status and assign respective scores. When possible, the patient and/or their caregivers were also interviewed by phone. This study received approval from the institutional Investigational Review Board (IRB).

3. Results

Twelve modular proximal femoral prostheses in 11 patients composed the primary replacement group. The mean follow-up time in this group was 44 months (range 2 months to 11 years). Duration of follow-up is detailed in Table 1. Co-morbidities at the time of injury are summarized in Table 2 and post-operative complications are listed in Table 3.

Overall, there were four complications in three patients. One patient sustained pneumonia and dislocated the prosthesis in the immediate post-operative period. The dislocation was treated with closed reduction and there were no further

Table 1 – Duration of follow-up for patients in the primary replacement and revision groups

Length of follow-up	Primary group	Revision group
Less than 6 months	1	1
6 months to 2 years	3	2
2 years to 5 years	5	5
Greater than 5 years	2	1

instances of instability in this patient after 44 months of follow-up. Another patient suffered a dislocation 4 months after surgery and was treated with closed reduction. This patient subsequently dislocated again at 27 months post-operatively, but has since remained stable. There was also one peri-prosthetic fracture, occurring 8 months after surgery. The fracture was located at the tip of the femoral stem and was treated with a locked supracondylar plate. After 32 months of follow-up, this patient was found to have a good functional result by MDA score (16/18). The prostheses in the primary replacement group exhibited 100% survival, with no patient necessitating a revision.

Of the 11 patients in the primary replacement group, 8 were classified as having a good result or better according to the Merle D'Aubigne scale (Table 4). Two patients were classified as having a fair result and 1 patient was found to have a poor result. Pain was absent in 9 patients while the others only complained of occasional discomfort. No patient reported chronic pain that was disabling in nature. Six patients ambulated with a normal gait or slight limp and 4 required a permanent cane or walker. The patient who was found to have a poor functional result was non-ambulatory at the time of final follow-up, but this seemed to be a function of her other co-morbidities (advanced dementia, Parkinson's disease, myocardial infarction) rather than a true reflection of poor surgical outcome. In fact, if only joint pain and range of motion are taken into account, this patient received an excellent post-operative result (MDA score 12/12). The average final MDA score in the primary group was 16/18. At the time of final evaluation, 9/11 patients were able to perform necessary activities of daily living without assistance.

Nine proximal femoral prostheses in 9 patients were included in the revision group. These patients received their femoral replacements as salvage procedures for failed internal fixation of proximal femoral fractures. All patients in this group completed a satisfactory post-operative course and healed their proximal femoral replacements. The mean follow-up time (Table 2) in this group was 37.5 months (range 2 months

Table 2 – Patient co-morbidities

Co-morbid condition	Primary group	Revision group
Chronic bone/joint problem	7	7
Coronary artery disease	4	3
Dementia/psychiatric disorder	4	1
Hypertension	5	2
Polytrauma	2	1
Open fractures	2	0
Cancer	1	1
Pulmonary condition	2	5

Table 3 – Post-operative complications

Complication	Primary group	Revision group
Myocardial infarction	0	0
DVT	0	2
Pneumonia	1	0
Deep infection	0	1
Dislocation	2	1
Pressure sores	0	0
Peri-prosthetic fracture	1	1
Hardware failure	0	1
Prostheses requiring revision	0	2

to 14 years). Co-morbidities and post-operative complications for this group are summarized in Tables 1 and 2.

Among subjects in the revision group, there were five complications in three patients. One patient suffered hardware failure, with loss of integrity of the cable grip attaching the greater trochanter to the prosthesis. This occurred 7 months post-operatively and was asymptomatic due to adequate bony ingrowth of the greater trochanter onto the prosthesis. One patient suffered two dislocations and a peri-prosthetic fracture of the greater trochanter, ultimately requiring a revision. The patient was revised to a larger femoral head and her greater trochanter was reattached to the prosthesis with cables. This patient also developed a deep venous thrombosis (DVT) in the immediate post-operative period following the revision procedure. Despite revision surgery, this patient was ultimately found to have a bad post-operative result by MDA score (2/18) with chronic pain and inability to ambulate. Another patient also suffered a DVT immediately following insertion of the megaprosthesis. This patient was treated with a Greenfield filter and recovered without further incident.

