JMSCR Vol||08||Issue||06||Page 585-594||June 2020

http://jmscr.igmpublication.org/home/
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v8i6.113

IGM Publication
Journal Of Medical Science And Clinical Research
An Official Publication Of IGM Publication

Treatment of Unstable Trochantric Fractures Using Proximal Femoral Locked Plate

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Abstract
Background: *Proximal fractures of the femur remain one of the most challenging orthopedic problems. Every effort should be made to allow elderly patients to resume their pre-injury functional activity, thus reducing the postoperative complications caused by immobilization.*
Aim: *The aim of this work was to evaluate the results of using the proximal femoral locked plate in the management of unstable intertrochantric fractures.*
Patients and Methods: *This study included 20 patients who were admitted to El-Hadra University Hospital, Faculty of Medicine, Alexandria University, suffering from unstable trochanteric fractures between September 2014 and February 2016. Every patient was followed up for at least 6 months. The follow up period ranged between 6 to 21 months with a mean of 7.5 months.*
The ethical committee in the Faculty of Medicine in Alexandria University accepted the performance of the study. An informed consent was taken from all patients subjected to this academic work.
A full workup including history, clinical examination, radiological examination and routine laboratory investigations was done for every patient.
Results: *This study included 20 patients who were admitted to El-Hadra University Hospital, Faculty of Medicine, Alexandria University, suffering from unstable trochanteric fractures between September 2014 and February 2016. Every patient was followed up for at least 6 months. The follow up period ranged between 6 to 21 months with a mean of (7.5 ± 3.57) month. Two cases out of the 20 studied patients were enrolled from the final assessment because one had metal failure and was revised with a DHS 2 weeks after the index procedure and the second was infected and ended up with a Girdlestone procedure after 3 months. Therefore, the final results included only 18 patients. The duration of surgery in this study ranged between 55.0 – 180.0 minutes with a mean of 104.5 ± 35.4 minutes.*
Conclusion: *PFLCP is a fair implant choice in the treatment of unstable trochanteric fracture pattern.*

Introduction

Proximal fractures of the femur remain one of the most challenging orthopedic problems. Every effort should be made to allow elderly patients to resume their pre-injury functional activity, thus reducing the postoperative complications caused by immobilization.[1, 2]

Pertrochanteric fractures account for nearly 50% of all fractures of the proximal femur[3] of which 50% to 60% are classified as unstable[4, 5] Unstable fracture patterns occur more commonly with increased age and low bone mineral density.[6] The functional outcome of patients who have suffered a poorly managed intertrochanteric fracture is poor and many are limited to ambulation within their homes and dependent on caregivers for activities of daily living[7] The care of patients with pertrochanteric fractures has advanced dramatically since the advent of internal fixation. However, the differences in failure rates between stable and unstable intertrochanteric hip fracture patterns have been emphasized[8, 9]

Evans based his classification system on the stability of the fracture pattern and the potential to convert an unstable fracture pattern to a stable reduction.[10] Evans observed that the key to a stable reduction is restoration of the posteromedial cortical continuity. In stable fracture patterns, the posteromedial cortex remains intact or has minimal comminution, making it possible to obtain a stable reduction. Unstable fracture patterns, on the other hand, are characterized by greater comminution of the posteromedial cortex.[10]

Restoring mobility in patients with unstable intertrochanteric fractures ultimately depends on the strength of the surgical construct.[11] Kaufer described five variables that affect the biomechanical strength of repair[12] Surgeon-independent variables are bone quality, which is related to age and osteoporosis, and fracture pattern or fracture stability, which must be understood and will affect the variables that are surgeon dependent. Surgeon-dependent variables are implant choice, quality of fracture reduction, and positioning of the implant[13, 14]

Several versions of sliding hip screw and plate devices were introduced in the 1950's by Massie et al.[15] Since then the sliding hip screw has become the standard fixation device for extracapsular hip fractures[16] However failure of fixation is reported in up to 10% of patients. [12, 17] Simpson et al discussed the modes of failure of dynamic hip screw devices and listed the following mechanisms; screw cut-out, plate pull-off from the shaft, implant disassembly, and fatigue failure in cases of delayed union[12] shortening, medialization of the distal fragment, uncontrolled lateralization of the proximal fragment, and varus collapse.[18]

These considerations led to the development of the proximal femoral locked plate. The locking compression plate was introduced as a new implant that allows angular-stable plating for the treatment of complex comminuted and osteoporotic fractures. The locking plate system behaves like an external fixator but without the disadvantages of an external system not only in the transfixion of the soft tissues, but also in terms of its mechanics and the risk of sepsis. It is actually more an "internal fixator".[19] The fixed-angle locking plate/screw construct increases the stiffness and stability of the fracture/implant construct, but is technically difficult and requires more accurate plate application to the fracture fragments to provide adequate screw purchase and anchoring.

