Is geriatric patient satisfaction related to pre-injury osteoarthritis after locking plate fixation for distal femoral fractures?

Ihab I. El-Desouky, Khaled A. Hafez, Ayman M. Shaheen

Department of Orthopaedics and Traumatology, Kasr Alainy School of Medicine, Cairo University, Cairo, Egypt

Correspondence to Ihab I. El-Desouky, MD, Cairo, 11562, Egypt. Tel: +20 237 619 269; e-mail: ehabede@hotmail.com

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Objectives
In elderly patients, distal femoral fractures are mostly related to osteoporosis. Osteoporosis weakens the supracondylar region, resulting in complex intra-articular fractures and metaphyseal comminution. The prevalence of knee osteoarthritis (OA) in this age group may affect the final functional outcome after fixation. The study assessed the relationship between pre-injury OA stage and postoperative functional outcome after fracture fixation by monoaxial lock plates.

Patients and methods
A prospective study was conducted between November 2016 and May 2019. A total of 38 cases of distal femoral joint fractures, including 18 extra-articular fractures (group-1; 33-A) with an average age of 67.6 ± 4 years and 20 cases of complete articular fractures (group-2; 33-C) with mean age of 69.2 ± 2.9 years, were included. Domestic fall was the mode of trauma, and the fractures were treated with a monoaxial distal femoral locked compression plate through a mini-invasive incision. Pre-injury knee conditions were assessed according to Knee Injury and Osteoarthritis Outcome Score. The final 1-year outcome was assessed using the Knee Society Score systems.

Results
In extra-joint fractures, the mean healing time was 17.6 ± 1.1 weeks (16–20 weeks), and in the complete articular fractures, the mean healing time was 23 ± 2.3 weeks (20–30 weeks). Complications were recorded as a single case of nonunion development that needed revision and grafting, and the union was achieved 20 weeks later. Joint line pain was observed in 15 (39%) of all patients. The final result of the Knee Society Score system for group 1 fractures was 74.7 ± 8.3 (60–90), and the mean for group 2 was 65.2 ± 9.5 (50–80). *P* value was less than 0.001. A clear correlation between the degree of pre-injury OA (Knee Injury and Osteoarthritis Outcome Score) and the final functional outcome (*P*=0.7) was identified, regardless of the severity of the fracture.

Conclusion
Monoaxial locking plate fixation for distal femoral fractures in the elderly population is a stable construct to stabilize this osteoporotic bone. It allows sound healing; however, the functional outcome is affected by the pre-injury joint OA.

Keywords:
articular, femur, locking, monoaxial, osteoarthritis, plating

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Introduction

Fractures of the distal femur are uncommon and severe injuries. The estimated frequency is 0.4% of all fractures and 3% of femoral fractures. A classic bimodal distribution is found with a peak incidence in young men (in their 30 s) and elderly women (in their 70 s). The usual context is a high-energy trauma in a young patient and a domestic falls in an elderly patient [1].

Osteoporosis weakens the supracondylar region of the distal femur in the elderly, resulting in complex fractures. Intra-articular involvement and comminution of the metaphysis are common in this population [2]. Locked plating fixed-angle devices allow fixation of these poorly mineralized bone, situations where there was a significant bone loss, or in areas of structurally weaker bone such as the metaphysis [3].

The locking plates provide better stability in the fragile bone; the primary stability of the plate is independent of friction effect, as screw presses plate, and is obtained

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by locking the screw into the plate. The anatomical design of the plate allows it to use as a reduction mold, molding bone to the plate [4].

Screw placement through the locked plate can vary by monoaxial or poly-axial. It was proposed that the polyaxial locking screw mechanism provides a more biomechanically sound fixation. The locking mechanism allows maintenance of angular stability while affording the option of variable screw placement [5].

However, the polyaxial design offers the same benefits as the monoaxial type in treating distal femoral fractures [6,7]. Polyaxial screw fixation may have advantages if intramedullary implants are present [6].

The prevalence of osteoarthritis (OA) among elderly patient is estimated as 33% among those aged 60–70 to 43.7% among those over 80 years of age [8].

This study managed extra and complete articular distal femoral fractures in elderly patients by open reduction and internal fixation with monoaxial locked distal femoral plates. Bone healing, both radiologically and clinically, was the primary outcome. The range of motion and knee function were the secondary outcomes.

Patients and methods

A prospective study was conducted between November 2016 until May 2019, including 38 displaced distal femoral fracture cases. Inclusion criteria were patients above 60 years of age, who have displaced distal femoral fracture, either extra-articular (AO/OTA 33-A) or complete articular types C fractures), after domestic falls.

