Early Experience With the Proximal Femoral Locking Plate

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abstract

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The purpose of this study was to evaluate the failure rate of proximal femoral locking plates after an initial 2 years of use at a Level I trauma center. This retrospective chart review included 13 patients with intertrochanteric or peritrochanteric femoral fractures who underwent open reduction and internal fixation. Average patient age was 47 years (range, 23-80 years); average follow-up was 12.7 months (range, 2 weeks to 23 months). Three (23%) patients experienced catastrophic failure of the implant. The overall revision rate was 46% (6 of 13). One patient experienced avascular necrosis and required a planned total hip arthroplasty. In the appropriate setting, the proximal femoral locking plate can offer stable fixation for fractures involving the proximal femur; however, this series highlights the difficulties associated with treating these injuries, especially in patients with multiple injuries. Care must be taken to avoid varus malalignment and to address metabolic bone dysfunction.

Figure: Postoperative anteroposterior radiograph at 4 months showing the beginning of varus collapse.

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Subtrochanteric femur fractures present a treatment challenge because of the biomechanical demands of the proximal femur.[1,2] Anatomic reduction can be achieved by either open or closed methods, which often is dictated by fracture pattern and implant selection. Choice of implant can be influenced by fracture pattern, bone quality, and surgeon preference. Several different instrumentation systems have been developed to treat these complex fractures. Intramedullary devices, which have been available for years, are a means of fixation for subtrochanteric fractures; however, adequate reduction can be difficult. A fixed-angle construct using a blade plate offers stable fixation but is clinically demanding and requires more extensive soft tissue dissection, potentially disrupting vital blood supply.

More recently, the development of hybrid locking plates has increased implant options for fractures in osteoporotic bone and fractures with significant comminution. Two studies that compared a hybrid locking plate contoured to the proximal femur with a blade plate concluded the locked plate construct was mechanically stronger than the blade plate construct.[3,4] Mitchell et al[5] reported promising results with early clinical experience; however, the strength and stability of the proximal femoral locking plate has been called into question in clinical practice. Glassner and Tejwani[6,7] reported a 70% (7 of 10) failure rate in recent reports. Anecdotally, at the current authors' institution, a perceived high failure rate existed.

The purpose of this study was to evaluate the failure rate of 2 plates designed to treat subtrochanteric femur fractures after 2 years of use at a Level I trauma center.

Materials and Methods

This retrospective case series analyzed the failure rate of the Synthes 4.5-mm proximal femoral locking plate and the 4.5-mm proximal femoral hook plate (Synthes, West Chester, Pennsylvania). Institutional review board approval was obtained prior to data collection. Patients who underwent treatment between June 2006 and October 2009 were identified from the patient database using Current Procedural Terminology (CPT) codes 27507 (open treatment of femoral shaft fracture with plate/screws, with or without cerclage) and 27244 (treatment of intertrochanteric, peritrochanteric, or subtrochanteric femoral fracture; with plate/screw type implant, with or without cerclage). All patients treated with proximal femoral locking plates and proximal femoral hook plates were included in the study; patients treated with other types of implants were excluded.

A total of 134 patients were identified; of these, 13 patients met the inclusion criteria. During the study period, 12 proximal femoral locking plates and 1 proximal femoral hook plate were implanted. Average patient age was 47 years (range, 23-80 years); 7 patients were men and 6 were women. Eight different attending surgeons (J.C.F., D.F.H.) (range, 1-4 procedures per surgeon) performed the operations. The right side was involved in 7 patients and the left side in 6 patients. Patients underwent clinical follow-up for an average of 12.7 months (range, 2 weeks to 23 months). Patient demographics are summarized in **Table 1**, and fracture pattern frequency is summarized in **Table 2**. In brief, the proximal femur is designated as type 31, and the proximal femur is subdivided into trochanteric (A), neck (B), and head (C), which then are further classified based on fracture complexity. Shaft fractures are designated as type 32 and then subdivided based on complexity of the fracture pattern.

The surgical technique has been described by Hasenboehler et al.[8] Briefly, a lateral approach to the proximal femur was used in all cases, taking care to minimize soft tissue disruption. Anatomic alignment was attempted using clamps or K-wires. When needed, lag screws outside of the plate were used. In 1 patient, tension banding of the greater trochanter was used to offload the pull of the abductors. If significant comminution was present, bridge plating was performed.

