

Minimally Invasive Treatment of Intertrochanteric Hip Fractures with the Gotfried Percutaneous Compression Plate

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The Gotfried percutaneous compression plate procedure is a minimally invasive, viable therapeutic alternative in the treatment of intertrochanteric hip fractures.

The treatment goal of intertrochanteric fractures is to maintain the patient's quality of life. Recent studies have shown that intertrochanteric fractures can result in significant morbidity and mortality.¹ Deficits in activities of daily living due to hip fractures resulted in considerable morbidity, mortality, and costs.² The United States Center for Disease Control: National Center for Injury Prevention and Control reports "Of all fall-related fracture, hip fractures cause the greatest number of deaths and lead to the most severe health problems and reduced quality of life."³ Approximately 300,000 hospital admissions for hip fractures occur annually, with the projected number to exceed 500,000 by the year 2040.⁴

The primary complication of unstable intertrochanteric fractures is failure of fracture fixation with redisplacement or collapse. Rates of redisplacement or collapse with unstable intertrochanteric hip fractures are reported at 26%,⁵ with reported failure rates up to 23%.⁶

Redisplacement frequently results in lag screw cutout or sliding with distal fragment medialization, or varus malunion. Given the reported secondary fracture redisplacement rate of the compression hip screw at 34%, the Gamma nail at 18%, and the dynamic hip screw and trochanteric stabilizing plate at 9%,⁷ the Gotfried percutaneous compression plate procedure and device were designed to provide an improved therapeutic alternative in the treatment of unstable intertrochanteric fractures.

This retrospective study was conducted on our initial series of patients undergoing the Gotfried percutaneous compression plate procedure. Healthcare outcomes with regard to packed red blood cell transfusion requirements, postoperative complications, mortality factors,

postoperative mobility were determined, in particular the status of independent mobility were determined, level of pain, use of pain medications, and living status. This article reports our results with this new device and examines the functional outcomes of patients treated with the Gotfried percutaneous compression plate procedure.

Materials and Methods

A retrospective study was conducted on nonconsecutive patients with intertrochanteric hip fractures, who were treated with the Gotfried percutaneous compression plate system at our institution between January 4, 2000 and July 6, 2002. This study, starting with our initial patient, is a consecutive series of the Gotfried percutaneous compression plate implanted at our institution. We believe that our initial patient was the first Gotfried percutaneous compression plate implanted in the United States.

A total of 143 intertrochanteric hip fractures were treated during this time period at our hospital. The senior author (E. Y.) performed the first 5 and initial 15 of 17 Gotfried percutaneous compression plate procedures. More Gotfried percutaneous compression plate procedures were performed as the rest of the attending staff (6 surgeons) were trained and felt comfortable with the new procedure.

The attending of each patient made the choice of implant. In addition, the Gotfried percutaneous compression plate was not always available due to a nationwide change in distributors. The other implant used at our institution was the Dynamic Hip Screw (Synthes). There was no attempt to select out patients for the Gotfried percutaneous compression plate procedure.

Unstable intertrochanteric hip fractures were found to be more easily treated with the Gotfried percutaneous compression plate, and this became the preferred implant. Once an unstable intertrochanteric hip fracture is reduced on the fracture table with the posterior reduction device, the procedure is performed easily, as if the fracture was nondisplaced. Seventy-nine percent of patients in this study had unstable intertrochanteric hip fractures.

The Gotfried percutaneous compression plate system includes a plate with a chisel end for insertion through the vastus lateralis to the lateral femoral cortex and along the femoral shaft, 2 telescoping compression neck screws, and 3 shaft screws for distal fixation. The plate, attached to an introducer, is passed through a 2- to 2.5-cm incision, with a second, similar length distal incision, made to accommodate fixation screws.

The Gotfried percutaneous compression plate device is indicated for the surgical treatment of intertrochanteric and base of neck fractures, and enables controlled fracture impaction to be achieved actively during surgery, and passively with postoperative ambulation. The Gotfried percutaneous compression plate is not indicated for reverse obliquity and subtrochanteric hip fractures. Gotfried^{8,9} reported the treatment protocol and description of the device.

Total number of patients, y	56
Mean age, y (range)	78.1 (35-99)
Sex ratio, male:female (%)	29:71
Side of fracture, left:right (%)	55:45
ASA, No. (%)	
1	0 (0)
2	20 (36)
3	29 (52)
4	7 (12)

Abbreviation: ASA=American Society of Anesthesiologists.
^aThe American Society of Anesthesiologists' (ASA) physical status classification system was used in determining the ASA status of each patient.

