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RESEARCH ARTICLE

PERCUTANEOUS LOCKING PLATES FOR FRACTURES OF THE DISTAL TIBIA: OUR EXPERIENCE AND A REVIEW OF LITERATURE

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ABSTRACT

Background: Distal tibia fractures are rare fractures of lower limb. This study assessed the outcomes of distal tibial fractures treated with percutaneous locking plates.

Methods: 50 patients were selected based on the fracture pattern and classified using the AO classification and stabilized with medial tibial locking plate. Time to fracture union, complications, and outcomes were assessed with the American Orthopedic Footand Ankle Society Ankle score at 14 months.

Results: Out of 50 patients 37 were males and 13 were females. The mean plate hole was 12.08±1.82. Mean proximal screw was 3.94±0.42. Mean distal screw was 4.12±0.22. Mean no. of compressions were 0.56±0.76. Mean operative time was 82.66±23.56 min while union was 4.98±1.58 months. 44(88%) patients gave satisfactory results. It was found that there is no significant association of satisfactory result were observed with gender, injury, fracture type, fibula fracture and fibula fixation.

Conclusions: Distal tibial locking plates have high fracture union rates, minimum soft tissue complications, and good functional outcomes. The literature shows similar fracture union and complication rates using locking plates.

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INTRODUCTION

Distal tibia fractures are rare fractures of lower limb. They account for less than 1 percent of all fractures of lower extremity. They involve weight bearing articular surface and overlying metaphysis. (Bartlett *et al*., 2008) These fractures are usually caused by high energy axial forces which account for severe soft tissue damage. (Bartlett *et al*., 2008) The management of complex distal tibial fractures is challenging and triggers debate among trauma surgeons regarding optimal surgical treatment. (Ahmad *et al*., 2012) The most important variables that affected the final clinical result are the type of fracture, associated soft tissue injury, the method of treatment and the quality of the reduction. (Ranjeesh and Renu, 2013; Ovadia and Beals, 1986; Streicher and Reilmann, 2008) Distal tibia fractures classified by AO as extra articular, partial articular and complete articular. (Ruedi and Murphy, 2000) In literatures the treatment options for distal tibia fractures are open reduction and internal fixation (ORIF), interlock nailing, external fixators and minimally invasive bridge plating. However these treatment modalities are not without complications. Open reduction and internal fixation (ORIF) can result in wound infection and dehiscence. External fixators and interlocking nails undoubtly minimize soft tissue trauma but their use is complicated by malunion, nonunion, imperfect reduction and pin tract infection. (Shindle *et al*., 2012) Intramedullary nails are technically very demanding, however minimally invasive techniques are best as they do not require large exposure for reduction. (Francois *et al*., 2004) Percutaneous fracture fixation of tibial fractures has been shown to be a successful technique with minimal complications. (Redfern *et al*., 2004; Hasenboehler *et al*., 2007) The minimally invasive plate osteosynthesis (MIPO) technique as a treatment for distal tibial fractures is gaining acceptance nowadays. Minimally invasive surgical approach for the stabilization of distal tibia fractures is desirable since it reduces the risks of soft tissue and bone healing disturbances. (Cheng *et al*., 2011; Lau *et al*., 2008) The locking compression plate (LCP) provides enhanced stability with a minimum number of screws. Therefore, it acts like a closed external fixator. (Egol *et al*., 2004) These plates are designed to apply in minimally invasive fashion to preserve local biology and avoid problems with fracture healing and infection. (Nork *et al*., 2005)

Several minimally invasive plate osteosynthesis techniques have been developed, with unionrates ranging between 80% and 100%. (Francois *et al*., 2004; Toms *et al*., 2004; Vallier *et al*., 2008) These techniques aim to reduce surgical trauma and to maintain a more biologically favorable environment for

