Functional and Radiological Outcome of Longer Lever Arm Plates with Minimally Invasive Plate Osteosynthesis (MIPO) in AO Type C Distal Femoral Fracture

Muhammad Khalid ur Rehman, Muhammad Hanif, Imran Ghani

ABSTRACT

Objective: To evaluate the functional and radiological outcome in AO type C, distal femoral fractures using longer lever arm anatomical plates with minimally invasive plate osteosynthesis (MIPO) technique.

Methods: This prospective cases series was done using probability sampling technique at two centers including Orthopedics and Spine Institute, Doctors Hospital, Medical Center, Lahore and Department of Orthopedics Surgery and Traumatology, Post-graduate Medical Institute, Lahore General Hospital, Lahore from January 2016 to August 2017. AO type C close distal femoral fractures fulfilling the inclusion criteria were included in the study. We fixed all fractures with longer lever arm anatomical plates with minimally invasive plate osteosynthesis (MIPO) technique. On each follow up patients were assessed using American Knee Society Score(AKSS) for functional outcome and x rays for union. SPSS version 20.00 was used to analyze the data and p-value <0.05 was taken as significant.

Results: Out of the total 35 cases there were 21 (60%) males and 14 (40%) females. The mean age of the patients was 39.7429±12.577. There was primary union in 31 (88.6%) cases and non-union in two (5.8%) cases, delayed union in two (5.8%) patients. Amongst 35 cases, 32 (91.4%) didn't required bone graft and only 03 (8.6%) had primary bone grafting due to severe comminution. Post-operatively American knee society score was excellent in 24 (68.4%), good in 6 (16.1%), fair in 04 (11.4%) and poor in only 01 (2.9%) patient.

Conclusion: Longer lever arm plates with MIPO has good to excellent results regarding union, knee range of motion and minimal infection.

Key Words: American Knee Society Score, AO Type C, Longer lever arm plates (LLAP), Union.

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INTRODUCTION

Femur distal end comminuted fractures, intra-articular remain the most challenging fractures for orthopedics surgeons, and they account for 4-7% of all fractures of femur. [1-4] The incidences are increasing with the time, highest in older aged women and adolescent between 15 to 24year old boys.[5] Locked plates provide better stability in poor bone quality or comminution. They are also used as an alternative to non-locking condylar plates, intra-medullary nail and blade plates.[6]

Department of Orthopaedics, Lahore General Hospital, Lahore
Correspondence: Dr. Khalid ur Rehman
Email: rehmansurgeon@gmail.com

Distal femur fracture with extensive comminution were fixed with angle devices or retrograde nail. Historically, they were associated with non-union or mal-union. These fractures were also fixed with medial and lateral plates prior to advent of locking plates. It results into surgical insult by hampering fracture Physiology.[7, 8] The forces applied in this area even in restricted activity are high and broad canal with thin cortex in distal end of the bone requires stable implant. Inadequate fixation and in-appropriate implant choice has resulted into non-union. Angled blade implant including dynamic condylar plate is forgiving to soft tissue, provides correction in sagittal plane after lag screw insertion and most commonly used device for such fractures.[9]

Locked plates with fixed-angle screws provides better fixation strength of plate construct and interfragmentary compression is not achieved when they are used as bridge plates in comminuted fractures, therefore healing occurs with secondary intention. [10, 11]

The objective of our study was to determine the functional and radiological outcome of AO type C, distal femoral fractures fixed with longer lever arm anatomical plates with minimally invasive plate osteosynthesis (MIPO) technique.

METHODOLOGY

This prospective cases series was done using non-probability convenient sampling technique at two centers including Orthopedics and Spine Institute, Doctors Hospital, Medical Center, Lahore and Department of Orthopedics Surgery and Traumatology, Post-graduate Medical Institute, Lahore General Hospital, Lahore between July 2015 to August 2017. We included 35 cases within two weeks after injury between 20 to 70 years of age with AO type C close distal femoral fractures admitted through emergency and out-patient department (OPD) of the hospital diagnosed on history, clinical examination, conventional radiographs and later 3D-CT scan wherever needed. We excluded patients with open fractures, head injury, multiple fractures, deranged RFT's, LFT's and uncontrolled diabetes mellitus.