The patient population demographics are described in Table 1. All patients received perioperative antibiotics and anti-thromboembolic prophylaxis. Medical history, radiographs, laboratory studies, including hematocrit nadir, hematocrit on discharge and transfusion rates were reviewed. Anesthesia clearance was obtained for each patient prior to the Gotfried percutaneous compression plate procedure. Blood loss, incision length, surgical time, intraoperative as well as postoperative complications, immediate weight-bearing status and independent mobility status on follow-up were recorded.

All patients included in the study were out of bed on postoperative day 1 or 2, and physical therapy was initiated within 4 days of the procedure. The start date of physical therapy was dependant on individual factors, such as whether the patient's medical condition was stable, and availability of the physical therapy staff during weekends or holidays.

An institutional review board approved a questionnaire used in 46 of 56 patients. Ten patients either died or were lost to follow-up at the time of their interview. A simplified telephone friendly questionnaire was created to achieve maximal compliance.

The outcome analysis was simplified with less possible outcomes to achieve results with statistical significance. Attempts were made to contact all patients for a telephone interview and to encourage their return to the hospital for a follow-up physical examination.

Statistical analysis was performed by an independent observer. For data on a nominal scale, either Chi square test or Mantel-Haenszel Chi square tests were performed. Statistical significance was considered when $P < .05$.

Results

A total of 56 nonconsecutive patients with intertrochanteric hip fracture were studied in this retrospective study. Of the 56 patients studied, 46 were interviewed using the IRB approved questionnaire: 8 patients had died at the time of interviews, and 2 patients were lost to follow-up. Radiologic follow-up examinations were obtained on 46 patients.

Preoperative Results

Patients were admitted from various places: 40 (71%) were admitted from their homes; 15 (27%) from the street; and 1 (2%) from an institution. Pre-fracture morbidity, injury mechanisms, and associated injuries are outlined in Tables 2 and 3, respectively.

Functional Status	No. of Patients (%)
Community	
1 ^d	19 (34)
2 ^e	17 (30)
Household	
3 ^f	5 (9)
4 ^g	15 (27)

^a $n = 56$.
^b $(1 + 2 + 3 = \text{Total independent mobile patients: } 41 (73\%))$.
^cFunctional status defined by Hoffer et al.²⁴
^dNo assistance.
^eWith assistance.
^fNo assistance.
^gWith assistance.

Table 3	
Injury Mechanism and Associated Injuries	
	No. of Patients (%)
Location of Accident	
Fall at home	62 (63)
Fall in street	10 (18)
Fall down stairs	5 (9)
Pedestrian struck	4 (7)
Motor vehicle accident	1 (2)
Assault	1 (2)
Associated Injuries	
None	51 (91)
Distal radius fracture	3 (5)
Midshaft femur fracture	1 (2)
Proximal tibia with bilateral pubic rami fracture	1 (2)

Of the 56 patients studied, 23 (41%) lived independently, 27 (48%) received partial nursing care, which was defined as assistance provided <24 hours, and 6 (11%) received 24-hour assisted care.

Fracture stability classification was performed according to the method described by Evans¹⁰ and modified by Jensen.¹¹ The ratio of fractures considered stable (Evans I, II) versus unstable (Evans III, IV, V) was 12/44 (21%/79%). The studied patient population ranged from Evans II to Evans V classifications as follows: 12 (21%) Evans II; 8 (14%) Evans III; 7 (13%) Evans IV; and 29 (52%) Evans V. The total time between fracture and operative procedure ranged between 0 and 8 days, with 2 (4%) patients undergoing surgery the same day, 8 (14%) day 1, 17 (30%) day 2, 8 (14%) day 3, 8 (14%) day 4, 7 (13%) day 5, 2 (4%) day 6, 1 (2%) day 7, and 3 (5%) day 8.

Perioperative Results

The dual incision lengths were between 2 and 3 cm in 93% of patients. Hematocrit values on initial presentation, nadir, and discharge were as follows: initial values ranged from 23% to 49.1%; nadir ranged from 19% to 45.9%; and discharge values ranged from 26.9% to 45.9%. No intraoperative complications were reported, and all procedures were performed uneventfully and percutaneously through 2 separate incisions. Surgical time averaged 60 minutes (range: 29–122 minutes).