Exclusion criteria were patients with major organic failure (renal, hepatic, severe cardiac, dementia, or known neoplastic disease), with impaired prefracture mobility, high-energy trauma, presence of associated injuries, and open fractures.

After stabilizing the patients' general condition, the fractured limb was splinted, and patients were given analgesics. Radiograph films of affected distal femur and knee in anteroposterior and lateral views were taken. Computed tomoraphy scan films were done for intra-articular fractures. As per protocol, low-molecular-weight heparin was given as thromboprophylaxis. In this study, (a) all of the patients gave informed consent before being included in the study and (b) the study was authorized by the local ethical committee and was done per the ethical standards of the 1964 Declaration of Helsinki as revised in 2013.

Preoperative prophylactic antibiotic (1 g intravenous cefotaxime) was given at the time of induction of anesthesia. All patients received spinal anesthesia, and all surgeries were done by the same surgeon (K.A.H.). The lateral approach was used in all patients, and fractures were fixed by monoaxial stainless-steel, large-fragment locked compression plate (LCP) 4.5/5.0 with combi holes plating system. In group 2, the fixation of the articular fragments was started by lag screws outside the plate (either 4 mm or 6.5 mm lag screws according to the size of the fragments). The plate was then fixed to the bone by the combination of locking and cortical screws with a total number of four to five screws proximal to the fracture and four to five screws distal to it. Closure of the wound was done in layers and a suction drain was applied (Fig. 1).

Postoperatively, the limb was placed in a compressive dressing. Patients could sit up on the day of surgery with the leg supported on a soft pillow. The suction drains were left for up to 48 h. Active motion exercises and quadricep strengthening exercises were started on the first postoperative day. Patients were mobilized on a walker, and toe-touch weight-bearing was allowed. Antibiotics were given for 5 days. Stitches were removed at 2 weeks. Partial weight-bearing was allowed at 6 weeks and full weight bearing at about 12 weeks guided by radiological healing. Follow-up visits were done at the 2-week interval for 6 weeks, then monthly till healing, then at 6 months, and at 1 year.

The patients' demographic data, pre-injury knee state assessed by Knee Injury and Osteoarthritis Outcome Score (KOOS), fracture pattern, duration of surgery, length of hospital stay, and time to heal (clinical and

Figure 1

Intraoperative photograph after fixation of the fracture.

radiographic) were documented. The final follow-up was at the end of the first year for every case, assessed using the Knee Society Score (KSS), and complications were documented. Bone healing, both radiologically and clinically, was the primary outcome. The range of motion and knee function were the secondary outcomes. Physiotherapy was conducted for all patients, determined according to the bone healing status.

Data were coded and entered using the Statistical Package for the Social Sciences (SPSS), version 25 (IBM Corp., Armonk, New York, USA). Data were summarized using the mean, SD, minimum, and maximum in continuous data and the frequency (count) and relative frequency (percentage) for categorical data. Student's *t* test for continuous variables and Pearson's χ^2 test for categorical variables were used. Statistical significance was set at *P* value less than 0.05.

Results and complications

This study was conducted on 38 consecutive patients with distal femur articular fractures. A total of 18 patients had extra-articular subtype (group 1) (OA 33-A1-A2), whereas the remaining 20 had complete articular subtype (group 2) (AO 33-C1 and C2). The age of the patients in group 1 ranged from 60 to 73 years (average of 67.6 ± 4). In group 2, the age of the patients ranged from 64 to 74 years (average of 69 ± 2.9). The *P* value was 0.18, which was insignificant. Most patients had significant comorbidities. In group 1, three (16%) patients were registered as American Society of Anesthesiologists (ASA) [9] grade I, five (27%) were registered as ASA II (30%), and 10 ((55%) as ASA III. In group 2, two (10%) patients were recorded as ASA I, five (25%) were ASA II, and 13 (65%) were ASA III. These categorical variables are summarized in Table 1.

The time interval from trauma to surgery ranged from 1 to 10 days (mean of 4.5 days). The delay of more than 1 week was attributed to the control of medical illness or the late transfer of patients from another place. Between the two groups, there were significant statistical differences regarding some parameters. The average operative time was 110.5 ± 8 min in group 1, and in group 2, it was 124 ± 4 min. The *P* value of this parameter between these groups was 0.12, which was statistically insignificant. On the contrary, total blood loss (intraoperative and postoperative) was recorded to be in the range from 350 to 550 ml (mean, 438.8 ml±69.7) in group 1 patients, and in group 2, it ranged from 600 to 800 ml (mean, 675 ml±75). *P* value was 0.000063, which was statistically significant.

