

Single-Incision Double-Plating Approach in the Management of Isolated, Closed Osteoporotic Distal Femoral Fractures

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Abstract

Introduction: Distal femoral fractures in elderly population had recorded an increase in incidence in the last 2 decades. Lateral distal femoral locking plating is considered one of the best options especially when dealing with comminuted fractures but varus collapse of the medial femoral condyle occurs frequently in patients with osteoporosis. Anatomical reduction of the fracture with stable rigid fixation using double-plating approach allows early mobilization of geriatric population and prevents varus collapse minimizing the comorbidities in such fractures. **Patients and Methods:** Between September 2014 and January 2017, a prospective study on 23 patients with comminuted osteoporotic distal femoral fractures managed through the double-plating approach through a single parapatellar approach has been conducted. Only osteoporotic geriatric patients with isolated distal femoral fractures were included. Polytraumatized, open fractures, and fracture type 33-A1, 33-A2, and 33-B were excluded. The mean age was 69.6 years (61-80). All patients have been evaluated as regard duration of procedure, time to union, EQ-5D-5L score, the need of autologous bone grafts, range of knee motion, and presence of complications. **Results:** The average follow-up was 14.1 months. The majority of fractures were type 33-C2 (13 patients). Average procedure time was 148 minutes (117-193 minutes). Mean EQ-5D-5 L score was 83.8 (72-82). Average time to union was 9 months (3-12 months). Four (17.4%) cases needed autologous bone graft after 6 months. No loss of reduction in any of the cases was evident, although 6 (26%) cases had screw breakage or cutout in one of the plate fixation. Two (8.7%) patient developed superficial wound infection and 1 (4.3%) developed DVT. **Discussion:** This study aimed at evaluation of the success of double plating of distal femoral fractures in geriatric population. different fixation methods were studied for reduction and fixation of such a fracture such as external fixation, intramedullary nails and lateral plating. the quality of fracture reduction, functional and radiological outcomes, time to union, the need for bone grafting and complication are the main debatable issues. **Conclusion:** Single-incision double-plating approach for distal femoral osteoporotic fractures is effective and provides stable construct without reduction loss allowing early rehabilitation. Delayed union and the need for bone graft are the major drawbacks for this technique.

Keywords

distal femoral fracture, osteoporotic fractures, double plating, parapatellar approach, geriatric knee injuries

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Introduction

Distal femoral fractures in the elderly population had recorded an increase in incidence in the last 2 decades with a change in the epidemiological pattern as regard female to male ratio (2:1).¹⁻⁴ They compromise 3% to 6% of all femoral fractures.^{1,5,6} Although the high mortality and comorbidity that are encountered are comparable to the proximal femoral fractures,⁷ a paucity of literature addressed the best fixation implant especially in this age group.⁸

Low-energy trauma following fall from a standing height predominates as the mechanism of injury in osteoporotic

elderly population.^{1,6,9} Surgical intervention showed better outcomes in comparison to conservative treatment.¹⁰ On the other hand, many complications were encountered including prolonged hospital stay, early (up to 8%) and late mortality rates

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Figure 1. Preoperative anteroposterior and lateral X-rays of comminuted fracture distal femur (33-A3).

(up to 25% in 1 year), DVT (6%), and inability to return to the same level of activity which is a major problem specific to this age group who are in need to rapidly return to their physical performance to avoid being dependent and to avoid other associated comorbidities like sarcopenia.¹¹⁻¹³

Osteoarthritis following operative intervention for distal intra-articular femoral fractures recorded in up to 50% at 6-year follow-up, especially in cases with varus malunion, which is associated with high disability and may need a total knee arthroplasty with the problems of retained hardware and multiple previous scars.^{14,15}

Nonunion after lateral plating was reported in 0% to 21% of cases.¹⁶ Obesity, open fractures, diabetes, infection, and use of stainless steel implants are independent factors that increase the need for additive surgical interference up to revision of the fixation procedure.¹⁴

In this study, our hypothesis was that anatomical reduction of the articular and metaphyseal fracture with stable rigid fixation that allows early rehabilitation and mobilization may decrease the associated high rates of morbidity and mortality including prevention of varus collapse, accelerated arthritic changes, and other specific complications for this fragile population like sarcopenia.