Postoperative Results

Postoperative weight-bearing status was nonweight bearing in 2 (4%) patients, toe touch weight bearing in 1 (2%), and weight bearing as

tolerated in 53 (94%). These 3 patients were not weightbearing as tolerated due to other injuries that precluded them from full weight bearing.

Screw placement was determined to be good, fair, or poor based on radiographic findings on anteroposterior (AP) and lateral radiographs. A good position was defined as screw positioning within the middle third of the femoral neck on lateral radiographs, and within 1 cm of the inferior medial aspect of the femoral neck on the AP view. A fair position was defined as only one of the criteria being met, and a poor position was defined as neither of the criteria being met. It is important to note these criteria were established to determine screw placement because measurements, such as the tip-apex distance, are not applicable with the presence of two neck screws.

Blood transfusions were performed in 16 (28%) patients. The remaining patients received no transfusions. Only 12 (21%) patients received a postoperative transfusion. Transfusions requirements are outlined in Table 4.

Time of Transfusion	No. of Patients (%)
Preoperative	4 (7)
Postoperative	
Day 1	7 (12)
Day 2	2 (4)
Day 3	1 (2)
Day 5	1 (2)
Day 9	1 (2)
No transfusion given	40 (72)

^a(n=56).
^b0.57 packed red blood cells per patient.
^cTransfusion was not significantly correlated with mortality (P=.63).

On transfer from the orthopedic service, 38 (68%) patients participated in short term rehabilitation, 11 (20%) transferred home, 4 (7%) attended long term rehabilitation, and 2 (3%) transferred to the medical service. One (2%) patient died on the orthopedic service. Patient ambulatory statuses on discharge from the orthopedic service ranged from independent to nonambulatory: 18 (33%) were independent, 35 (63%) ambulated with assistance, and 2 (4%) were nonambulatory. Fracture classification was not statistically correlated with ambulatory status on discharge from the orthopedic unit (P=.57).

A total of 15 patients died during this study period. Postoperative complications and mortality factors are outlined in Tables 5 and 6, respectively. Mortality statistics with the Gotfried percutaneous compression plate procedure included: 0% mortality in the operating or recovery rooms, 1 (2%) patient on the orthopedic service, and 2 (4%) patients in other departments within the hospital. The remainder of the mortality occurred outside the hospital in 12 (23%) patients for a total of 15 (27%) patients. It is important to note that factors statistically significant to mortality were the patients ASA status ($P=.0031$) and an age >85 years ($P=.0018$).

Table 5

Postoperative Complications ^a	
Complication	No. of Patients (%)
None	47 (82)
Aspiration pneumonia	1 (2)
Cardiac failure	1 (2)
Deep venous thrombosis	1 (2)
Hyponatremia/Atrial tachycardia	1 (2)
Pneumonia	1 (2)
Peroneal nerve palsy	1 (2)
Spinal cord compression	1 (2)
Urinary retention	1 (2)
Urosepsis	1 (2)
Infection	0 (0)
Cut outs	0 (0)
Collapse	0 (0)

^a $n=56$.

Table 6

Mortality ^{abc}		
Location/Timing	No. of Patients	Ratio (%)
In operating room (%)	0 (0)	
In recovery room (%)	0 (0)	
On orthopedic service	1	1/56 (2)
On other service in hospital	2	2/56 (4)
Within 6 months	5	5/56 (9)
Within 1 year	2	2/56 (4)
Since operation, exact timing unknown	5	5/56 (9)
Total	15	15/56 (27)

^a $n=56$.
^bConsistent with other studies, age >85 years was statistically correlated with mortality ($P=.0018$), as was anesthesia risk ($P=.0031$).
^cDiabetes, dementia, history of malignancy, and fracture classification were not statistically related to mortality ($P=.19$, $P=.11$, $P=.28$, $P=.84$).

Interview Results

The mean time from surgery to telephone interview was 21.4 months (range, 6–37 months). The junior author (S.D.) conducted all the telephone interviews. The interview included criteria with regard to hip pain, frequency of pain medications, mobility, and living status. Interview results with regard to patient mobility are detailed in Table 7. Percentages were calculated based on the 46 interviews completed. Eight patients died and left no one to interview and 2 were lost to follow-up. Seven interviews were conducted with family members and the remainder were conducted with the patient.