Furthermore, the locking screws are more resistant to shearing and pullout forces.[20] The application of the proximal femoral locked plate using minimal invasive plate osteosynthes MIPO technique has shown high rate of fracture healing with the advantage of biological fixation, simple and reliable fixation methods, strong anti-rotation, less surgical trauma, without stripping the periosteum and limited occurrence of complication in treatment of inter-trochantric femoral fractures[21] So it can be a feasible alternative to the treatment of intertrochantric femoral fractures[21, 22]

Patients and Methods

This study included 20 patients who were admitted to Alexandria University Hospital, suffering from unstable trochanteric fractures between September 2014 and February 2016. Every patient was followed up for at least 6 months. The follow up period ranged between 6 to 21 months with a mean of 7.5 months.

The ethical committee in the Faculty of Medicine in Alexandria University accepted the performance of the study. An informed consent was taken from all patients subjected to this academic work.

A full workup including history, clinical examination, radiological examination and routine laboratory investigations was done for every patient.

The inclusion criteria

In this study, patients with unstable intertrochanteric fractures of the femur types Ic, Id and type II were included according to Evans' classification

Type I: Fracture line extends upwards and outwards from the lesser trochanter. Type I fractures are further subdivided into:

- **Type Ic:** Three-fragment fracture without posterolateral support, owing to displacement of greater trochanter fragment or without medial support, owing to displaced lesser trochanter.
- **Type Id:** Four-fragment fracture without posterior-lateral and medial support (comminuted).

Type II: Fracture line extends downwards and outwards from the lesser trochanter (reversed obliquity). These fractures are unstable and have a tendency to drift medially.

The exclusion criteria:

- **Type Ia:** Un-displaced two-fragment fracture
- **Type Ib:** Displaced two-fragment fracture and reducible.

A) Age:

The distribution of the studied patients regarding their age group is shown in . The age of the patients ranged from 60-93 years with a mean age of 66.70 ± 8.32.

B) Sex:

This study included 14 (70%) males and six (30%) females

Twenty patients with unstable intertrochanteric fracture were managed surgically using the proximal femoral locking compression plate (PFLCP) as the method of fixation after closed reduction in 19 cases and open reduction in 1 case.

A. Pre-operative management:

- First aid management: Skin traction was done as a first aid to splint the fracture during transport and until the definitive management was planned.
- Care of the general condition was carried out in the ward as correction of dehydration and blood loss by transfusion of appropriate infusions or blood transfusion if needed.
- Pre-operative antibiotic prophylaxis: Broad-spectrum antibiotics in the form of intravenous cephalosporins 1 hour pre-operatively for 48 hours post-operatively.

B. Anesthesia:

- Spinal anesthesia was used in 18 patients while combined spinal anesthesia and general anesthesia was utilized in two patients.
- Once anesthesia was administered, the patient was transferred to the fracture table. The patient positioned supine with a well-padded perineal post was put between the patient's lower limbs and both feet were put in padded foot holders.

C. Operative techniques

Minimally Invasive Plate Osteosynthesis (MIPO)

Fracture reduction:

Trochanteric femur fractures are associated with a characteristic deformity, which may vary depending on the fracture pattern and are predicted by the muscle attachments on each fragment. The trochanteric segment is most often abducted, externally rotated, and may be translated proximally, whereas the fragment attached to the lesser trochanter is usually medially displaced. The proximal head and neck segment are often quite flexed. The distal femoral shaft may be medially displaced from the combined effect of the weight of the leg (in the lateral position) and the pull of the adductors. Supine patient positioning can create marked posterior sag at the fracture site that must be corrected.(10)

Gross skeletal alignment was obtained using applied traction, adduction the internal rotation in 19 patients and reduction forceps was used in the one openly reduced patient. Avoiding varus was important for a successful stable proximal fragment fixation and good alignment.(11)

Landmarks and Incision

Landmarks

The posterior edge of the greater trochanter was palpated by moving the fingers anteriorly and proximally to identify its tip. The shaft of the femur was palpable as a line of resistance on the lateral side of the thigh. [12]

Incision

Two separate incisions were made at and below the fracture site. In one case open reduction was required so, a longitudinal incision was made, beginning over the middle of the greater trochanter and extending down the lateral side of the thigh over the lateral aspect of the femur.

