

# Locked plate fixation of the distal femoral fractures by using the less invasive stabilization system (LISS).

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**The Egyptian Orthopedic Journal; 2020 supplement (1), June, 55: 81-87**

## Abstract

### Background

Distal femur fractures are serious injuries that can be difficult to treat, can carry an unpredictable prognosis and can lead to long term disability and morbidity.

The aim of this study was to assess the early results of the treatment of distal fractures of the femur by locked plate using the minimally invasive percutaneous osteosynthesis

### Patients and methods

The study was a randomised prospective study that included 20 patients suffering from distal fractures of the femur . All patients treated by distal femoral locked plate using LISS. The mean of follow up duration was 26 months (range; 15 to 36 months)

### Results

The final results obtained were excellent in four patients (20%), good in twelve patients (60%), fair in 2 patients (10%) and poor in two patients (10%). The mean time for union was  $3.45 \pm 0.79$  months. Complications encountered were knee stiffness delayed union , infection and shortening .

### Conclusion

Distal femoral locking plates through minimally invasive approach is relatively easy, safe and provide angular stability. It helps to preserve periosteal blood supply, provide better purchase and stability in osteoporotic bone and decrease the need for primary bone grafting and high union rate.

### Key words

Distal femoral fractures, Locked plate, Biological fixation.

## Introduction

The distal femur are complex injuries that can be difficult to manage<sup>[1]</sup> They are the fractures that involve the distal 15 centimeters of the femur including supracondylar and intercondylar areas<sup>[2]</sup>

They account for only 7% of all femoral fractures in adults.[3] They occur in a bimodal distribution: 15-50 years of age, predominantly in males, sustaining high-energy trauma, and 50+ years of age predominantly in females, with osteoporosis, who sustain relatively low energy trauma.[4]

Historically, the treatment of distal femur fractures has not produced a high percentage of excellent clinical results .Osteoporosis, a wide intramedullary canal, and comminution have made stable fixation of these injuries difficult to achieve and maintain with traditional operative methods[5]

Many different fixation methods have been described including the 95° angled blade plate, dynamic condy-

lar screw plate, condylar buttress plate and retrograde supra-condylar inter-locking nail. [6]

currently, “locked plating” systems have been developed, where screws lock to the plate forming a multiple fixed-angle construct that functions as an “internal fixator” avoiding compression of the periosteum, thus potentially allowing maintenance of the vascularity to the injured bone[7]

Open reduction and internal plate fixation of distal femoral fractures is associated with extensive dissection, decrease bone vascularity with increase susceptibility to infection and nonunion. [8]

Less invasive stabilization system (LISS) plate was designed for use with minimally invasive approaches and indirect reduction techniques ,with the aim of solving the problems encountered with conventional methods.[9]

### Aim of the work:

The aim of this work was to evaluate the results of Minimally Invasive Plate Osteosynthesis (MIPO) in treatment of distal femur fractures using locking plate.

### Patients and methods

This study was a consecutive prospective study and included 20 patients, suffering from supracondylar fractures of the femur. All of them were treated by Less Invasive Stabilization System (LISS) locking plate through minimally invasive percutaneous osteosynthesis (MIPO) approach (fig.1) [10] between January 2016 and September 2017 .



**Fig.1:** LISS of the distal femoral fractures.<sup>(10)</sup>

The age range was 19-80 years with a mean age of  $52.80 \pm 14.79$ . Six patients were males (30%) and fourteen were females (70%). Body mass index ranged between 23-43 Kg/m<sup>2</sup> with a mean of  $28.50 \pm 4.77$  Kg/m<sup>2</sup>.

The right side was affected in twelve patients (60%) and the left side in eight patients (40%). The mechanism of trauma was road traffic accidents (RTA) in nine patients (45%) and falling at home in eleven patients (55%). Eleven patients (55%) had associated medical conditions; Four had hypertension, two suffered from ischemic heart disease, two had uncontrolled diabetes, two had both diabetes and hypertension and one was asthmatic .

Three patients (15%) had associated injuries. The first had ipsilateral supracondylar fracture humerus that was managed by open reduction and internal fixation (ORIF) using plate and screws, The second pa-

tient had ipsilateral bimalleolar fracture ankle that was managed by (ORIF) with plate and screws. The third patient had ipsilateral tibial plateau schatzker type I fracture that was managed by pinning with screws under image intensifier .