Data collected included patient age, fracture pattern, laterality, associated injuries, staff surgeon, implant type, clinical follow-up, and revision procedures. The definition of failure was implant breakage causing fracture displacement; revision surgery was defined as any surgery after the initial fracture management procedure. Fractures were classified by consensus of the authors using the Orthopaedic Trauma Association (OTA) Fracture and Dislocation Compendium 2007.[9]

Results

Catastrophic failure occurred in 3 (23%) of 13 patients; these 3 patients subsequently underwent revision with a blade plate at 6, 9, and 34 weeks postoperatively, respectively. Varus collapse of the fracture occurred in 1 of the revisions at 4 weeks postoperatively, and this revision was converted to a total hip arthroplasty (THA). In addition to the 3 failures, 2 patients underwent hardware removal because of symptomatic hardware at 6 months and 18 months postoperatively. In both patients, hardware removal was uneventful. One patient underwent revision surgery 11 days after the initial surgery to revise a nonanatomic reduction noted intraoperatively. One patient experienced a proximal screw break with no clinical effect. One patient experienced varus collapse and avascular necrosis of the femoral head that required THA scheduled after the study period.

No staff surgeon experienced more than 1 failure or revision and no infections occurred. One patient died during the study period after his 7-month follow-up visit. At that time, he was still experiencing pain, and his fracture had begun to collapse into varus.

Patients who required revision are described in detail in the following section Patients are reported in chronological order, and, unless discussed specifically, the patients went on to heal.

Table 1

Patient Characteristics

Patient No./Sex/ Age, y	Surgeon No.	Side	Mechanism of Injury	OTA Fracture Pattern	Implant Type	Failure	Time to Revision
1/F/41	1	Left	Motor vehicle collision	31-A1.2(1)	Locking	No	11 d
2/F/24	2	Left	Motor vehicle collision	31-A3.3(1)	Locking	No	NA
3/M/29	3	Left	Motor vehicle collision	31-A3.3(1)	Locking	No	NA
4/F/23	4	Right	All-terrain vehicle	31-A2.3	Locking	No	18 mo
5/M/37	3	Left	Motor vehicle collision	32-B2.1, 31-B2.3	Locking	No	NA
6/M/74	3	Right	Motor vehicle collision	31-A3.3(1)	Locking	No	NA
7/M/42	4	Right	Fall from 8 feet	31-A3.3(1)	Locking	No	NA
8/F/69	5	Right	Fall from standing	31-A3.3(1)	Locking	Yes	8 mo
9/F/80	2	Left	Fall from standing	31-A2.1	Locking	No	NA
10/F/70	6	Right	Fall from standing	31-A3.3(1)	Locking	Yes	6 wk
11/M/56	3	Right	Pedestrian vs motor vehicle	31-A3.3(2)	Locking	No	6 mo
12/M/36	7	Left	Motor vehicle collision	31-A3.3(1)	Hook	Yes	2 mo
13/M/25	8	Right	Motor vehicle collision	32-C1(3)	Locking	No	NA

Abbreviations: NA, not applicable; OTA, Orthopaedic Trauma Association.

Table 2

OTA Fracture Pattern Frequency

OTA Classification	No.
31-A1.2(1)	1
31-A2.1	1
31-A2.3	1
31-A3.3(1)	7
31-A3.3(2)	1
31-B2.3	1
32-B2.1	1
32-C1(3)	1

Abbreviation: OTA, Orthopaedic Trauma Association.

Patient 1

A 41-year-old woman who was involved in a motor vehicle collision sustained multiple injuries consisting of facial fractures, rib fractures, unstable pelvic ring fractures including bilateral superior and inferior rami fractures, right iliac wing fracture with right sacroiliac disruption, and left proximal femur fracture. She underwent pelvic external fixation at which time the orthopedic team attempted to address the left proximal femur fracture with a 95° blade plate. However, reduction could not be maintained with the blade plate. Multiple attempts were made to hold the fracture reduced with K-wires, but the proximal fragment continued to displace into flexion. Using a bone clamp, the fracture was reduced, and a 6-hole proximal femoral locking plate was placed. Again, once the clamp was removed, the proximal fragment flexed. Due to this flexed fragment, the kickstand screw did not enter the bone. Because of the patient's general condition and the length of time she had been in the operating room, the team elected to accept the reduction as temporary fixation and planned to revise it when the patient underwent additional surgery. Eleven days later, the patient returned to the operating room for open reduction and internal fixation (ORIF) of her pelvic injuries. At this time, the proximal femur was revised using the same plate. She was discharged to rehabilitation out of state 14 days later and was lost to follow-up.