Patients and Methods

From September 2014 till January 2017, a pilot prospective clinical cohort study was conducted in level I academic center on 23 patients with osteoporotic distal femoral fracture. Only osteoporotic geriatric patients with isolated distal femoral fractures were included. Osteoporosis criterion was based on previous patients' medical records; geriatric population was defined on basis of chronological age above 60. Polytraumatized, open fractures, fractures type 33-A1, 33-A2, and 33-B were excluded. Patients who met the above criteria were included consecutively in the study. Informed written consent according to ethical committee was taken as regard the surgical intervention and follow-up protocol. The mean age was 69.6 years (61-80), 19 females



Figure 2. Preoperative anteroposterior and lateral X-rays of comminuted intra-articular fracture distal femur (33-C2).

and 5 males. Three of the patients were classified as 33-A3 (Figure 1), 2 were 33-C1, 5 were 33-C3, and the majority (13) of the patients were classified as 33-C2 (Figure 2), according to the AO/OTA classification. The average time of surgery was 5 days postinjury. The main cause of delay was adjustment of associated medical comorbidities (with a mean of 9 days of hospitalization; Tables 1 and 2). Two of the patients were smokers with an average of 15 cigarettes/day.

The procedure was done under combined spinal epidural anesthesia, except in 2 patients where general anesthesia was done due to failed spinal anesthesia. The surgery was done on a translucent orthopedic table in supine position without tourniquet inflation and with a bolster underneath the knee.

One gram of tranexamic acid was given 2 hours prior to surgery and continued for another 3 doses of 500 mg at 8-hour interval. One thousand five hundred milligrams of third generation cephalosporins was given half an hour prior to skin incision that is continued for 3 days postoperatively unless in cases of cross sensitivity where 400 mg of teicoplanin was used. Anticoagulant according to American College of Chest Physician guidelines was given.

After standard sterilization and draping, a midline skin incision was done followed by either a medial or lateral parapatellar approach according to the proximal extent of the lateral condyle fracture. Where more distal lateral condyle fractures preferably approached through a lateral parapatellar arthrotomy to facilitate adjustment of the lateral plate position and lateral plate screws insertion. Reduction of the medial condyle was done first with preliminary K-wires followed by fixation using antishear plate (locked L-plate or medial distal femoral osteotomy locked plate) with 2 proximal and 2 distal screws.

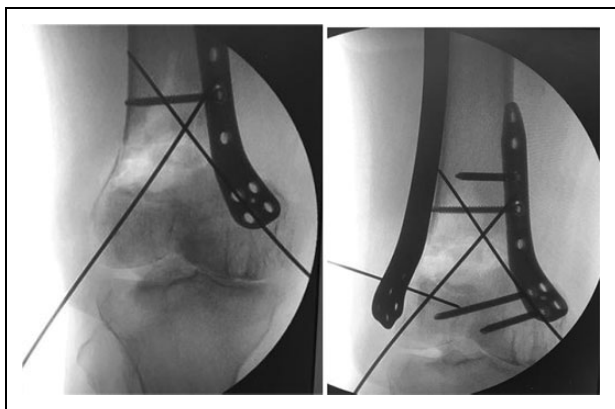


Figure 3. Preliminary K-wire fixation of the fracture followed by application of the medial locked plate followed by the lateral one.

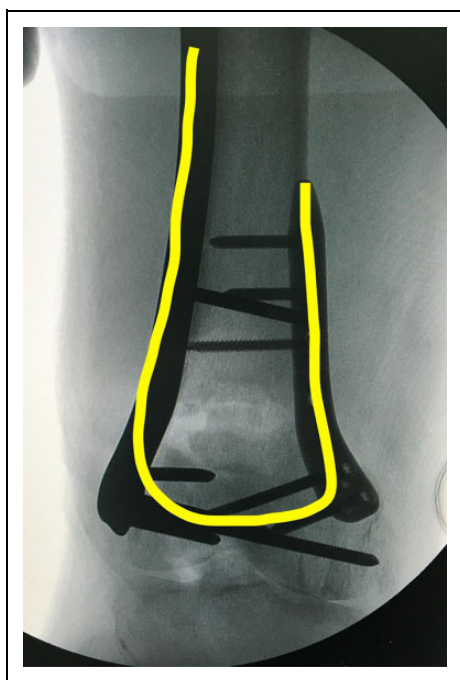


Figure 4. Intraoperative image intensifier after application of the U-shaped fixation using the medial and lateral plates with distal screws interdigitating in the condylar area.