Table 1 Preoperative variables

	Group 1	Group 2	*P* value
Type of fracture	33-A	33-C	
Number of patients	18	20	
Age of patients (mean by years)	67.6 ± 4	69 ± 2.9	0.18
Male/female	9/9	11/9	0.15
Mode of trauma	Domestic falls	Domestic falls	
Comorbidities (ASA) [*n* (%)]			
ASA I	3 (17)	2 (10)	
ASA II	5 (28)	5 (25)	
ASA III	10 (55)	13 (65)	

ASA, American Society of Anesthesiologists.

No patient was lost during the follow-up. No mortalities were recorded during the follow-up period (1 year for every case). However, there were significant differences during the follow-up parameters between the two groups. Healing was defined as the radiographic presence of trabeculae across the fracture site with the absence of pain on palpation and weight-bearing. In group 1, the mean healing time was 17.6 ± 1.1 weeks (range, 16–20 weeks), and in group 2 was 23 ± 2.3 weeks (range, 20–30 weeks). *P* value was 0.000008, indicating statistical significance (Figs 2 and 3). At the last follow-up (1 year for each case), no complications were encountered in group 1 patients, whereas in group 2, one case showed no attempted healing with medial collapse at 10 weeks because of a short plate. Revision by a longer lateral plate with medial plating and grafting was done, and the union was achieved 20 weeks later.

The functional outcome at the final follow-up was assessed by the KSS system. The average KSS scoring for group 1 was 74.7 ± 8.3 and ranged from 60–90, and for group 2 the score averaged 65.2 ± 9.5 and ranged from 50 to 80, with *P* value of 0.00251, which was statistically significant.

There were six patients with joint line knee pain in group 1, despite the excellent reduction. Narrowing of the joint spaces of the opposite noninjured knees was observed in these patients. The pre-injury KOOS for these patients was below 65 (range, 64–55, with a mean of 60.8 ± 3.3). Compared with the final KSS, there was a clear relationship between the two scores, with a *P* value of 0.7, as shown in Fig. 4.

Similar cases were detected in group 2, where nine patients experienced persistent knee pain despite the adequate reduction. The mean pre-injury KOOS of these patients was 54 ± 7 (range, 45–64). These patients developed knee stiffness with a limited flexion range, with an average of 90°. Four of the nine patients had an extension lag of an average of 10°. Similar measurements were recorded from the noninjured limbs with lesser limitations of the motion range. Three of these nine patients had improved motion range at the final follow-up after physiotherapy sessions. None of the patients had significant malalignment (Fig. 5).

One patient in group 2 developed a superficial infection. This patient had uncontrolled diabetes, and repeated dressings and antibiotics resolved the condition. Another patient in group 2 showed no attempted healing with medial collapse, revision by a longer plate, and grafting was done, and union was achieved. Tables 1 and 2 show postoperative complications.

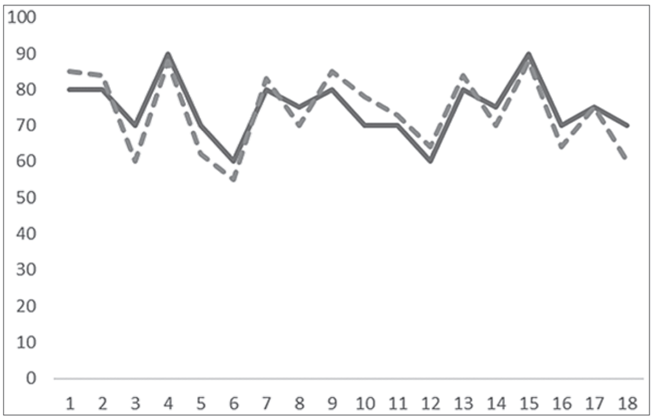
Figure 2

Postoperative radiograph: (a) preoperative radiograph of type-C fracture. (a) Immediate postoperative radiograph. (b) After 6 months with healed fracture with bridging callus.