Eight patients had type A1 fracture (40%), one had type A2 fracture (5%), five had type A3 fracture (25%) , one had type C1 fracture (5%) and five patients had type C2 fracture (25%). This means that 14(70%) patients had extra-articular fractures (type A) and 6 (30%) had simple intra-articular component fractures (type C1, C2).[11]

The minimum time lapse before surgery was one day and the maximum was 14 days with a mean of 4.6 days. Fifty percent of the patients were operated upon within three days, 35% within 3-8 days , 15 % within 8-14 days . Reasons for delay of the surgery were mainly due to the bad general condition of the patient or the local soft tissue condition.

All patients were subjected to clinical and radiological examination in order to collect the data needed for analysis of the results.

An approval was given by the institutional review board (IRB) and informed consent was obtained from each patient.

### Operative treatment:

- Anaesthesia: Spinal anaesthesia.
- Patient positioning:

The patient was positioned supine. A towel bump was then placed under the ipsilateral buttock to counteract the normal external rotation of the lower limb. Operative intervention was performed on a completely radiolucent table, which allows complete imaging of the lower leg. Preparation and disinfection of the entire limb including the iliac crest to allow for complete exposure of the proximal femur and hip region, especially if the longer 13-hole plate was to be utilized .Closed reduction was performed utilizing various reduction techniques.

### 1-If no intra-articular extension (AO A1-3 Fracture Patterns) :

A 3-cm distal lateral incision was made just proximal to the lateral epicondyle. The incision is sharply continued through the iliotibial band and underlying vastus lateralis in line with their fibers. The plate was then submuscularly introduced and passed deep the vastus lateralis along the lateral femur by the MIPO technique. Fig.2



**Fig.2:** Submuscular insertion of the plate by MIPO technique in a case of extra-articular supracondylar distal femoral fracture

## 2- If Intra-Articular Extension (AO C1–3 Fracture Patterns):

A 5-cm skin straight incision approximately 2 cm lateral to the midline of the patella was made then lateral parapatellar arthrotomy was done by Sharp dissection through the subcutaneous tissue to the level of the extensor retinaculum, then deep to the articular surface. Visualization, anatomical reduction, and fixation of the articular surface.

After the articular block has been reconstructed, the plate is passed submuscularly beneath the vastus lateralis after indirect reduction of the metaphyseal fracture has been achieved by the MIPO technique .

Stitches were removed 10-15 days postoperatively. Patient examination and radiological evaluation was carried out monthly. Follow up of all patients continued for at least six months.

The data collected from patients was evaluated using the functional evaluation scoring system described by Sanders et al [12] for distal femoral fractures at the last follow up of each patient.

Excellent= 36-40 points, Good = 26-35 points, Fair = 16-25 points, Poor= 0-15 points.

Excellent and good results were considered satisfactory, fair and poor results were considered unsatisfactory.

### Statistical analysis:

Statistical analysis was performed using the statistical program for the social sciences (SPSS), IBM, New York, United States version 20. The following formulae were used for analysis (Arithmetic mean ( $\bar{X}$ ), Standard

deviation (SD), The “t” test, Chi-square ( $X^2$ ). The results were considered to be significant at P value less than 0.05.

## Results

The mean of follow up duration was 26 months (range; 15 to 36 months). The overall final results were **excellent** in four patients (20%), **good** in twelve patients (60%), **fair** in two patients (10%) and **poor** in two patients (10%). (Fig.3)

**Union:** The mean time of radiological union, in which bony trabeculae crossed the fracture gap, was  $3.45 \pm 0.79$  months (range 2.5 – 5.5 months). 45% of the patients achieved radiological union within 3 months, 40% within 4 months and 15% more than 4 months.

**Knee flexion:** The mean range of knee flexion score at the end of follow up was  $3.60 \pm 2.21$  points (100-124 degrees) 20% of the patients did not reach 90 degrees of flexion by the end of the follow up.

**Knee Extension :** The mean knee extension score at the end of follow up was  $2.95 \pm 0.22$  points with 95 % of patients achieving full extension (0 degree)

**Pain:** The mean pain score was  $5.45 \pm 2.28$  ( occasional pain) at final follow up.

### Deformity:

**A. Angulation:** The mean score of angulation was  $2.65 \pm 0.49$  ( less than 10 degrees varus or valgus angulation) at the end of follow up.