Patient 4

A 23-year-old woman who was involved in an all-terrain vehicle accident sustained multiple orthopedic injuries, including a right proximal femur fracture, a right distal tibia-fibula fracture with associated compartment syndrome, and a left talus fracture. She underwent fasciotomy of the right leg and temporizing external fixation of the tibia fracture at the time of the proximal femur ORIF. Three days later, the external fixation was removed, ORIF was performed for the tibia and talus fractures, and the fasciotomy wounds were closed.

Postoperatively, the patient was doing well, with weight bearing advanced as tolerated by 10 weeks and the fractures healed by 6 months. However, the ankle and proximal femoral locking plate implants were symptomatic, and at 18 months postoperatively, the hardware was removed uneventfully. The patient was released from follow-up 20 months following her initial surgeries.

Patient 6

A 74-year-old man sustained a right proximal femur fracture and several soft-tissue lacerations to his extremities that formal irrigation and debridement. In addition, he sustained a small subarachnoid hemorrhage and an L4 vertebral compression fracture, neither of which required surgery. Radiographs obtained at his 10-week follow-up visit showed minimal varus collapse (**Figure 1**). This collapse had increased slightly at his 12-week visit, but at 7 months, it appeared unchanged. The patient died prior to his next follow-up visit.

At his last visit, he had good range of motion of the hip, but he reported frequent groin pain with motion. He also required a shoe lift for a small leg-length discrepancy. The hardware remained intact.

Patient 8

A morbidly obese 69-year-old woman sustained a right proximal femur fracture after a fall from a standing position. In addition, she sustained ipsilateral proximal and supracondylar humerus fractures treated with ORIF during the same hospitalization. At her 5-month follow-up visit, she was doing well, but at 8 months postoperatively, she sustained an atraumatic failure of the implant just distal to the 135° (5 mm) locking hole. She was diagnosed with an atrophic nonunion and underwent revision to a blade plate; the humerus fractures were healed at this time. Ten months after her revision surgery (18 months after the initial surgery), the fracture had healed and she was essentially pain free. Unfortunately, she still struggled with immobility and deconditioning from her obesity and her injuries.

Patient 10

A 70-year-old woman sustained an isolated right proximal femur fracture after a fall from a standing position. At her 2-week postoperative visit, the 135° (5 mm) and the 120° (7.3 mm) locking screws were backing out. At her 6-week postoperative visit, she reported an increase in pain. Radiographs revealed that the proximal screw had broken at the interface with the plate. She underwent revision to a blade plate, which failed approximately 4 weeks later when the fracture collapsed into approximately 10° of varus. After revision to a THA, she still had a nonunion of her greater trochanter, which was addressed in an additional procedure.

Six months after the greater trochanter nonunion revision, she still had no radiographic sign of healing but was pain free. Her main complaint involved a substantial limp. Seven months after her final orthopedic procedure, the patient underwent a parathyroidectomy for primary hyperparathyroidism. She had follow-up with an endocrinologist for her longstanding metabolic bone disease.

Patient 11

A 56-year-old man who was struck by a car sustained an open left femoral shaft fracture, an open left segmental tibial shaft fracture, an open left bimalleolar ankle fracture, a right closed pilon fracture, and a right proximal femur fracture. He underwent emergent irrigation and debridement of the open fractures, temporizing external fixation of the left tibia and ankle, fasciotomy of the left leg, retrograde nailing of the left femoral shaft, initial skeletal traction for the right proximal femur fracture, and a vascular repair of his left femoral artery. Seven days later, he underwent ORIF of the right proximal femur fracture, ORIF of both of his ankles, and intramedullary nailing of the left tibia. An 18-gauge wire was looped around the greater trochanter in an effort to offset some of the tensile forces at the fracture site. Unfortunately, he required a below-knee amputation of the left leg 1 week later for ischemic changes in the lower leg. He had progressed to full weight bearing on the right leg at 10 weeks. Prosthesis fitting did not occur until 4 months postoperatively due to wound problems.