Discussion

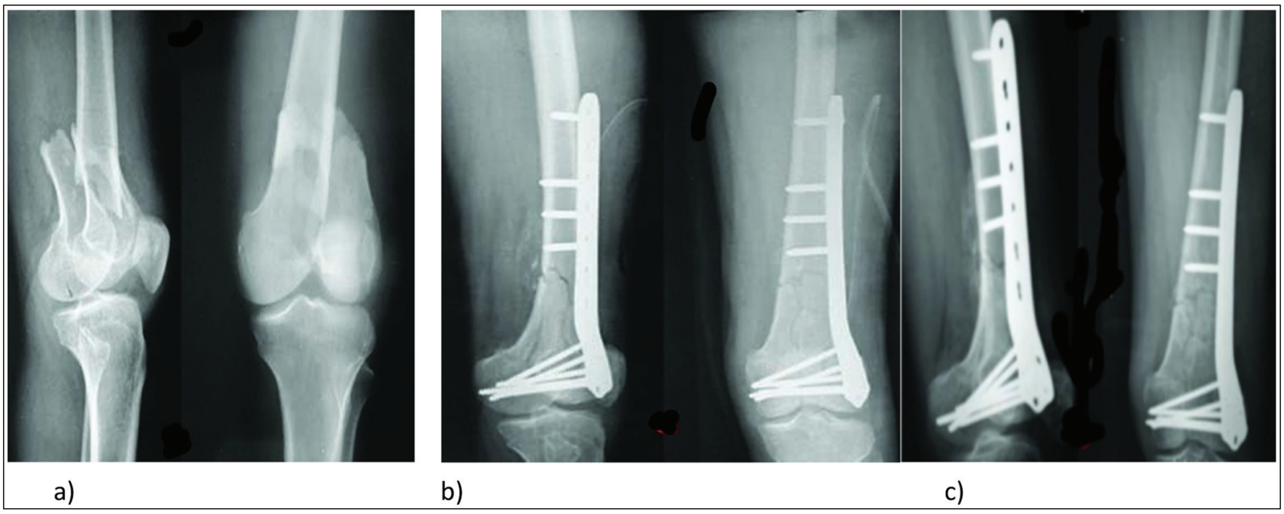
Failure of fixation of distal femoral fractures is attributed to the failure of the implant and poor bone quality rather than soft tissue or the fracture type [10]. These were resolved with the development of a locking

Figure 4



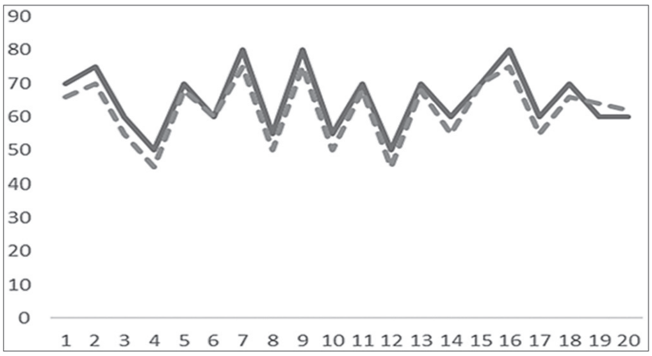
Relation between the pre-injury KOOS and final follow-up KSS in group 1 patients. Dashed line for pre-injury KOOS. Solid line for final KSS. KOOS, Knee Injury and Osteoarthritis Outcome Score; KSS, Knee Society Score.

Figure 3



(a) Preoperative radiograph of type-C fracture. (b) Immediate postoperative radiograph, (c) after 6 months with healed fracture with bridging callus.

Figure 5



Relation between the pre-injury KOOS and final follow-up KSS in group 2 patients. Dashed line for pre-injury KOOS. Solid line for final KSS. KOOS, Knee Injury and Osteoarthritis Outcome Score; KSS, Knee Society Score.

plate that provides preservation of periosteal blood supply, effective load transmission to the plate, angular stability, and low risk of nonunion [11]. Therefore, locking plates provide better fixation in osteoporotic bone and lower the rates of fixation failure in distal femoral fractures [12]. The controversy of whether to use monoaxial or poly-axial screw anchorage types has its place. The variable-angle polyaxial locking plate was designed to allow versatility for the surgeons in terms of screw placement and fixation. Hanschen and Biberthaler [13] presented improved radiological and functional outcomes with poly-axial plating compared with the less-invasive stabilization system (LISS) system. This study included young patients without showing a precise incidence of comorbidities. A biomechanical study favored polyaxial plating regarding load-to-failure, to the stiffness of the plate [5]. Nevertheless, in a more recent study of a retrospective review of 67 patients in a major trauma center (level III evidence), polyaxial plating showed a high failure rate, with a 14% failure rate in the LISS group, an 8% failure rate in the poly-axial group, and 0% failure rate in the locking condylar plate group in AO 33-C fractures [14]. Another study reported the results of two tools of fixation (variable angle LCP) and 4.5 mm distal femur locking plate system), where fixation failures were reported only with variable angle plates [15].