**B. Shortening:** The mean amount of shortening score at final follow up was  $1 \pm 0.15$  (<1.5 cm).

**Walking ability:** The mean score of walking ability at the end of follow up was  $3.70 \pm 1.75$  (Walking up to 60 minutes)

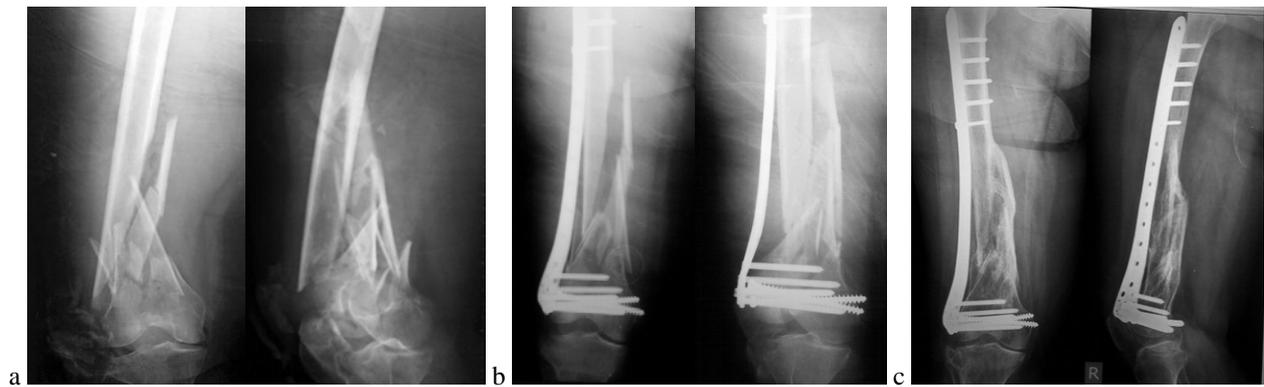
**Stair climbing:** The mean score was  $1.90 \pm 0.85$  (stair climbing while holding the rails)

**Return to work:** Eighty percent of the patients returned to their pre-injury job or life style at the end of follow up. The mean score at final follow up was  $4.0 \pm 1.84$ .

### Factors affecting the final outcome: (Table 1)

The younger the age of the patients the better were the results. However the relation between the age and the final score was statistically insignificant.

Male patients achieved better results than female patients. However, this was proved to be statistically insignificant. There was no statistically significant relationship between the side of the patient affected and the final outcome.



**Fig.3.**a.Pre-operative antero-posterior(AP) and lateral views of an 80 year old female who sustained a closed intraarticular (AO type C2) supracondylar fracture of her right femur after road traffic accident. **b.** Immediate post-operative AP and lateral views. Fixation with LISS locked plate. **c.** post-operative AP and lateral views at final follow up .the fracture was united after 3 months. The final score was satisfactory with good knee flexion.

The lower the BMI of the patients, the better were the results. However this relation was proven to be statistically insignificant. Excellent and good results were achieved in 57% of the house wives, 75% of the manual workers, 100% of the office workers. However, these differences were statistically insignificant.

Nine patients (45%) were injured due to high energy trauma such as road traffic accidents (RTA). Whereas eleven patients (55%) were injured due to low energy trauma such as falling at home. The relation between the final results and mechanism of injury was statistically insignificant.

Seventy five percent of the patients who achieved excellent results had no associated medical conditions while 25 % of them had associated medical conditions. It was noted that the two patients who achieved poor results had associated medical conditions. However, these differences were statistically insignificant.

Seventy five percent of patients who achieved excellent and good results had no associated injuries while 25% of them had associated injuries, three patients had associated injuries, one patient achieved excellent final score and two patients achieved good score, However, these differences were statistically insignificant.

There was no statistically significant relation between the time lapse before operation and the final outcome.

Although, fourteen patients (70%) had AO type A (extraarticular) fractures and six patients (30%) had type C (intraarticular) fractures, the differences between the type A and C groups were statistically insignificant.

## Complications

### 1. Knee stiffness:

Knee stiffness with limited range of flexion of vary-

ing degrees occurred in 4 patients (20%). There were not any statistically significant correlation with the preoperative factors (Mechanism of trauma, medical conditions, associated injuries, fracture classification and time lapse before surgery ) ( $p= 0.591, 0.591, 1.000, 0.857$  and  $0.309$  respectively)

### 2. Shortening:

Five patients (25%) had shortening of less than 1.5 cm. Two/five patients achieved fair final score and one patient achieved poor final score. Shortening had no statistically significant relation with the previously mentioned pre-operative factors (  $p= 1.000, 1.000, 1.000, 1.000$  and  $0.394$  respectively).