Direct anatomical reduction of the intra-articular part of the lateral femoral condyle was done followed by temporary fixation with K-wires. Fixation of the lateral column was completed using long-locked lateral distal femoral plate with 4 proximal screws in a screw-hole density of 50% through minimally invasive percutaneous plate osteosynthesis (MIPPO) technique. Distally, at least 4 locking screws were inserted taking into consideration not to interfere with the screws from the medial plate (Figure 3). Completion of the fixation with the medial and lateral plates presume the configuration of a U-shaped fixation similar to that proposed in fixation of the distal humeral fractures with 2 longitudinal columns (the plates) interdigitating in the condyles with their screws (Figure 4).

As regard the metaphyseal comminution, all effort was done to preserve the vascularity of the fragments trying to be biological as much as possible. Closure of the extensor mechanism was done in a watertight manner with knee flexed 90° after drain insertion, followed by subcutaneous and skin closure in layers without tension.

An accelerated rehabilitation program with early range of motion of 30° on CPM postoperative increased gradually as tolerated to 90° at 3 weeks that progressed to achieve the full range in comparison to the other side at 6 weeks. Assisted weight bearing from the early postoperative days was encouraged in order to get the patients out of bed as soon as possible. Quadriceps strengthening exercises started from the second postoperative day.

Patients were discharged from hospital on the basis of physiotherapy progress when getting from bed to chair and assisted weight bearing was achieved. Patients have been evaluated regarding the duration of the procedure, time of union, quality of reduction, EQ-5D-5 L score (a standardized measure of health status), the need of autologous bone grafts, range of knee motion, and presence of complications. Data were collected and statistical analysis was done.

Follow-Up

Radiological follow-up was done regularly on 2-week intervals in the first 6 weeks to assess any loss of reduction quality with early-assisted weight bearing, followed by X-rays every month till 6 months and then every 3 months till union occurred. Union of the fracture was defined by bridging bone at least in 3 out of 4 cortices. In case of delayed union, computed tomography scan was done. The minimum follow-up was 12 months and maximum was 36 months with a mean of 14.1 months.

Statistical Analysis

The analysis was done using the Statistical Package for the Social Sciences (SPSS software version 19). Differences between variables were analyzed using the nonparametric test Kruskal-Wallis (χ^2) test. $P < .05$ was considered statistically significant

Results

As regard the fracture type of the patients included in this study, the majority of them were 33-C2 (13 patients) according to the AO/OTA classification (Figure 5). Three of the patients were free from any medical comorbidities, while the rest had associated medical comorbidities either alone or combined (Tables 1 and 2). The average procedure time was 148 minutes (117-193 minutes).

Union of the fracture achieved in 19 cases without any further surgical intervention (Figure 6-8), while 4 (17.4%) cases needed autologous bone graft after 6 months where no signs of union progression evidenced radiologically. One

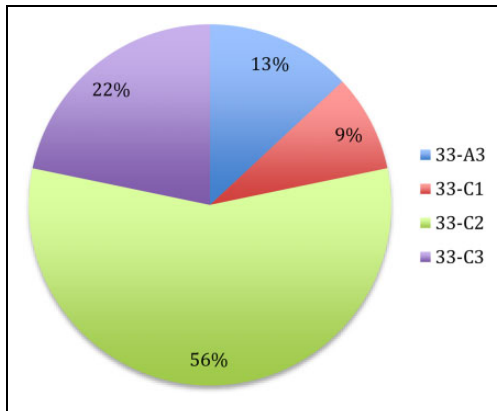


Figure 5. Percentage of patients according to AO/OTA classification.

Table 1. Associated Medical Comorbidities in the Patients.

Comorbidity	Number of Patients
DM	15
ISHD on clopidogrel	7
COPD	2
CLD	5

Abbreviations: CLD, Chronic liver disease; COPD, Chronic obstructive pulmonary disease; DM, Diabetes mellitus; ISHD, Ischemic heart disease.

Table 2. Combined Medical Comorbidities in the Patients.

Combination of Comorbidities	Number of Patients
RA on steroids with DM	1
DM with ischemic heart disease	5
DM with ischemic heart disease and chronic liver disease	2

Abbreviations: DM, Diabetes mellitus; RA, Rheumatoid arthritis.



Figure 6. Seven months postoperative anteroposterior and lateral X-rays of the patient in Figure 1 with 33-A3 fracture managed by U-shaped fixation technique showing healed fracture.