There was one instance of deep infection involving the femoral component. This occurred 6 years after megaprosthesis insertion. The patient was found to have *E. coli* sepsis, as well as osteomyelitis, and was ultimately revised to a total femur after appropriate treatment with antibiotic spacer and long term intravenous antibiotics. After 8 years of additional follow-up, this patient remains pain free, with full joint range of motion and unlimited ambulatory status (excellent result by MDA score, 18/18).

Of the 9 patients in the revision group, 3 were found to have a good result or better according to the Merle D'Aubigne scale. Three patients were classified as having a fair result, 1 patient had a poor result and 2 patients were determined to have

a bad result (Table 4). Regular pain was an issue in 5 patients, with 3 complaining of pain with physical activity and 1 patient having hip pain with ambulation. One patient was unable to ambulate secondary to constant pain and hip instability. In only 4 subjects was there a complete absence of pain. One patient in the revision group was able to ambulate without the use of an assistive device, while two patients were completely non-ambulatory. In two instances the difficulty with ambulation can be attributed to medical co-morbidities (stroke and renal failure) and in one patient, the recipient of a bad functional outcome by MDA score (2/18), failure of her initial sliding hip screw construct, with bone loss and infection, would appear to be partially responsible.

Most patients in the revision group sustained catastrophic failure of their initial osteosynthetic constructs with hardware failure appreciated in every instance. Due to such substantial failure, 6/9 patients in the revision group presented with a pre-operative MDA score of 0. The average pre-operative MDA score was 3.77/18 and this was improved to an average final MDA score of 12.5/18.

4. Discussion

Complex proximal femoral fractures pose significant challenges to orthopaedic surgeons. Severely comminuted fractures and injuries with significant loss or devitalization of tissues may not be amenable to standard techniques of internal fixation and, even if osteosynthesis is achieved, the patient's overall result can be unsatisfactory. Intertrochanteric fractures treated with standard internal fixation devices demonstrate a failure rate of 3–12%¹⁰ and this number can be assumed to increase in the event of complex injuries. The complication rate in patients with complex femoral fractures has been estimated at 10–80%.^{2,3,7–9,19,20} In these instances, failure occurs as a result of fracture collapse, or hardware cut-out, and the resultant damage can be more severe than that incurred from the initial injury. Individuals who have multi-fragment fragility fractures, poor bone stock, and medical or cognitive conditions that inhibit compliance with weight-bearing status, can also be expected to have a worse functional outcome than younger, healthier patients who sustain an isolated femoral injury.¹²

The primary goal of surgical intervention for hip fractures is restoration of function and insertion of a durable, stable construct. In the vast majority of these cases, adequate primary fixation can be achieved with the use of locked plates, sliding hip screws or cephalomedullary constructs such as the gamma nail. In certain instances, however, complex proximal femoral fractures do not lend themselves to successful treatment with standard modes of fixation. If such options for internal fixation are recognized to be suboptimal prosthetic replacement may provide a reasonable alternative.

Although some researchers have reported on the use of primary prosthetic replacement for the treatment of complex femoral injuries, most investigations have focused on the use of hip arthroplasty or proximal femoral replacement as salvage for failed internal fixation.^{2–6,9–13,17,18,23–25} Stoffelen et al. reported on 12 patients who received a revision prosthesis for the failure of internal fixation in intertrochanteric

Table 4 – Comparison of final outcome based on Merle D'Aubigne score

Outcome (MDA score)	Primary group	Revision group (pre-op)	Revision group (post-op)
Excellent (18/18)	3	0	1
Very good (17/18)	2	0	1
Good (15–16/18)	3	0	1
Fair (13–14/18)	2	0	3
Poor (9–12/18)	1	0	1
Bad (<9/18)	0	9	2

Table 5 – Functional comparison and morbidity/mortality for study groups and reported studies