Biomechanical studies of variable angle plates indicate that the highest resistance to rotation is provided by the locking screws perpendicular to the plate, reducing rotation resistance, with an increase in the deviation off-axis of the perpendicular axis [16]. Later analysis has shown that screw insertion is key in fixation success, with a reduction of load resistance of poly-axial screws to 60% of monoaxial screws if inserted at 10° off-axis [17].

Table 2 Postoperative complications

Complications	Group 1	Group 2
Pain	6	9
Superficial infection	–	1
Stiffness	–	9
Nonunion	–	1

LISS showed satisfactory fixation in osteoporotic bone [18]. Still, a meta-analysis of 21 studies demonstrated a loss of reduction of up to 19%, with a 6% rate of delayed union or nonunion and a 5% rate of implant failure [11]. Another study reported fixation failure of 14% after LISS fixation compared with 0% in LCP [14]. A retrospective cohort showed the results of 339 patients with distal femoral fractures. The fixation devices were LISS (titanium, monoaxial locking screws) in 185 patients and LCP (stainless-steel monoaxial locking screws, combi-holes) in 154 patients. The study found that postoperative infection and nonunion were comparable between LISS and LCP for both open and closed distal femoral fracture fixation [19].

A study included 191 patients with distal femoral fractures who were treated by titanium plate in 38 patients and stainless-steel plate in 152 patients. The mean age was 74 years. Reoperation due to nonunion was documented in 11 (29%) out of 38 fractures that were fixed by titanium plate but were recorded in 27 (18%) of 152 fractures that were fixed by stainless-steel plate [20].

Rotational malalignment is a documented complication after minimally invasive plating osteosynthesis (MIPO) of the distal femur. Although it combines the mechanical advantages of plate fixation with the preservation of fracture biology, it does not allow direct reduction of the fracture site [21].

The open reduction technique allows for better reduction than MIPO with more accurate rotational alignment [22,23]. Kim *et al.* [24] found unsatisfactory results regarding rotational malalignment, which was found in 48.6% of patients with complex fractures and 26.7% of patients with simple fractures after MIPO fixation of distal femoral fractures. So, three-dimensional printed navigation template was used to assist the MIPO of distal femoral fractures, improving the obtained results [25].

Limited knee motion after fixation of distal femoral fractures is documented. The incidence of knee stiffness after intra-articular knee trauma that needed surgical release was reported up to 14.5% [26].

Decreased range of motion in knee flexion after distal femoral fractures was reported in some studies. After the fixation of supracondylar femoral fractures, patients lost between 30° and 40° of knee flexion compared with the healthy knee [27]. Another study reported that 13% of patients failed to achieve 90° of knee flexion, with 48% of patients achieving less than 120° of flexion after submuscular plating of the distal femur [28].

The functional outcome is also affected by the pre-injury status of the knee. Primary total knee arthroplasty has been proposed as an alternative solution to internal fixation for acute knee fractures in the complex articular fracture in elderly patients with symptomatic OA before the fracture [10,29].

This study evaluated the radiological and clinical healing after fixation by monoaxial LCP of intra-articular distal femoral fractures in the elderly. The age of patients ranged from 60 to 74 years, who are, according to gerontology, considered the youngest old population [30]. Accurate reduction and restoration of length and alignment (angular and rotational) were obtained in all cases after open reduction; however, functional outcome was mismatched with healing.

After complete fracture healing, 15 (39%) patients developed joint line knee pain coinciding with the pre-injury status's OA stage. Knee stiffness happened in nine (45%) cases of group 2, which persisted after completing physiotherapy courses. The limitation of knee motion was recorded in the uninjured knees of these patients to similar degrees. This mismatch between the healing of the distal femoral fractures in the elderly, after secure and anatomical fixation, and the functional outcome can be attributed to the OA stage of the affected knee before the injury.

To our knowledge, this is the first study that directly correlated the degree of pre-injury knee OA with the functional outcomes after geriatric distal femoral fractures. The limitations of our study were the sample size and there was no control group for comparison between the open technique that we used and the minimally invasive one. All patients are among the youngest old age groups, without the presence of older age groups. Moreover, there was no presurgery measure of bone mineral density to detect the osteoporosis level of these patients and its effect on the time to union. However, the strength of this study includes its prospective nature, the inclusion of a single mode of trauma that can be compared with other severe forms. It highlights the effect of the pre-injury OA stage of the affected knee upon the outcome.

Conclusion

Monoaxial locking plate fixation for intra-articular distal femoral fractures in elderly people is a stable construct for stabilizing this osteoporotic bone. It allows sound healing; however, the functional outcome is affected by the pre-injury stage of OA.

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Conflicts of interest

There are no conflicts of interest.

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