Figure 7. Postoperative anteroposterior and lateral X-rays of the patient in Figure (2) with 33-C2 fracture managed by U-shaped fixation technique.

of them was a smoker and 2 of them had combined medical comorbidities. Mean time to full union was 9 months (3-12 months).

No loss of reduction in any of the cases was evident, despite 6 cases had screw breakage or cutout in one of the plate fixation (26%; Figure 9). The mean EQ-5D-5 L score was 83.8 (72-92). In this score, 100 means the best health the patient can get and 0 means the worst health. In the last follow-up, all cases regained their knee range of motion that was 3° to 5° less when compared to the contralateral nonfractured side.

Two (8.7%) patients who were diabetic developed superficial wound infection, antibiotics were continued for 2 weeks with daily dressing, and the condition improved without surgical intervention. DVT occurred during hospital stay in 1 (4.3%) case despite strict anticoagulant prophylaxis. The patient was shifted to the therapeutic dose of the same anticoagulant without further complications.

There was no statistically significant difference between different classification patterns of the fracture with regard to age, duration of surgery, and EQ-5D-5 L scores, except in time to union where it was statistically significant ($P < .01$); as in type 33-C3 fracture, the mean time to union was 10.2 months, which is delayed than the other 3 types (Table 3). The statistical correlation between smoking and medical morbidities to time of union cannot be measured due to the small sample size.

Discussion

Distal femoral fractures are considered as one of the osteoporotic fractures that had raised the concern toward the best fixation method in such condition in the last 2 decades.^{1-4,10} Different fixation techniques including intramedullary retrograde nailing, plating, and external fixation have been described. Locked