### 3. Infection:

Infection occurred in two patients (10%). The first was a 60 year old diabetic female with poorly controlled diabetes who had an AO type A3 supracondylar fracture. The wound was managed by debridment , irrigation and proper antibiotics were given. Remarkably the fracture was healing quite well and the patient showed no more signs of infection.

The second patient was a 55 year old diabetic female who had an AO type C2 supracondylar fracture. She presented with a small oozing sinus 4 months post-operatively which was cultured and treated with antibiotics. At nine months of follow up the fracture had healed and the patient was fully weight bearing.

### 4. Delayed union:

Delayed union is considered if the fracture did not unite after four months. Delayed union occurred in 2 patients (10%). The first was a 65 year old female housewife who was diabetic and hypertensive . She had AO type C1 supracondylar fracture. The X- ray showed full union at the six month post operatively, her final score was fair.

The second patient was 62 year old female housewife who had diabetes, ischemic heart disease and hypertension, she had AO type A1 supracondylar fracture. She had body mass index of 32. She did physio-

therapy for only 2 weeks and the radiological union started to appear at the fifth month postoperatively and showed full union at the seventh month postoperatively, her final score was poor.

**Table 1:** Factors affecting the final score

|                                      | Score        |       |              |       |              |      |                   |      | MCP   |
|--------------------------------------|--------------|-------|--------------|-------|--------------|------|-------------------|------|-------|
|                                      | Poor (n = 2) |       | Fair (n = 5) |       | Good (n = 9) |      | Excellent (n = 4) |      |       |
|                                      | No.          | %     | No.          | %     | No.          | %    | No.               | %    |       |
| <b>Age</b>                           |              |       |              |       |              |      |                   |      |       |
| <20                                  | 0            | 0.0   | 0            | 0.0   | 0            | 0.0  | 1                 | 25.0 | 0.224 |
| 20 – 40                              | 0            | 0.0   | 0            | 0.0   | 1            | 11.1 | 1                 | 25.0 |       |
| 41 - 60                              | 1            | 50.0  | 2            | 40.0  | 7            | 77.8 | 2                 | 50.0 |       |
| > 60                                 | 1            | 50.0  | 3            | 60.0  | 1            | 11.1 | 0                 | 0.0  |       |
| <b>Sex</b>                           |              |       |              |       |              |      |                   |      |       |
| Male                                 | 0            | 0.0   | 1            | 20.0  | 3            | 33.3 | 2                 | 50.0 | 0.750 |
| Female                               | 2            | 100.0 | 4            | 80.0  | 6            | 66.7 | 2                 | 50.0 |       |
| <b>Side</b>                          |              |       |              |       |              |      |                   |      |       |
| Left                                 | 2            | 100.0 | 2            | 40.0  | 2            | 22.2 | 2                 | 50.0 | 0.234 |
| Right                                | 0            | 0.0   | 3            | 60.0  | 7            | 77.8 | 2                 | 50.0 |       |
| <b>BMI</b>                           |              |       |              |       |              |      |                   |      |       |
| ≤ 25                                 | 0            | 0.0   | 2            | 40.0  | 2            | 22.2 | 2                 | 50.0 | 0.093 |
| > 25 - 30                            | 0            | 0.0   | 3            | 60.0  | 2            | 22.2 | 2                 | 50.0 |       |
| > 30                                 | 2            | 100.0 | 0            | 0.0   | 5            | 55.6 | 0                 | 0.0  |       |
| <b>Job</b>                           |              |       |              |       |              |      |                   |      |       |
| House wife                           | 2            | 100.0 | 4            | 80.0  | 6            | 66.7 | 2                 | 50.0 | 0.261 |
| Manualwork                           | 0            | 0.0   | 1            | 20.0  | 3            | 33.3 | 0                 | 0.0  |       |
| Clerks                               | 0            | 0.0   | 0            | 0.0   | 0            | 0.0  | 2                 | 50.0 |       |
| <b>Mechanism of trauma</b>           |              |       |              |       |              |      |                   |      |       |
| Falling at home                      | 2            | 100.0 | 4            | 80.0  | 4            | 44.4 | 1                 | 25.0 | 0.262 |
| RTA                                  | 0            | 0.0   | 1            | 20.0  | 5            | 55.6 | 3                 | 75.0 |       |
| <b>Associated medical conditions</b> |              |       |              |       |              |      |                   |      |       |
| No                                   | 0            | 0.0   | 1            | 20.0  | 5            | 55.6 | 3                 | 75.0 | 0.263 |
| Yes                                  | 2            | 100.0 | 4            | 80.0  | 4            | 44.4 | 1                 | 25.0 |       |
| <b>Associated injuries</b>           |              |       |              |       |              |      |                   |      |       |
| No                                   | 2            | 100.0 | 5            | 100.0 | 7            | 77.8 | 3                 | 75.0 | 0.672 |
| Yes                                  | 0            | 0.0   | 0            | 0.0   | 2            | 22.2 | 1                 | 25.0 |       |
| <b>Time lapse before operation</b>   |              |       |              |       |              |      |                   |      |       |
| ≤ 3                                  | 2            | 100.0 | 3            | 60.0  | 4            | 44.4 | 1                 | 25.0 | 0.819 |
| > 3 – 8                              | 0            | 0.0   | 1            | 20.0  | 4            | 44.4 | 2                 | 50.0 |       |
| > 8                                  | 0            | 0.0   | 1            | 20.0  | 1            | 11.1 | 1                 | 25.0 |       |
| <b>Fracture classification</b>       |              |       |              |       |              |      |                   |      |       |
| A <sub>1</sub>                       | 1            | 50.0  | 1            | 20.0  | 3            | 33.3 | 3                 | 75.0 | 0.104 |
| A <sub>2</sub>                       | 0            | 0.0   | 0            | 0.0   | 0            | 0.0  | 1                 | 25.0 |       |
| A <sub>3</sub>                       | 1            | 50.0  | 0            | 0.0   | 4            | 44.4 | 0                 | 0.0  |       |
| C <sub>1</sub>                       | 0            | 0.0   | 1            | 20.0  | 0            | 0.0  | 0                 | 0.0  |       |
| C <sub>2</sub>                       | 0            | 0.0   | 3            | 60.0  | 2            | 22.2 | 0                 | 0.0  |       |