Mobility Status	No. (%)	
	Preoperative	Postoperative
Community 1	19 (41)	10 (22)
Community 2	16 (35)	21 (46)
Household 3	3 (6)	5 (11)
Household 4	8 (17)	7 (15)
Transfer only	0 (0)	3 (6)
Independent mobility (1+2+3)	38 (82)	36 (79)
Remained at same level		26 (57)
Dropped 1 level		11 (24)
Dropped >1 level		6 (13)
Improved		3 (6)

^an=46.
^bAge >85 years was not statistically correlated with postoperative mobility (P=.11).

The patients' preoperative mobility statuses were significantly correlated with the postoperative mobility statuses ($P=.003$), consistent with previous studies.¹¹ In addition, the patients' preoperative living statuses were significantly correlated with the postoperative living statuses ($P=.0001$). We considered community 1, community 2, and household 3 to be independent ambulators, ie, ambulate without another person's assistance. Only 3 (6%) patients lost their ability to ambulate independently.

All patients were asked to rate their hip pain subjectively using one of the following four categories: no pain, mild pain, moderate pain, and severe pain. Interview results revealed 35 (76%) patients had no pain, 8 (17%) had mild pain, 3 (7%) had moderate pain, and 0 (0%) had severe pain.

The usage of pain medications was categorized as no pain medications, intermittent nonsteroidal anti-inflammatory drugs (NSAIDs), chronic NSAIDs, and intermittent narcotics. Interview results revealed 34 (74%) patients took no pain medications; 7 (15%) were treated with intermittent NSAIDs; 3 (7%) were treated with chronic NSAIDs; and 2 (4%) were treated with intermittent narcotics.

Patient living status was evaluated during the interview and results are demonstrated in Table 8. Sixteen of the 23 patients living independently remained independent.

Living Status	No. (%)	
	Preoperative	Postoperative
Independent	23 (50)	16 (35)
Partial care (<24 hrs)	20 (44)	22 (48)
Full 24 hour care	3 (6)	8 (17)
Remained at same level		28 (61)
Dropped 1 level		12 (26)
Dropped >1 level		2 (4)
Improved		4 (9)

^an=46.
^bDementia statistically correlated with postoperative living status (P=0.004).
^cPatients aged ≥85 years demonstrated a trend toward requiring full 24 hour assistance (P=.059).

Follow-up Radiographic Results

Of 56 patients studied, radiographic follow-up was conducted on 46 patients.

The mean time for radiographic follow-up evaluation was 14.0 months. In 25 patients with a minimum of 12 months between the Gotfried percutaneous compression plate procedure and radiographic follow-up, 23 patients had healed, 0 patients experienced nonunion, 1 patient healed in 10° varus, and 1 patient was determined to have avascular necrosis.

Fracture impaction was categorized as mild, moderate, or severe according to Bendo et al based on femoral head position relative to the proximal tip of the greater trochanter in treated intertrochanteric hip fractures. Controlled fracture impaction, in contradistinction to fracture collapse, was defined according to Gotfried's definitions.^{9,12} Fracture impaction rates seen in the patients on radiologic follow-up were as follows: 18 (39%) had no fracture impaction, 18 (39%) mild, 6 (13%) moderate, and 4 (9%) severe. Neither fracture collapse nor fracturing of the lateral wall

was observed. The fracture classification showed a trend in the amount of impaction ($P=.059$), and impaction statistically correlated with postoperative pain ($P=.02$); however, the degree of fracture impaction was not statistically correlated with postoperative mobility or living status ($P=.52$).

Case 1

An 85-year-old woman reported right hip pain after falling at home. Her medical history was significant for noninsulin dependent diabetes mellitus, hypertension, and hyperlipidemia. Prior to the injury, she was a community ambulator with the assistance of a cane. She presented with a left Evans type V intertrochanteric hip fracture (Figures 1-3).



Figure 1: Case 1. An 85-year-old female community ambulator with a cane presented with a left Evans type V intertrochanteric hip fracture after slipping and falling at home. **Figure 2:** Case 1. Postoperative radiograph with Gotfried percutaneous compression plate 1 day after admission. **Figure 3:** Case 1. Pelvic radiograph 2.5 years post-injury. The patient is ambulating in the community with a cane.

Case 2

A 70-year-old woman with a past medical history of hypertension reported pain and inability to ambulate after sustaining a fall. She presented with a right Evans type V intertrochanteric hip fracture (Figures 4-6).