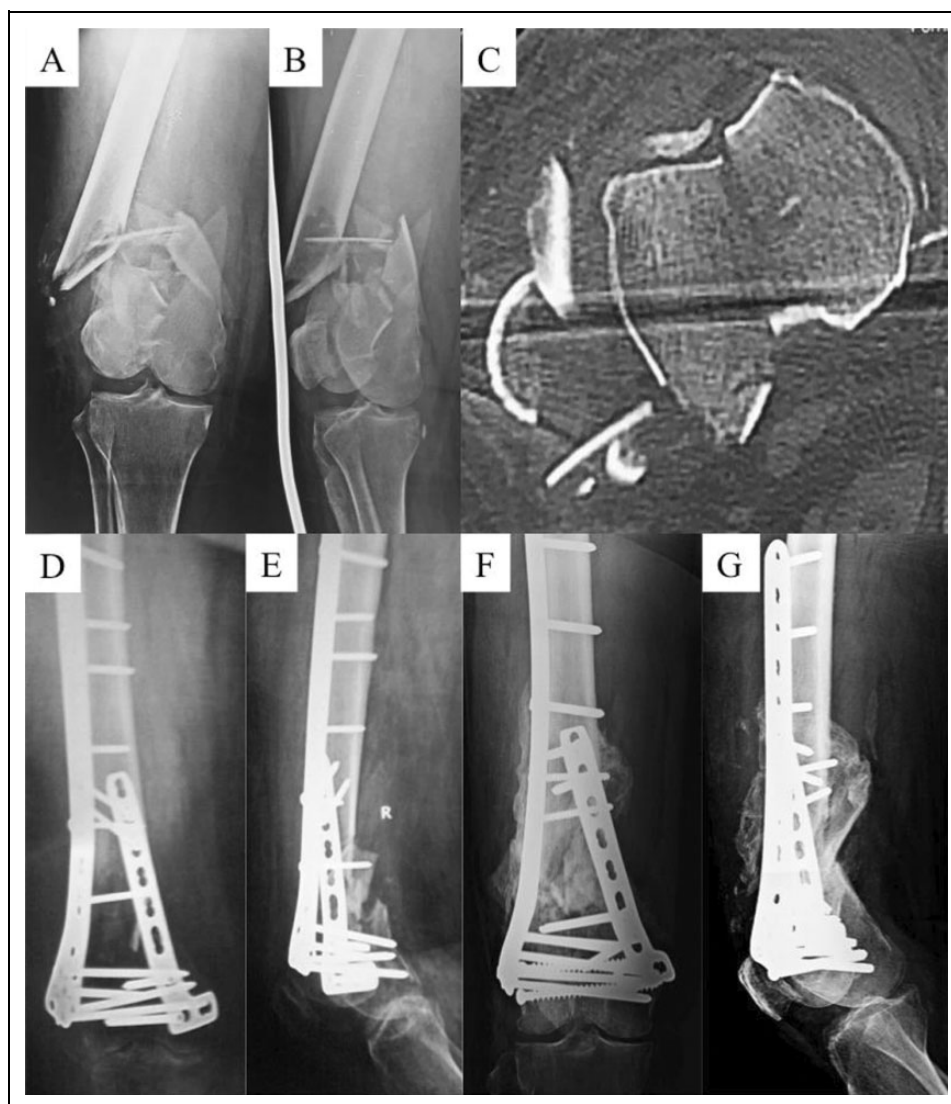


Figure 8. Example of 33-C3 fracture. (A and B) Preoperative anteroposterior and lateral X-rays, (C) axial computed tomography (CT) scan, (D and E) postoperative anteroposterior and lateral X-rays, and (F and G) 3 months anteroposterior and lateral X-rays showing fracture union.

plates inserted through MIPPO technique are now widely used and show better overall results as regard union rates and complication occurrence.^{17,18}

Several studies used external fixation as a method of treatment, especially in patients with open fractures, poor skin conditions, and multiple injuries. The authors reported healing of the fracture in 4 to 6 months with a union rate of about 92.3%. The major drawbacks for using such a method in fixation include high pin tract infection rates, soft tissue tethering, and high inconvenience rates. All these complications decreased its popularity in management of such fractures.¹⁹⁻²²

Many studies used intramedullary nails in managing distal femoral fractures especially type 33-A and to a lesser extent 33-C1 and 33-C2. In fractures type 33-C3, intramedullary nails aren't recommended, as reduction of the intra-articular element should be achieved first by interfragmentary screws with difficulties in inserting the nail. Commonly, there was loss of distal

fixation during axial loading leading to nail failure; this resulted in catastrophic penetration of the nail in the knee joint.²³

Reduction of the fracture insufficiently, a bad starting point, or eccentric reaming can result in poor fracture alignment with loss of reduction.²³ Knee stiffness is common in about 48% of the cases; other complications such as reduction loss (7%), breakage of the locking screws (8%), and anterior knee pain (22%) were recorded.²⁴⁻²⁸

Many authors in the literature evaluated the effectiveness of lateral locked plates in managing distal femoral fractures whether in an open manner or using the less invasive stabilization system with good union rates ranging from 81% to 95% but with many complications related to the single-plate use such as loss of reduction, malunion, rotational malpositioning, and breakage leading to revision surgeries in a rate of 19% to 23%.^{14,28-32}

Rotational malalignment compromises up to 10% of distal femoral fractures, and the risk increases with the MIPPO

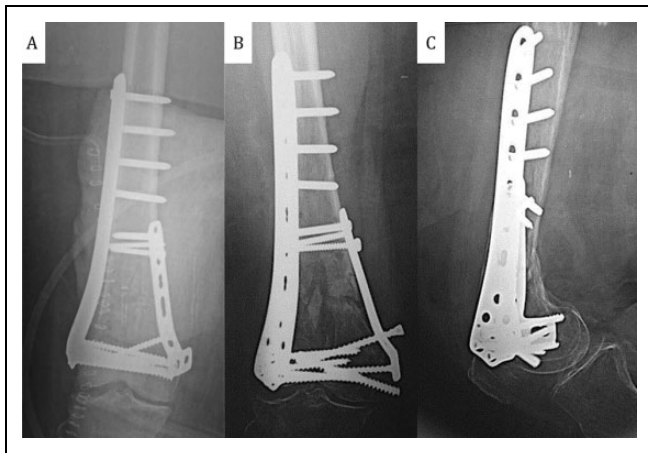


Figure 9. A, Postoperative anteroposterior X-ray of 33-C2 fracture fixed with the double-plating technique. B, Eight months postoperative anteroposterior. C, Lateral X-rays showing screw cutout in the medial column with no loss of reduction.

approaches due to the unique geometry of the distal femoral condyles with a 25° of inclination in the medial femoral condyle and 10° of the lateral femoral condyle. This malrotation alignment affects mainly patellofemoral articulation leading to anterior knee pain and aggravates osteoarthritic changes.^{24,33}

In this study, the authors implicated the column theory that was described in different intra-articular fractures with double-plating techniques like in distal humerus, acetabulum, tibial plateau, and plafond fractures. So it is wise to consider it in intra-articular distal femoral fractures, especially in elderly population whom bone quality is jeopardized. In addition, recent biomechanical studies proved better stiffness and stability as regard medial plating in comparison to the commonly used lateral distal femoral plates.³⁴

In the current study, the authors used anterior midline approach for reduction of the fracture. It has advantages in better visualization of the fracture configuration, especially with intra-

articular extension avoiding malrotational alignment associated with MIPPO technique, and also, it is the same approach if needed in the future for total knee replacement when osteoarthritis becomes the late sequel of such a comminuted fracture.