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fracture healing. Nevertheless, complications, such as angular deformities greater than 7^0 (range, 7.1%–35%). (Vallier *et al*., 2008; Khoury *et al*., 2002) hardware failure (range, 0–10%), (Khoury *et al*., 2002; Zou *et al*., 2013) and nonunions (range, 0–20%) have been reported. (Zou *et al*., 2013) Early detection and appropriate treatment of these fractures are critical in minimizing patient disability and reducing the risk of documented complications. Careful and thorough assessment of severity, with particular attention to identifying high-energy injuries, is critical in achieving optimal outcomes and avoiding complications. (Dirschl and Del Gaizo, 2007) Literature reported that very few studies have been conducted in local population to assess the functional outcome of distal tibia fractures treated with percutaneous locking compression plate using minimally invasive plate osteosynthesis technique. The reason for conducting this study is to assess the satisfactory outcome of this technique. Insertion of implant through limited incision is a newer technique and is gaining acceptance.

MATERIALS AND METHODS

We retrospectively report a series of patients who were treated for fractures of the distal tibial in January 2015 to May 2016. Patients of either sex having age 18 years to 60 years were taken. Inclusion criteria were the distal tibia fracture with closed fractures of either type. Exclusion criteria were diaphyseal fractures, non rec onstructable pilon fractures requiring fine wire external fixation, and open fractures. Each fracture was classified retrospectively according to the AO classification and confirmed by an independent observer. Patients who will fulfill the inclusion criteria will be included in this study. An approval from institutional ethical review committee was taken. All risk and benefits was discussed with each patient and after explaining the purpose of the study a formal written and verbal informed consent were taken from the patients in both English and Urdu Languages. The radiographs of all distal tibial fractures were taken to generate our patient group. Physical and radiological examination was done by principal investigator. All patients was operated using a standard prescribed surgical technique in arms by the experienced surgeons having ≥ 5 year experience. A 3.5-mm locking compression plate (LCP) plate was inserted subcutaneously through a 3-cm incision over the medial malleolus to act as a bridging device across distal tibia fracture. The plate was secured onto the tibia with the fracture reduced using pointed reduction clamps. Patients were follow up protocol at 2^{nd} and 6^{th} week, and 3, 6, 10, and 14 months after operations. On follow up, patients were asked to answer AOFAS questionnaire.

American Orthopaedic Foot and Ankle Score (AOFAS)

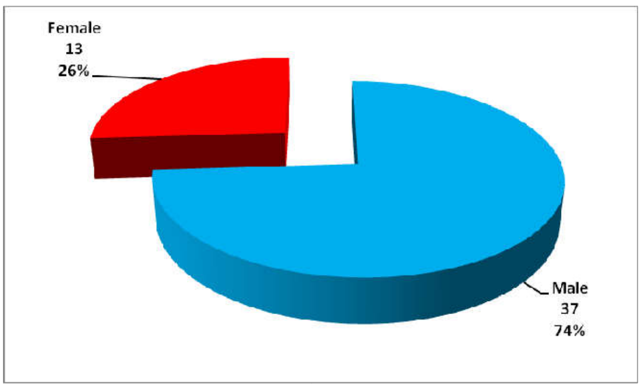
The AOFAS is a 09-item questionnaire intended to assess the function and symptoms of persons with disorders of the foot and ankle. It comprises of a score that is meant to assess the functional outcome of foot and ankle with respect to pain, function and alignment of ankle and foot. Ankles are examined for pain, activity limitations, maximum walking distance, walking on a surface, gait abnormality, stability in flexion and extension, inversion and eversion, anteroposterior and varus-valgus and alignment. The maximum functional score for each ankle is 100 points. This includes pain (40), function (50) and alignment (10). Deductions are made for flexion extension or varus-valgus abnormality and alignment. Score of 75 or more is taken as satisfactory and less than 75 is unsatisfactory. Demographic, observational, and AOFAS score data was collected. Confounding variables as well as bias will be controlled by strictly following the exclusion criteria. On follow up at 6 weeks patients were assessed by pain at fracture site, stiffness, ankle function and range of motion and X-ray assessment of union and implant status. At 3, 6, 10, and 14 months fracture union were assessed clinically and radiologically. Any complications will be noted. At 6 months assessment of results with reference to scoring system for ankle function will be noted and if it is ≥ 75 than labeled as satisfactory. Data was entered and analyzed through Statistical Package for Social Sciences (SPSS) Version 21. Mean and standard deviation was calculated for the quantitative variable i.e. age and AOFAS score. Frequency and percentage were calculated for qualitative variables like gender, mode of admission, type of fracture, and satisfactory outcome. Effect modifiers were controlled by stratification of age, gender, and type of fracture to observe the effect of these modifiers on outcome through chi square test taking P value ≤ 0.05 will be taken as significant.