Inter-nervous Plane

There is no inter-nervous or intermuscular plane, because the dissection is deep to vastus lateralis muscle.

Superficial Surgical Dissection

The fascia lata of the thigh was incised in line with the skin incision. At the upper end of the wound, the distal portion of the tensor fasciae lata was split in line with its fibers to expose the vastus lateralis.

Deep Surgical Dissection

Through a proximal trochanteric incision, a submuscular tunnel was made under the vastus lateralis without disturbing the fracture site. The plate was slid extra-periosteally through this sub-muscular tunnel and then fixed to the distal femoral shaft through a distal incision.

In the one openly reduced case, the vastus lateralis muscle was split by blunt dissection. As dissection proceeded, several vessels that cross the field were exposed. These were coagulated before they were avulsed by the blunt dissection. Splitting the vastus lateralis revealed the underlying lateral surface of the femur.

Insertion of the wire guides and establishing of the screw trajectories

Prior to placing the plate on the bone, the wire guides were threaded onto the plate holes for each of the three proximal locking screws. The wire guides were used as a manipulation aid for positioning the plate on the proximal femur using fluoroscopic image control (AP and axial). The guide wires were then inserted through the wire guide in the three proximal locking screw holes .

Plate Positioning:

Locked Proximal Femur Plate was positioned against the lateral aspect of the greater trochanter. Extending distally, the plate was lined up along the lateral cortex of the femoral shaft. [13]

For preliminary plate positioning, the guide wire technique was used under fluoroscopic image control in anteroposterior and axial views. First, the most proximal K-wire, with a 95° angle, was positioned in the inferior -medial quadrant of the femoral head. If satisfactory sagittal plane alignment of the plate in relation to the femoral neck and shaft fragment was achieved, the two distal guide wires (120° and 135°) were inserted under biplanar fluoroscopic control. Then the 6.5 mm locking cancellous screws were inserted in the head of femur.

In one case, one non-locking screw was inserted into the shaft of femur as a reduction tool and was removed. Finally, multiple 5 mm locking cortical screws were inserted into the femoral shaft.

During reduction and fixation, emphasis was placed on the restoration of limb length and mechanical and rotational alignments.

At least two to three holes of the plate were left empty at the level of the fracture. This allowed a larger area of stress distribution on the plate and reduced the strain at the fracture, which could prevent implant failure after cyclic weight bearing.[17]

Plate length was chosen as two to three times longer than the length of the fracture zone, and at least three screws were fixed distally. Proximally, three screws were fixed through the condylar portion of PFLCP. The kickstand screw is the third proximal screw and it was found that it is better to be positioned within the femoral neck. No bone grafting was performed and correct alignment and rotation was checked using an image intensifier.

Post-operative:

A pre-requisite for using the PFLCP in unstable fracture patterns, was restricted weight bearing and straight leg raising until callus formation was seen. Active hip, knee and ankle flexion and extension were allowed from day one post-operatively. Active hip abduction exercises were initially prohibited and were encouraged to begin after eight weeks, depending on the specific fracture pattern. Weight bearing started partially after callus appearance at the plain radiographs at least after six weeks. Weight bearing started partially using walking frame then crutches then without walking aids if the patient could.[8]

IV. Methods of assessment of the results:

Foster grading system: [9]

All patients were followed up both clinically and radiologically for a period of at least six months according to the Foster grading system described in 1958

Working length:

The working length is the distance between the kickstand screw (the third proximal screw) and the first distal screw .The working length is described in the form of unfilled screw holes.[11]

Plate span ratio:

The plate span ratio is the quotient of the plate length and overall fracture length. The fracture length was measured from the greater trochanter till the end of the fracture along the axis of the femur. Empirically, the plate span ratio should be between 2–3 in multi-fragmentary fractures and 8–10 in simple fractures.[13]

Plate Screw Density:

The plate-screw density is the quotient formed by the number of screws inserted and the number of plate holes. Empirically, values below 0.5–0.4 have been recommended. This means that fewer than half of the plate holes should be occupied by screws.[30]

V. Methods of statistical analysis:

After data collection, the results were tabulated as frequency distribution for different qualitative values. The arithmetic mean and standard deviation were calculated for quantitative variables.

Informed consent was taken from every patient to be involved in the study.

Statistical analysis of data:[15]

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0**.** **(**Armonk, NY: IBM Corp**)**.[13] Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Significance of the obtained results was judged at the 5% level.