	Primary group (N = 11)	Revision group (N = 9)	Haentjens ³ (N = 37)	Chan ²¹ (N = 52)
Average follow-up	44 mos.	37.5 mos.	20 mos.	13.6 mos.
Average final MDA score	16	12.6	NA	NA
Use of ambulatory assistive device	4	6	NA	30
Non-ambulatory	1	2	NA	7
Hip dislocation	2	1	2	0
Additional hip surgery	1	2	NA	4
High dependency care (nursing home, 24 h caregiver)	2	5	NA	27
Serious morbidity	1	3	3	13
Mortality				
At 1 month	0	0	6	4
At 1 year	1	1	11	12
At time of study conclusion	2	3	33	12

fractures.²⁴ Nine of the 12 patients in this study received a modular proximal femoral replacement and 8 were classified as having a good outcome or better. Mehlhoff and co-workers found that patients who received total hip arthroplasty as salvage for failed internal fixation of intertrochanteric fractures enjoyed less satisfactory results than patients receiving primary total hip arthroplasty for osteoarthritis.¹⁰ Meanwhile, Chan and Gill reported satisfactory results with 54 consecutive intertrochanteric fractures treated with cemented hemiarthroplasty.²¹ Based on their findings, these researchers concluded that standard cemented hemiarthroplasty was a reasonable alternative to the sliding hip screw. Three European studies have also reported results of unstable intertrochanteric and subtrochanteric fractures treated with primary arthroplasty.^{3,19,20} These studies showed favorable results for the groups treated with primary arthroplasty, along with a decreased incidence of post-operative complications and increased ambulatory function.

None of these investigations, however, were able to evaluate results of both primary proximal femoral replacement and salvage arthroplasty for complex proximal femoral fractures. This study obtained results for two groups treated by the same orthopaedic surgeons and approximated each other in terms of average age, co-morbidities and intermediate range follow-up. The subjects in our primary replacement group achieved good functional results and had few complications while patients in the revision group had less optimal outcomes (Table 5) although, in no instance did the MDA score decrease post-operatively and patients, on average, appreciated a post-operative improvement of 8.7 points (Table 4). Better outcomes in the primary replacement group may be attributed to the preservation of additional bone stock, as well as the absence of presumed morbidity resulting from hardware failure.

Additionally, this study addressed a patient population similar in age to other investigations reporting outcomes of femoral replacement for complex fractures.^{3,19–21,24} The patients in the primary replacement group enjoyed similar functional results to those reported in previous studies and we did not appreciate a high, or unacceptable, complication or failure rate. While these results are comparable to prior investigations, our cohort size is too small to facilitate more comprehensive comparisons.

Advantages to the use of proximal femoral replacement include early restoration to immediate ambulation and full weight-bearing status, decreased risk of complications associated with prolonged immobilization as well as fracture failure, non-union or collapse. Disadvantages of the procedure include a theoretically larger, technically challenging surgery, an increased risk of infection and overall cost-effectiveness of the procedure. While the majority of hip fractures are amenable to standard modes of internal fixation, primary proximal replacement may be considered for complex, comminuted peritrochanteric fractures (OTA 31A2.2/.3) in elderly patients who are relatively healthy (ASA 2 or less). While cost remains a concern in these situations, there is little known regarding the economic repercussions of multiple surgeries and prolonged hospitalization.¹² Therefore, we propose that one successful surgery might result in an overall savings of healthcare expenditure by eliminating the possibility of further complications and subsequent interventions.

This study was a Level IV retrospective analysis based on cases treated with prosthetic replacement by two attending orthopaedic surgeons. As a result, the study suffers from methodological difficulties inherent to retrospective investigations. This study was also limited by a small sample size with diverse demographic characteristics. Despite these limitations, however, this investigation was able to document results with a validated outcome instrument.

Based on presented findings, it would appear that proximal femoral replacement may have a role in the treatment of certain complex proximal femoral fractures, especially in individuals with significant osteoporosis and comminuted fracture patterns. Primary modular proximal femoral replacement may be a practical option to prevent complications associated with hardware failure, allow early weight bearing and improve overall patient function while revision modular replacement can play a role in the treatment of patients who have failed initial internal fixation.

5. Conclusion

The treatment of complex femoral injuries is a difficult problem facing orthopaedic surgeons, especially in patients who

are osteoporotic or have multiple medical co-morbidities. Standard modes of internal fixation may not be suitable for these injuries, increasing complication rates and adversely affecting outcome. Modular proximal femoral replacement of the fractured proximal femur is a viable option, and has been shown to have a reasonable outcome as a primary or revision prosthesis, especially when the nature of injury is taken into account.

Conflicts of interest

None of the authors involved in this work have any financial or personal relationships with other people, or organizations, that could inappropriately influence (bias) this study.

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Ethical approval

This study received approval from the institutional Investigational Review Board (IRB).

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