Follow-Up

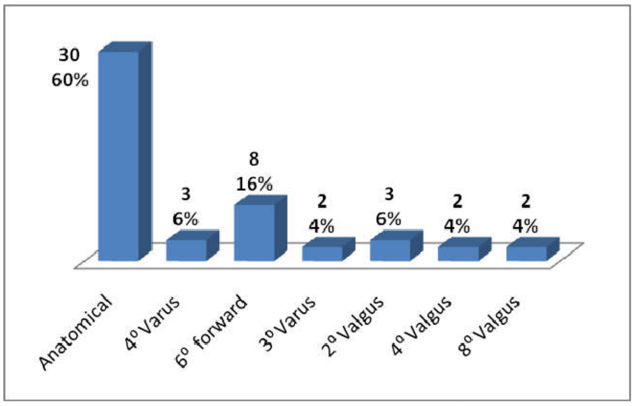
At follow-up the patients answered a questionnaire and were examined according to a standardized protocol. Medical records and radiographs were assessed. A healing time less than 6 months was considered as normal, whereas a healing time between 6 and 9 months was considered to be a delayed union. Fractures not healed within 9 months were classified as a nonunion. Malalignment was defined as angulation, or rotational deformity of 58 or more. Healing was defined as bridging mature callus combined with pain-free full weight-bearing.

RESULTS

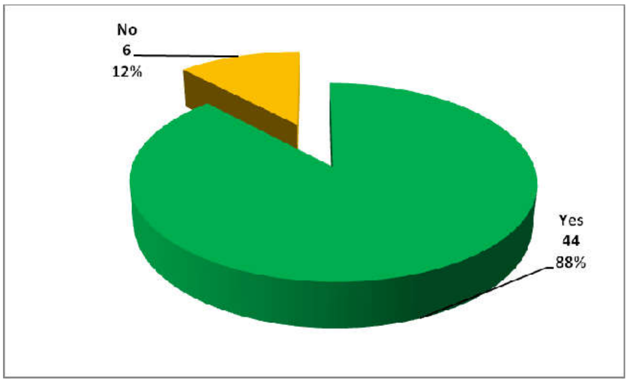
Statistical package for social sciences (SPSS 21) was used for data compilation and analysis. Mean (SD) was calculated for quantitative variables. Frequency and percentage were calculated of qualitative variables. Post stratification, chi-square and fisher exact test was applied to see the association of Satisfactory Result with other factors by considering P-value ≤0.05 as significant. Total 50 patients were Included in Study. Out of 50 patients 37 were males and 13 were females with a male to female ratio of 2.84:1 as presented in Graph 1.Their ages ranged between 18 years to 73 years. The mean plate hole was 12.08±1.82. Mean screw proximal was 3.94±0.42. Operative Time was 82.66±23.56 min while union was 4.98±1.58 months as presented in Table-1.