The duration of surgery in this study ranged between 55.0 – 180.0 minutes with a mean of 104.5 ± 35.4 minutes.

Results

Correlation between the studied factors and the final anatomical result:

Correlation between age and anatomical result:

The mean age of the patients who achieved satisfactory results was 64.89 ± 4.57 years, while that of patients who achieved unsatisfactory results was 66.11 ± 7.08 years. There was no statistically significant relation between age and the anatomical result ($p = 0.3427$).

Correlation between sex and anatomical result:

There was no statistically significant relation between patients' sex and the anatomical result ($p = 0.3173$).

Correlation between occupation and anatomical result:

There was no statistically significant relation between patients' occupation and the anatomical result ($p = 0.6373$).

Correlation between affected side and anatomical result:

There was no statistically significant relation between the affected side and anatomical result ($p = 1.000$).

Correlation between co-morbidities and anatomical result:

There was no statistically significant relation between patients' co-morbidities and the anatomical result ($p = 0.6287$).

Correlation between mechanism of trauma and anatomical result:

There was no statistically significant relation between the mechanism of trauma and the anatomical result ($p = 0.0679$).

Correlation between type of fracture according to Evans' classification (10) **and anatomical result:**

There was no statistically significant relation between type of fracture and the anatomical result ($p = 1.000$).

Correlation between type of reduction and anatomical result:

There was no statistically significant relation between type of reduction and the anatomical result ($p = 0.0858$).

Correlation between anatomical grading and limb length discrepancy:

More satisfactory results were seen in patients with less limb length discrepancy with a mean of 0.39±0.48 cm compared with those who had more shortening with a mean limb length discrepancy of 2.11 ± 0.42 cm. It was found that there was **a significant statistical relation** between limb length discrepancy and the final anatomical results ($p = 0.042$).

Correlation between anatomical grading and time lapse between injury and surgery and operative time:

More satisfactory results were associated with patients who had less operative time with a mean of 96.11 ± 26.78 minutes compared to those with longer operative time with a mean of 106.011 ± 37.90 minutes. The difference however was statistically insignificant ($p = 0.7263$). Moreover, the relation between anatomical grading and time lapse between injury and surgery was statistically insignificant ($p = 0.2713$).

Discussion

The high incidence of hip fractures among the elderly is a worldwide major health problem with severe medical consequences affecting quality of life and mortality among the aging population. The aim of surgery is to return to pre-fracture condition as quickly as possible with low incidence of complications. Elderly patients may not withstand a great surgical trauma associated with a major operation. Minimally invasive techniques are considered to improve surgical outcomes by reducing soft-tissue damage, blood loss, postoperative pain and morbidity. Therefore, the development of minimally invasive technique of fracture fixation would likely help patients avoid the hazards of long anesthesia times, tissue trauma, and help to return to pre-fracture function.[20]

In this work, at the end of the six months follow up period, 18 patients out of the 20 studied patients with unstable trochanteric fracture treated with PFLCP were assessed by the Foster grading system. The other two patients included one who had failure of fixation after two weeks and was revised with a DHS and the second developed infection after three months and was treated by resection arthroplasty so they were excluded from the final assessment. The latter patient was diabetic and had an Evans' type I C right inter trochanteric fracture, ipsilateral bimalleolar ankle fractures and contralateral lateral tibial plateau and distal end radius fractures. The patient developed infection in his trochanteric, tibial plateau and bimalleolar fractures. After two sessions of debridement, his trochanteric fracture's plain radiographs revealed subluxation of the hip joint and resorption of the femoral head. Therefore, resection arthroplasty was carried out.

The present study resulted in nine patients with satisfactory and nine patients with unsatisfactory anatomical results. While from the functional point of view 13 patients achieved satisfactory and five patients unsatisfactory results. Therefore, the patients' functional score was better than the anatomical score. This result corresponds with the results obtained by Foster.[26] The patient may have a medical co-morbidity that hinders his functional result despite a perfect anatomical result. Vice versa, the patient may have a varus mal-union and can walk without assistance.

Schatzker et al have shown that the compression strains on the proximal femur are considerably greater than the tension strains. These large stresses on the medial cortex in the per-trochanteric area make cortical restoration at the time of internal fixation mandatory to prevent cyclic loading and failure of any device used on the tension side of the femur.[25] Velasco and Comfort reported that as little as 2 mm of separation of the medial cortex will lead to medial collapse and lateral plate bending. In most reports of pertrochanteric fractures, patients with severe medial cortical comminution consistently have had an increased rate of failure secondary to these biomechanical and anatomical considerations.[19]

Union:

The time to union in this study ranged between 1.5 to 6 months with a mean of 3.09±1.8 months and the union rate was 94.44% (17 out of 18 fractures).