\*Significant= p value <0.05

## Discussion

Fractures of the distal femur present many challenges for treatment, with numerous fixation methods having been designed to improve stability and promote healing. The results obtained were compared with the results of other studies that used the same method of treatment. Kayali et al (2007).[13] conducted prospective observational study to 26 patients with 27 supracondylar fracture femur, the mean age of the patients was 49 years (range 26–80 years) There were 14 supracondylar (AO type A) and 13 intercondylar (AO type C) fractures, Clinical assessment was conducted at least 6 months post-operatively , the results were

excellent in six (22%) cases, good in 15 (56%) cases, fair in four (15%) cases, and poor in two (7%) cases.

Wanga SH et al (2019) <sup>(1)</sup> reported the results in 29 patients treated by distal femoral locked plate inserted by MIPO technique, six (21%) patients had nonunion requiring bone graft and 3 (10.5% ) had Varus malalignment.

In this study the mean period to fracture union was 3.45 ± 0.79 months (range 2.5 – 5.5 months). All fractures united without primary or secondary bone grafting. Forty five percent of the patients achieved radiological union within 3 months, 40% within 4

months and 15% more than 4 months. In the study of **Kim JW et al** (2017) <sup>(14)</sup> of 51 patients with distal femoral fractures with a mean age of 54.3 years (range, 13–98 years) treated by the same technique. They reported primary bony union was achieved in 44 (86.3%) of 51 patients at an overall average of 18.6 weeks after surgery (range, 12–28 weeks). They had 8 cases of non-union, all were healed after bone grafting and/or calcium sulfate bone graft substitute. Three patients needed implant change. Revision surgery was performed in 2 patients secondary to coronal and rotational malalignment.

Measurement of the range of motion (flexion/extension) yielded a mean of 112 (100–124 degrees) in type A fracture and 96° (30° - 125°) in type C fractures. There was only one case (5%) that failed to achieve full knee extension, seven (35%) patients showed less than (10 degrees) valgus or varus angulation. Shortening was recorded in 5 (25%) cases; all of them were less than 1.5cm. In the study of **Kim JW et al** (2017) [14], they reported that coronal and sagittal alignments were satisfactory in 96.2% whereas the rotational alignment was satisfactory only in 56.9% of patients.

In the study of **Fankhauser et al** (2004) [15], they treated 30 distal femoral fractures (type A and C) using the LISS and patients were followed up for a mean period of 20 months. They reported a mean period of union of 12 weeks with a range of 8–23 weeks and the time till full weight bearing ranged from 6 to 18 weeks. The mean knee range of motion was 113° (90° -140°) in type A fractures and 101° (60° - 130°) in type C fractures.