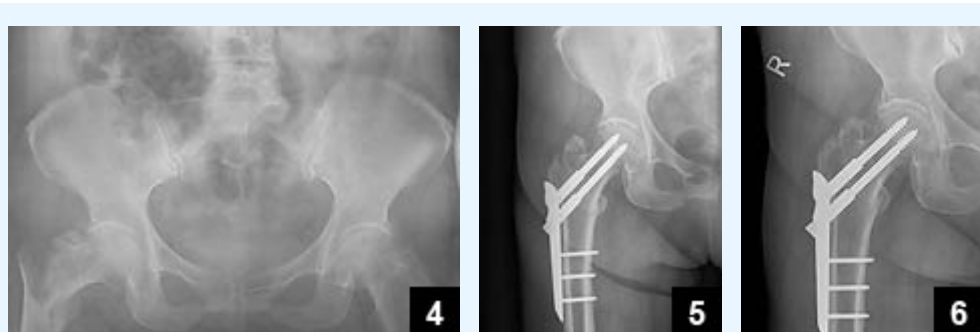


Figure 4: Case 2. A 70-year-old female community ambulator without assistance sustained a

right Evans type V intertrochanteric hip fracture after falling at home. **Figure 5:** Case 2. Two-week postoperative radiograph. The patient was ambulating with a walker and was weight bearing as tolerated. She was discharged to home after surgery. **Figure 6:** Case 2. One-year postoperative radiograph. The patient is ambulating in the community independently without assistance. She is not taking any pain medication.

Discussion

The findings of this retrospective study demonstrate the Gotfried percutaneous compression plate and procedure are effective in the treatment of intertrochanteric hip fractures with the resultant satisfactory healthcare outcomes.

Packed red blood cell transfusion requirements were low for these Gotfried percutaneous compression plate patients, which correlated with the findings of Brandt et al.¹³ They reported a “significant reduction in the incidence of blood transfusion and hematoma found with Gotfried percutaneous compression plate in comparable groups of stable and unstable pertrochanteric hip fractures.”¹³ Kosygan et al¹⁴ reported similar findings in a study of 111 patients comparing the Gotfried percutaneous compression plate with the classic hip screw.

A benefit of the Gotfried percutaneous compression plate is the ability for the patient to attain full weightbearing status immediately postoperatively. This benefit is important in improving the quality of life in elderly patients, in whom early restoration of function is the most important consideration. Prolonged immobilization in this group is associated with extensive morbidity.⁷ All of our patients were able to ambulate full weight bearing as tolerated unless other injuries precluded this.

Eighty-two percent of patients receiving the Gotfried percutaneous compression plate reported no postoperative complications, which correlate with the findings of Brandt et al,⁸ who reported a decreased number of postoperative complications in the Gotfried percutaneous compression plate, as compared with the dynamic hip screw implants. The failure rate of hip screws have ranged from 4% to 25%.^{7,15-18} The failure rate of intramedullary hip screws has been reported to be from 5% to 8%.^{7,15,17,19}

Due to the propensity for implant cut-out with single axis fixation devices such as the dynamic hip screw, compression hip screw, and the Gamma Nail,⁷ the Gotfried percutaneous compression plate system comprises double axis telescoping neck screw fixation,⁹ providing rotational stability.²⁰ In addition, the Gotfried percutaneous compression plate was

designed with a plate having only a 135° shaft-neck angle for optimization of impaction. Hence, controlled fracture impaction is attained via postoperative ambulation on a passive basis. The importance of controlled fracture impaction lies within the necessity for maintaining both an intact lateral wall and reduction stability, yet allowing cyclic loading and remodeling across the fracture line.⁹

The mortality rate with the Gotfried percutaneous compression plate procedure was 3 patients before hospital discharge and 12 patients at 12-month follow-up. This compares with the mortality rate reported for the dynamic hip screw and Gamma Nail with 16% to 35% of patients dead at 1 year.^{7,15,17,19,21}

Postoperative mobility remained at the same level as preoperative mobility in 57% of patients, with 24% of patients dropping 1 level in postoperative mobility, 13% of patients dropping >1 level in postoperative mobility, and 6% of patients with improved postoperative mobility as compared to their preoperative status. Only 2 (4%) patients lost their ability to ambulate independently. Independent ambulators include all ambulatory patients except those confined to the house with ambulatory aids. A high percentage of independent mobility on follow-up was demonstrated. This compares favorably to the literature that reports independent ambulation with a compression hip screw ranging from 50% to 73% and intramedullary hip screws from 66% to 83%.^{5,7,15,17,19,22} O'Brien et al¹⁹ reported that 70% of patients treated with either a Gamma Nail or dynamic hip screw dropped one level in walking aid dependence.