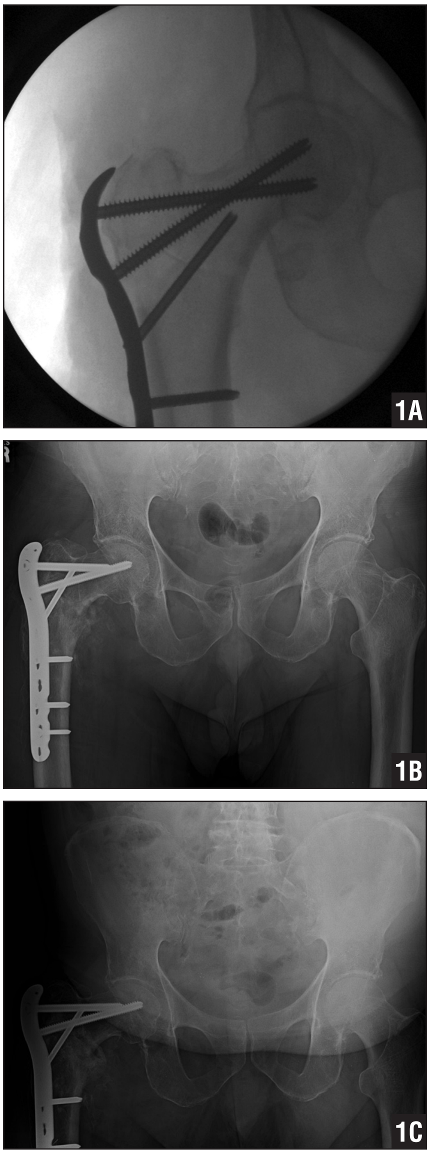

Figure 1: Patient 6. Intraoperative fluoroscopy (A) and postoperative anteroposterior radiographs at 10 weeks (B) and 7 months (C) demonstrating stable varus collapse.

At his 4-month follow-up visit, the patient reported increasing right lateral thigh pain. Radiographs (**Figure 2**) showed the fracture had collapsed slightly, but no evidence existed of a nonunion. He had good callus formation, but the 120° (7.3 mm) locking screw appeared to be violating the joint; however, this did not coincide with his clinical symptoms. At his 6-month fol-

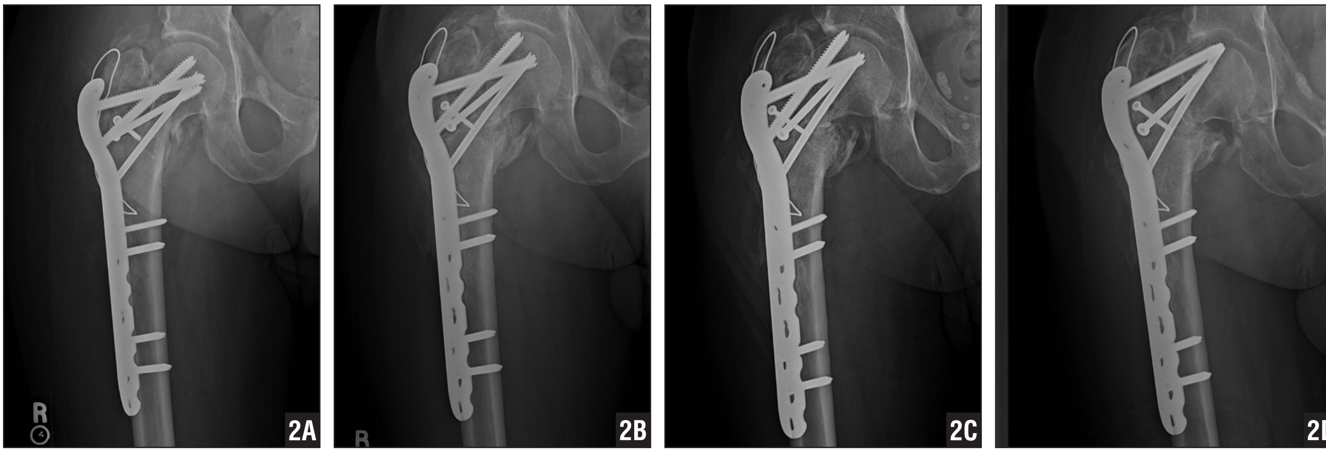

Figure 2: Patient 11. Postoperative anteroposterior radiographs at 2 months showing the plate construct (A), at 4 months showing the beginning of varus collapse (B), at 6 months showing continued collapse and screw penetration into the joint (C), and at 19 months showing continued collapse after screw removal (D).