After approval from ethical board, and explaining procedure, the purpose of the study, an informed written consent was obtained. We designed questionnaire after reading books, literature search and later on proof reading by the Heads of both institutions. All patients were administered with injection cefuroxime 1.5gm half an hour before surgery and twice a day till 48 hours postoperatively. All patients were operated under spinal anesthesia. We fixed all fractures with longer lever arm anatomical plates with minimally invasive plate osteosynthesis (MIPO) technique. We augmented union with primary bone graft in three cases with severely comminuted fractures. The partial weight bearing was started between 06 to 08 weeks.

Union was evaluated clinically and radiologically. We followed all patients till confirmed radiological and clinical union, first follow up was done two weeks after discharge from the hospital, subsequently at 6^{th} 12^{th}, weeks, and 6^{th} and 9^{th} months. On each follow up patients were assessed using American Knee society score for functional outcomes. The reported cases with infection were treated with implants removal, and application of external fixator with serial debridement's and anti-biotics according to culture and sensitivity. After eradication of infection, internal fixation was done, and cases were followed till union occurred.

SPSS version 20.00 was used to analyze the data and variables included gender, side of the limb was presented as frequency and quantitative variables like age, American knee society functional score was presented as mean and standard deviation. Paired t-test was applied as test of significance and p-values <0.05 was taken significant.

RESULTS

Out of the total 35 cases there were 21 (60%) males and 14 (40%) females. The mean age of the patients was 39.7429±12.577. The mean union time was 18.5±2.8 weeks with minimum 15 week and maximum was 23 weeks. There were 19 (54.3%) right sided and 16 (45.7%) left sided limb involvement. There was primary union in 31 (88.6%) cases and non-union in two (5.8%) cases, delayed union in two (5.8%) patients. Out of two cases of non-union, one patient had deep infection and one patient had implant failure. Amongst 35 cases, 32 (91.4%) didn't required bone graft and only 03 (8.6%) had primary bone grafting due to severe comminution. Post-operatively American knee society score was excellent in 24 (68.4%), good in 6 (16.1%), fair in 04 (11.4%) and poor in only 01 (2.9%) patients (Table 01). Paired t-test was applied between age of the patient and week of union which was found significant with p-value <0.001 (Table 02).

Table 1: Demographic data, age, side, union, AKSS and primary bone graft

Variables	Frequency (N=35)	Percent (%)
Gender		
• Male	21	60%
• Female	14	40%
Age in years	Mean 39.7429±12.575 (21 to 65year)	

Side of the patient		
• Right side	19	54.3%
• Left side	16	45.7%
Union		
• Primary union	31	88.6%
• Delayed union	02	5.8%
• Non-union	02	5.8%
Post-op AKSS		
• Excellent	24	68.4%
• Good	6	16.1%
• Average	04	11.4%
• Poor	01	2.9%
Primary Bone Grafting		
• **Yes**	03	8.6%
• **No**	32	91.4%

* (AKSS) American Knee Society Score

Table 2: Paired t Test of Age of the Patients with Union in Weeks

Variables	n	Mean	Standard Deviation	t	p-value
• Age of the patient with union time (weeks)	35	21.9	10.72	23.68	<0.001

Figure 1: A case with comminuted distal femur fracture treated with Longer lever arm plates with intervals screws.

DISCUSSION

Distal femoral AO type C injuries are complex injuries and irrespective to advances in fixation mechanics, plate designs and fixation techniques, they pose a challenge for Orthopedic Surgeon. With the introduction of locked plates, they can be used to bridge the comminuted area of the distal femur due to the fixed angle construct. It also improves the mechanics due to better security at the bone-screw interface.[5] Longer lever arm plates improve the mechanical stability at fixation site. They work as internal fixator and through minimally invasive percutaneous osteosynthesis (MIPO) technique, there is less soft tissue injury and fracture biology is least likely to be affected.