In patients interviewed with the approved questionnaire, 76% reported no pain, 17% mild pain, and 7% moderate pain. These pain level results correlated directly with the amount of pain medications ingested by the studied patient population. The interview revealed 74% of patients took no pain medications; 15% were treated with intermittent NSAIDs; 7% were treated with chronic NSAIDs; and 4% were treated with intermittent narcotics.

A prospective, randomized study by Janzing et al²³ comparing the Gotfried percutaneous compression plate with the dynamic hip screw revealed the Gotfried percutaneous compression plate statistically reduced patient operative time and postoperative pain. Operating time in our study ranged from 29 to 122 minutes. The mean time was 59 minutes. The first case took 122 minutes and the patient had hard bone.

Living status remained at the same level in 61% of patients, dropped 1 level in 26% of patients, dropped >1 level in 4%, and improved in 9% as compared to preoperative living status. This compares favorably to the

study of O' Brien et al¹⁹ where one-third of patients treated with the dynamic hip screw or Gamma Nail lost their independent level of care.

Radiographic follow-up evaluation at 1 year demonstrated 23 patients healed, 0 reported nonunion, 1 healed in 10° varus, and 1 was determined to have avascular necrosis. Radiographs at healing were analyzed and 39% demonstrated no fracture impaction, 39% revealed mild impaction, 13% moderate impaction, and 9% severe impaction. Of note, the amount of impaction statistically correlated with postoperative pain; however, it did not correlate with postoperative mobility or living status. We believe the maintenance of an intact lateral wall improves the patient's function and ability to ambulate.

The authors feel that the Gotfried percutaneous compression plate allows controlled fracture impaction. In the present study, the degree of fracture impaction did not correlate with postoperative deterioration in mobility and living status. These findings contradict the findings of Bendo et al,²⁴ which found in patients treated with a sliding hip screw with moderate and severe collapse, to have 93% poor functional result. The difference is explained by the definitions in which fracture controlled impaction presents a positive event, where collapse was observed to be negative.²⁴

We believe that the dynamic hip screw, when used to treat unstable intertrochanteric hip fractures, can lead to fracture of the lateral cortex and loss of the abductor mechanism. This leads to head fragment rotational instability, loss of reduction, pain, and fracture collapse. Eventual healing with moderate to severe collapse usually occurs. However, patients endure a prolonged period of disability and poor functional outcomes. The complication of the lateral trochanteric wall fracture has been shown to be present in all patients with severe collapse following internal fixation with a sliding hip screw.^{12,25} Most recently, it has been shown that the single most important predictor of reoperation after sliding hip screw fixation of an intertrochanteric hip fracture is the integrity of the lateral wall.²⁶

Patient quality of life is impeded when complications occur following intertrochanteric fracture fixation. Fracture of the lateral wall, thus converting the fracture to a subtrochanteric type, must be avoided to prevent increased patient discomfort and prolonged disability. One retrospective study performed on 118 patients receiving Gotfried percutaneous compression plate demonstrated no lateral wall damage and no fracture collapse.⁹ The present study supports these findings as no fracturing of the lateral wall and no fracture collapse was found in our patients. These findings were attributed to the small diameter,

orientation of the holes, and the 2-step (7.0–9.3 mm) drilling technique for the two neck screws of the device. Appropriate device positioning and screw placement confirmation via fluoroscopy is essential for successful Gotfried percutaneous compression plate placement. The device can be implanted percutaneously with a short learning curve, exemplified by 56 consecutive percutaneous cases.

Conclusion

This retrospective study analyzes the healthcare outcomes of a series of patients treated with a new device in the United States, the Gotfried percutaneous compression plate. We believe that our healthcare outcomes using this procedure and device for the surgical treatment of intertrochanteric fractures are equivalent or better than those reported in the literature. Satisfactory or improved healthcare outcomes are demonstrated on several parameters: 1) 96% of patients maintaining pre-fracture independent mobility; 2) risk of infection is likely lower due to use of a minimally invasive operative technique - 0% infection rate in this series; 3) low level of postoperative complications associated with Gotfried percutaneous compression plate; 4) full weight-bearing status implemented immediately following the procedure, except in patients with other injuries; 5) low levels of pain and pain medication ingestion; 6) low percentage of patients receiving blood transfusion; and 7) living status statistics demonstrate maintenance of pre-injury living status in the majority of patients.

The Gotfried percutaneous compression plate procedure is a minimally invasive, viable therapeutic alternative in the treatment of intertrochanteric hip fractures.

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