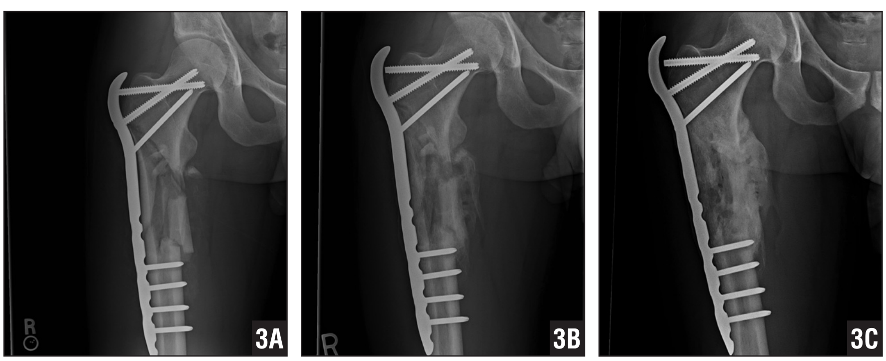

Figure 3: Patient 13. Postoperative anteroposterior radiograph at 2 weeks (A), 2 months (B), and 6 months (C) showing proximal screw breakage but a healed fracture at final follow-up.

low-up visit, his pain was still significant with motion, and the screw was removed. He continued to have issues with immobility from the hip pain and the contralateral below-knee amputation, but his pain stabilized. Subsequent radiographs showed posttraumatic osteoarthritis with evidence of avascular necrosis, and at 23 months he was released from follow-up with a plan to have a THA performed at another facility.

Patient 12

A 36-year-old man who was involved in a motor vehicle collision sustained an isolated left proximal femur fracture. He was doing well until he fell 8 weeks postoperatively and reinjured his hip. He presented as an outpatient for unscheduled follow-up 6 days after he fell, and he was diagnosed with an atrophic nonunion with breakage of the hook plate through the second of the combi-holes. He underwent revision to a blade plate. One year after blade plate revision, the nonunion had healed, and the patient reported only mild groin pain.

Patient 13

A 25-year-old man who was involved in a motor vehicle collision sustained facial fractures, a nondisplaced right clavicle fracture, a small nondisplaced right posterior wall acetabular fracture, and a right proximal femur fracture. The clavicle and acetabulum were treated nonoperatively. At his 2-month follow-up visit, he had been prematurely bearing full weight, but clinically he was doing well. Radiographs revealed the 95° (7.3 mm) screw had broken at the plate/screw interface (**Figure 3**). He continued to do well, and at 1 year postoperatively, he sustained another fall from a ladder while at work on light duty. Radiographs showed no interval changes in alignment, and the fracture had healed. He was released from follow-up.

Discussion

Managing subtrochanteric femur fractures presents a therapeutic challenge for the orthopedic surgeon. Intramedullary fixation can offer stable fixation with the advantage of preserving soft tissue attachments at the fracture site when adequate fracture reduction can be achieved. Unfortunately, subtrochanteric femur fractures often require open reduction secondary to the varus and flexion forces on the proximal fragment. The relatively new development of the hybrid locking plate contoured to the proximal femur may offer a new tool in managing these fractures. Several companies have developed different designs. These plates combine conventional limited contact compression plating with locking screw technology. The proximal femoral locking plate is precontoured to the proximal femur and offers 3 fixed angle screws at 95° (7.3 mm), 120° (7.3 mm), and 135° (5.0 mm, "kickstand"), whereas the proximal femoral hook plate has 3 fixed angle screws at 95° and 110° with the addition of

2 proximal hooks that engage the tip of the greater trochanter. This design and others like it offer the advantages of conventional compression plating while providing the strength and stability advantages of a fixed-angle construct.

In this case series, 3 failures of the proximal femoral locking plate/proximal femoral hook plate occurred; 2 failures occurred from plate fracture and the third failure occurred from loss of fixation. Unlike the patient population reported by Glassner and Tejwani,[6,7] this type of fracture fixation was used as the initial treatment for all 13 of the current patients. In the series reported by Glassner and Tejwani,[6,7] the average number of procedures prior to use of the proximal femoral locking plate was 1.7, which may have contributed to the higher failure rate in their series compared with the current series. Five of the 7 failures occurred within 21 days, with the 2 additional failures occurring at 1 and 6 months postoperatively. In the current series, the 3 failures occurred at 6 and 8 weeks and 8 months.

Although the failure rate of the proximal femoral locking plate and proximal femoral hook plate in this study was 23% (3 of 13), the overall revision rate was 46% (6 of 13) during the study period. Two failures were likely the result of poor biology. Patient 8 sustained a nonunion of the proximal femur despite healing the ipsilateral proximal and supracondylar/intracondylar humerus fractures. In patient 9, revision with a blade plate failed, requiring conversion to a THA. In addition, her greater trochanter also failed to heal, which suggests patient 9 may have had underlying biological issues with fracture healing. Incidentally, this patient was diagnosed with hyperparathyroidism and underwent parathyroidectomy 2 years after her initial fracture.