**Schutz et al** (2005) [16] treated 66 distal femoral fractures using the LISS and patients were followed prospectively for 12 months. Complete fracture healing was achieved in 85% of patients. valgus/varus angulation occurred in 26% of the cases. Flexion of the injured limb was on average 80% of the range of the uninjured limb. An extension deficit of more than 5° was measured in 3 cases. Six patients required bone grafting and 3 refixation of the implant due to implant loosening.

**Kolb et al** (2008) [17] in a retrospective consecutive study, recorded 50 patients who were treated with the LISS. The mean follow-up was 29 months (15–48 months). A revised osteosynthesis was performed for correction of a valgus deformity of 20 degrees after 4 months. There was no difference in leg length exceeding 2 cm. One patient had a valgus deformity of 10 degrees combined with a rotational deformity of 10 degrees. Range of motion of the knee joint was more than 120 degrees.

According to the results of this study, the younger the age of the patients the better were the results. However the relation between the age and the final score was statistically insignificant. As regards the mechanism of trauma, 33% of the high energy fractures achieved excellent outcomes while 9% of the low energy fractures achieved excellent outcomes which can probably be attributed to the older age group and the poor bone quality of the low energy patients.

**Fankhauser et al** (2004) [15] reported that the outcome depends primarily on the etiology of the fracture, the severity of the injury, concomitant trauma, bone quality and the time elapsed from injury to surgery. He also reported that intraarticular type C fractures tend to have poorer results as regards pain and function.

**Schutz et al** (2005) [16] looked at the relationship between fracture type, patient's age, mechanism of trauma, type of reduction, or soft-tissue injuries and the outcome parameters that he measured (fracture healing, weight-bearing, axial relationships and range of motion) and found no statistical significance to it.

**Thomson et al** (2008) [18] assessed the factors that might influence knee function and the development of secondary osteoarthritis at long-term and the results showed that age at the time of trauma does not seem to be of any significance. despite the fact that older patients have a prolonged hospital stay period.

Authors that used MIPO technique reported that it increases union rates and reduces infection rates as well as providing proper fixation to maintain fracture alignment in high-energy and mechanically unstable fractures.[15, 16]

LISS system showed biomechanical superiority over a variety of other devices that have been commonly used in the treatment of supracondylar femoral fractures including the supracondylar nail (SCN), the condylar blade plate, the dynamic condylar screw (DCS) and the condylar buttress plate (CBP).[19] In this study we did not report any implant failure.

The Supracondylar nails are not sufficient for stabilizing fragmented articular fractures.[19] There were some reported complications with the SCN included knee stiffness with loss of flexion, anterior knee pain, nail protrusion, loss of reduction and locking screw breakage. [20] Others reported femoral shaft fracture during reaming, implant failure and locking screws missing the nail. Protruding nails can cause significant damage to the patellofemoral joint. [21]

Some reported deep infection in 5–8%, non-union in 0–7% and malunion in 5–19% of cases treated with plates through ORIF technique. [22]

Shortening in this series occurred in 5 patients (25%) who had shortening of less than 1.5cm. Few authors commented on shortening as a complication of surgery in distal femoral fractures perhaps because it is a problem rarely encountered with the new implants and because of the bigger concern about more serious complications like varus angulation .

In this series, infection occurred in two patients (10%). Both of them were uncontrolled diabetic patients . **Kolb et al** (2008)[17] found that the infection rate of the LISS was 3% and the compression plating with the MIPO technique of 2.3% which is less than the 6% infection rate seen with conventional plate osteosynthesis.

Implant loosening did not occur in this series. We attributed that to good surgical technique and all proximal screws were bicortical .**Weight et al** (2004)[22] had no cases of fixation failure or implant breakage, and no fracture required bone grafting. **Schandelmaier et al** (2001) [23] found 4 patients whose fixation failed due to proximal screw pullout. In their series all proximal screws were unicortical.

The early early results in this study are encouraging but long term studies are needed to prove definitively acceptable outcomes.

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## Conclusions

Accurate positioning and application of locking plates through minimally invasive approach is relatively easy, safe and provide angular stability. It helps to preserve periosteal blood supply, provide better purchase and stability in osteoporotic bone, decrease the need for primary bone grafting .They provide reliable fracture healing in good alignment and permit early range of motion even in complex and osteoporotic fractures.

## Conflict of interest:

The authors declare no conflict of interest.

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