Neck Shaft Angle:

Preservation of the femoral neck shaft angle is a very important aspect during fixation of trochanteric fractures. If the hip is allowed to collapse into varus, this will create a severe Trendelenburg gait. Occasionally, the reduction may look perfect at the time of surgery, butdue to partial failure of fixation, it may change in the post-operative period. [21]

In this study, satisfactory functional results had a wider mean neck shaft angle compared with unsatisfactory results who had more varus. So valgus reduction is expected to give better anatomical and functional results than varus reduction. Valgus reduction at the time of operation is crucial as it provides better fracture position with such a static fixation device (PFLCP). There was a positive statistical relationship between neck shaft angle and both anatomical and functional Foster grading.

Type of Fracture:

Patients' fractures in this work were classified according to Evans' classification. Satisfactory results were seen in type IC (88.9%) compared to only 11.1% in type Id. This could be explained by the complexity of the fracture and difficulty in maintaining reduction with this type of implant in cases with type Id Evans' fractures. However, there was no significant relation between type of fracture and the final score.

Type of Reduction:

In this study, 19 out of 20 fractures were successfully reduced by closed means and fixed using MIPPO technique, and only one patient needed open reduction. There was no significant increase in time to union in the open reduction case than the closed reduction group. However, the study included only one fracture with open reduction which is too small a number to have a statistical bearing.

Complications:

1. Nonunion:

Nonunion occurred in one patient (5.56%), which was a 60-year-old male patient who fell from a height and had an Evans' type Id fracture which was fixed 10 days post injury. The patient was a smoker and manual worker who returned to work contrary to medical advice before union. The fracture ended up in non-union and was revised with a condylar blade plate after 1.5 year.

2. Malunion:

In this study, nine patients (50%) malunited in varus according to Foster grading. All were non-compliant and walked full weight bearing before full union. All were treated with a shoe lift and walking aids.

3. Failure of fixation:

This problem usually occurs secondary to osteoporotic bone or technical errors at the time of the original surgery. In severe osteoporosis, the implant may penetrate no matter where it was placed initially. This can be a difficult problem in elderly patients who have limited ability to cooperate with non-weight bearing instructions post operatively.[27]

In this study, the patient who had failure of fixation was a 93-year-old male patient who fell from a standing posture, had an Evans' type Ic fracture which was fixed with a PFLCP 9 days post injury. The fixation failed and was revised with a dynamic hip screw(DHS) after 2 weeks. This may be explained by inadequate initial closure of the fracture gap at the time of application of such a static device and inadequate length and direction of the proximal screws especially the kickstand screw.

4. Infection:

In this study, infection occurred in one patient (5.56%). He was 62-year-old male patient who was involved in a road traffic accident. He was a polytrauma patient who had an Evans' type IC trochanteric fracture, ipsilateral bi-malleolar fracture, contralateral tibial plateau fracture and distal end radial fracture. His trochanteric fracture was fixed with proximal femoral locked plate MIPO technique at the same session with fixation of distal end radius after 24 days from the injury. The trochanteric fracture was not united, infected together with the tibial plateau and the bimalleolar fractures. After serial debridement, the fracture ended with Girdle-stone procedure 3 months after the index procedure. This may be attributed to older age group, polytrauma patient, anemic, diabetic, long hospital stay for preparation of operation and also it was unwise to stabilize the fracture with two surgical teams working simultaneous.

Conclusions

1- Intertrochanteric fractures, specially the unstable types, remains challenging fractures to treat.

2- PFLCP is a fair implant choice in the treatment of unstable trochanteric fracture pattern.

3- PFLCP provides a biomechanically stable construct, three dimensional fixation and angular stable fixation compared with conventional treatment, especially in the case of unstable fracture in osteoporotic bone.

4- Fixation of unstable trochanteric fracture with PFLCP using MIPO technique is a technically demanding procedure with expected learning curve.

5- Position of screws is crucial especially the third proximal screw (kickstand screw) which increase the construct stiffness.

6- Anatomical reduction or even vulgus reduction at the time of fixation is crucial, as it affects the maintenance of reduction after fixation and the stability of the plate/bone construct.

7- PFLCP provides a static not dynamic fixation so reduction and compression at the time of operation is crucial.

8- Increasing the working length, provides more relative stability which is crucial to avoid nonunion.

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