To our knowledge, few studies published for double-plating technique for distal femoral fractures compared to other techniques. In a study published by Steinberg et al,³⁵ this technique has been used in 26 patients to manage acute fractures, non-unions, and periprosthetic fractures. Different methodology as regard the approach was noticed as they used combined medial and lateral approaches. The average union rate was 12 months that is comparable to the current study.

Another study published by Imam et al³⁶ evaluated 16 patients with C3 fracture type managed by the same principle and using the anteromedial skin approach. The mean follow-up was 12 months, and the average time to union was 6.0 ± 3.5 months, with a range of 3 to 14 months without loss of reduction in any case. Ten cases needed bone graft. Two cases had skin infection where surgical debridement was done. The majority of the patients had good to excellent outcome.

Zhang et al³⁷ reported similar findings, as they evaluated the efficacy of double-plating fixation through anterior-middle approach in treating type C3 distal femoral fractures with good to excellent patient's outcome.

In a biomechanical study on synthetic bone that was done by Prayson et al,³⁸ they reported that supplementation of the medial column by medial plate must be considered to prevent varus collapse, especially in highly comminuted metaphyseal fractures with bone loss.

The average time to union of distal femoral fractures managed by MIPPO technique is 3.5 to 6.1 months as published by many authors. This rate is incomparable to the current study and other studies using the double-plating technique, which is 9 months.^{39,40}

Delayed union noticed in the single-incision double-plating approach might be due to the high stiffness associated with locking plates together with the open direct reduction technique

Table 3. Results of the Double-Plating Fixation in Management of the Osteoporotic Distal Femoral Fractures.

Parameters	Groups				χ^2	P Value
	33 C1; n = 2	33 C2; n = 13	33 C3; n = 5	33 A3; n = 3		
Duration of surgery					6.095	.107
Range	120-145	125-193	120-160	117-160		
Median	132.5	155	135	130		
Mean rank	7.00	15.04	8.50	8.00		
Time of union					9.729	.021 ^a
Range	7-8	7-10	9-12	7-8		
Median	7.50	8	10	7		
Mean rank	7.00	11.38	19.20	6.00		
EQ-5D score					2.680	.444
Range	86-87	72-90	80-91	79-92		
Median	86.5	82	87	90		
Mean rank	14.75	10.04	13.80	15.67		

^aP < .05 is significant.

Mean (standard deviation) of participants age is 69.6 (4.7).

disturbing the fractures hematoma. Although screw breakage and cutout occurred, no loss of reduction was evident, and the patients' recorded outcome measures were satisfactory. This goes hand in hand with studies done by Henderson et al⁴¹ and Lujan et al⁴² who revealed that using of locking plate constructs with high stiffness achievement may limit the amount of callus, resulting in delayed healing or nonunion.

The need for bone grafting in cases of nonunion could not be attributed to the fracture subclassification nor the associated medical comorbidities; this might be linked to the occurrence of other complications such as implant failure that occurred in 3 of the 4 patients who needed bone grafting. But according to the small sample number, this could not be proven statistically.

The limitations of this study are the small group number and short term follow-up with no cases assessed for the need of total knee replacement and associated difficulties, so longer follow-up with larger group of patients need to be evaluated in further study. Also assessment of the effect of different comorbidities and smoking on union time cannot be assessed because of the same reasons.

Conclusion

Single-incision double-plating approach is a reliable and effective method for the management of osteoporotic distal femoral fractures. This may improve the stability of fixation and accordingly accelerate the rehabilitation of such fractures with higher range of motion achievement, mobilization of patients with earlier weight bearing, and progressive muscle strengthening exercises. It must be emphasized that if no signs of radiological healing was noticed within 6 months postoperatively and every 3 months afterward, autologous bone graft must be strongly considered.

Authors' Note

All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with Helsinki declaration and its later amendments. This article does not contain any studies with human participants or animals performed by any of the authors. Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

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