Data has reported the importance of appropriate implant choice and their clinical and functional outcome.[2,12] Intra-articular fractures need accurate reduction and comminution with gap defect after fixation sometimes required bone graft for early union. The mean age in our population was 39.7429±12.577 with minimum age of 21 years and maximum age of 65 years while in another study, the mean age was 68.75±3.31year.[13] this difference in age group was due

to the inclusion of different age groups in our study. Contrary to the above dated the mean age was 32year and that was similar to the age of patients reported in our study.[14]

In this study, the mean union time was 18.5±2.8 weeks with minimum of 15 week and maximum was 23 weeks which was high when compared with another study which was reported as 16.2weeks (ranging from 13 to 28 weeks)[14] and it was similar to Virk et al. whose reported mean age was 19 weeks till union.[15] In our study, the fracture united in shorter time. The relative shorter period of union was due to the cornerstone role of bone graft in severely comminuted fracture, use of long lever arm plates that provided stable fixation with acceptable reduction and minimal affect **to** fracture biology due to MIPO technique. This technique with longer lever arm plates also help achieved better results in this study with prevention of second intervention in same population.

Philip[16] reported the effect of secondary bone graft in patients with non-union and delayed union in patients with comminuted distal femur fractures. He reported that 7% fractures fail to heal with secondary procedure even with bone grafting. Another study attributed the early union with primary bone grafting in comminuted fractures.[17] Pascarella et al[18] reported in his study about the effect of cancellous grafts in patients after 32 weeks of first operation in terms of union after 3.5 weeks of bone grafting and Zlowodzki[19] declared that one of the technical error associated with failure of fixation was delayed bone grafting in patients with bone defect.

The standard management of internal fixation lies between bone healing and implant failure. There are increase chances of implant failure without adequate fixation and callus formation. In fractures with bone defect, increases load on medial side which may be associated with implant failure, if bone grafting isn't done. Thus, intact or restoration of medial cortex is vital to prevent implant failure. Therefore, adding bone graft with locked plate gives strength with early callus formation.[20] We hypothesized that longer lever arm plates are mechanically better construct and filling bone defect with primary bone graft helps in early union and better functional outcomes. Our study showed excellent results with this technique, implant choice and primary bone grafting wherever required. When bone defect is large, interfragmentary motion is too little and union may be hampered[21] in locked plate bridge construct union may occur by secondary intention. In locked plates with longer level arm and micromovements at fracture site enhances callus formation. Less number of screws with longer intervals were used in our study along with longer lever arm plates to minimize the rigid construct which yield a primary bone healing**.**

Patients functional status was assessed using American knee society score. It was excellent in 24 (68.4%), good in 6 (16.1%), fair in 04 (11.4%) and poor in only 01 (2.9%) patients, the results are similar to Rizk.[14] Amongst 35 cases, 32 (91.4%) didn't required bone graft and only 03 (8.6%) had primary bone grafting due to severe comminution.

The limitations of our study were small sample size and absence of control group. With randomization of the study population, we can draw a better result. The population with primary bone graft was also low but, the primary union in our study was good and it concludes that our objective was clear and appropriate.

CONCLUSION

We concluded from this study that functional and radiological outcome in severely comminuted distal femur fractures treated with longer lever arm plate produce good to excellent results. We therefore recommend this option as a procedure of choice to treat these fractures.

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Authorship and Contribution Declaration

Muhammad Khalid ur Rehman, Conception and design, Acquisition of data, Interpretation of Data
Muhammad Hanif, Revised the manuscript critically for important intellectual content, Final approval of the version for publication
Imran Ghani, Drafted the manuscript