The third failure occurred 8 weeks postoperatively in a 36-year-old man. Of note, the patient did not follow the touch-down weight-bearing restrictions during his postoperative course. One could assume he mechanically stressed the plate to the point of failure by weight bearing on the affected leg before adequate stabilization from bony healing had occurred. In essence, he was unable to "win the race" between fracture healing and implant failure noted by Haidukewych et al.[10] In their study, which analyzed reverse obliquity intertrochanteric fractures, 3 of 15 blade plates failed by plate fracture due to nonunion, indicating that even with stable fixation with sturdy implants, plate breakage is a risk in the absence of bony healing. Maes et al[11] reported their experience with 2 patients treated with a cephalomedullary device (Gamma Nail; Stryker, Kalamazoo, Michigan) that experienced implant breakage due to nonunion of a proximal femur fracture. The reported complication rate of implant breakage with that particular device is 0.2% to 5.7%.[11]

Three additional patients in our series required an additional procedure during the study period: 1 patient underwent revision for nonanatomical reduction and 2 patients required hardware removal. One patient (patient 4) underwent hardware removal because she could feel the plate. In the second patient (patient 11), the hardware was removed because a screw penetrated the joint as the head collapsed due to avascular necrosis.

Three key concepts were elucidated in this experience: technique is critical, protection of weight bearing until bony healing is important, and varus collapse can lead to failure. One patient (patient 10) experienced loss of fixation of the conical screws within 2 weeks, leading to the proximal screw breaking within 6 weeks; this patient required revision to a THA. The technique guide recommends replacing the conical screws with locking screws for angular stability prior to the end of the procedure. Two other patients failed at 8 and 34 weeks, respectively, due to lack of bony healing prior to weight bearing. No particular site of plate breakage existed. One plate broke just distal to the 120° locking hole, and the second plate broke through one of the combi-holes.

Varus collapse was noted in 3 patients (patients 6, 10, and 11). Patient 6 experienced steady progression of the collapse from 6 weeks to 3 months, but he showed no radiographic signs of progression from 3 to 7 months. It is possible that he was going to heal in that position, but he died prior to his next follow-up appointment. Patient 11 began to collapse into varus within 4 months and required screw removal due to joint penetration at 6 months. He continued to collapse during the next 18 months, and at his final follow-up at 23 months, he had significant symptomatic avascular necrosis requiring a planned THA. Varus collapse with proximal femoral locked plating appears similar to the varus collapse seen with locked plating of the proximal humerus. Once the bone collapses due to avascular necrosis or loss of fixation, the fixed angle of the screws prevents the screw tips from migrating to a safer (ie, nonarticular) position, thus leading to articular damage. Giannoudis et al[12] described a series of 14 patients treated for subtrochanteric nonunion with implant breakage. In their series, varus malposition was noted as a common finding in patients who developed nonunion.

Conclusion

Definitive conclusions are limited by several features of this study. The series included only 13 patients, and only 10 were available for follow-up longer than 7 months. Postoperative protocols were not standardized. Weight bearing was instituted based on surgeon preference, and 8 different staff surgeons performed the 13 procedures. Because 6 of the 8 surgeons in this study performed 1 procedure each and only 2 of the 8 had completed a trauma fellowship, it is possible that a learning curve exists in the use of this implant. This and other series[7,10-12] on the treatment of fractures of the proximal femur highlight the complex nature and difficulties of successful management.

As evidenced by this series, patients often have multiple injuries with significantly comminuted fractures of the proximal femur. Implant selection should focus on preservation of the blood supply and stable fixation leading to prevention of varus collapse. Focus must be on anatomic alignment intraoperatively, and metabolic bone deficiencies, including but not limited to osteoporosis, must be diagnosed and treated to help decrease the risk of nonunion postoperatively. At the authors' institution, the use of these 2 implants is limited. In most cases, a cephalomedullary device is used. If significant comminution of the peritrochanteric region exists, then consideration may be given to the use of the proximal femoral locking plate or hook plate. For more high-level evidence and stronger clinical guidelines, future investigations should include larger prospective studies to better define the role of the proximal femoral locking plate and proximal femoral hook plate in relation to other extramedullary and intramedullary devices.

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