Graph 1. Frequency and percentage of Gender of Patients



Graph 2. Presenting Reduction Type



Graph 3. Presenting Satisfactory Result

Table 1. Descriptive statistics

	Mean±SD	(Min-Max)
Age	38.74±15.17	18-60
Plate Hole	12.08±1.82	7-14
No of Proximal Screws	3.94±0.42	3-5
No. of Distal Screws	4.12±0.22	3-5
Compression	0.56±0.76	0-3
Operative Time(Min)	82.66±23.56	50-125
Union(Months)	4.98±1.58	4-6
AOFOA Score	86.56±14.43	49-100

Table 2. After 6 Months Follow up Result

After 6 Months follow Up		
		N(%)
Ankle Motion	Normal	27(54)
	-10	11(22)
	-15	10(20)
	-20	2(4)
Ankle Symptoms	Yes	21(42)
	No	29(58)
Walking Ability Reduced	Yes	29(58)
	No	21(42)
Tenderness over plate	Yes	29(58)
	No	21(42)
Stress Concetration	Yes	11(22)
	No	39(78)
Plate Removed	Yes	14(28)
	No	36(72)

Table 3. Frequency of Complications

	n	%
Delayed Union	2	4%
Superficial Wound Infection	1	2%
Implant Failure	1	2%
Prominent and Painful Implant	1	2%
Lost to Follow-up	5	10%
Chronic Osteomylitis	1	2%

Table 4. Association of Satisfactory Result with Gender, Injury, Fracture Type, Fibula fracture and Fibula Fixation

		Satisfactory Result		
		Yes N(%)	No N(%)	P-Value
Gender	Male	34(91.9)	3(8.1)	0.173**
	Female	10(76.9)	3(23.1)	
Injury	Fall From Height	16(84.2)	3(15.8)	0.672**
	Road Accident	15(93.8)	1(6.3)	
	Fall Down	10(90.9)	1(9.1)	
	Sports Injury	3(75)	1(25)	
Fracture Type	Spiral	32(86.5)	5(13.5)	1.000**
	Comminute	7(87.5)	1(12.5)	
	Spiral+Butterfly	5(100)	0(0)	
Fibula Fracture	Yes	35(85.4)	6(14.6)	0.576**
	No	9(100)	0(0)	
Fibula Fixation	Yes	16(88.9)	2(11.1)	1.000**
	No	28(87.5)	4(12.5)	

Chi-Square test was applied
*P-Value≤0.05, Considered as Significant
**P-Value>0.05, Considered as Insignificant

Most common type of reductions were anatomical as shown in Graph-2. Out 50 patients 44(88%) patients gave satisfactory result as presented in Graph-3. After 14 months follow up Ankle Motion, Ankle Symptoms, Walking Ability Reduced, and Tenderness over plate and Stress Concentration were observed and their frequency distribution is presented in Table-2. The complication were observed during follow-up period and presented in Table-3. It was found that there is No significant association of satisfactory Result with Gender, Injury, Fracture Type, Fibula Fracture and Fibula Fixation as presented in Table-4.

DISCUSSION

Distal tibial fractures remain one of the most substantial therapeutic challenges that confront the orthopaedic traumatologist. (Megas *et al*., 2003) The management of distal tibia fractures remains challenging and controversial. (Iqbal and Pidikiti, 2013) Though conservative management of these fractures has been described, these methods have been largely superseded by operative techniques for displaced or irreducible fractures, and fractures with intra-articular extension. (Megas *et al*., 2003; Iqbal and Pidikiti, 2013) MIPO is by now an established technique of management of fractures of the distal third tibia. MIPO of these fractures is technically feasible and advantageous in that it minimises soft tissue compromise and devascularisation of the fracture fragments. (Dickson *et al*., 2001; Collinge *et al*., 2007; Oh *et al*., 2003) With the introduction of Locking Compression Plates (LCP), Minimally Invasive Plate Osteosynthesis (MIPO) has become widely used. The plates act as internal fixators in a bridging manner, thus resulting in secondary bone healing. (Hasenboehler *et al*., 2007) MIPO with LCP for distal diametaphyseal tibia fracture has been found to be an effective treatment option. (Borrelli *et al*., 2002; Ahmad *et al*., 2010; Collinge and Protzman, 2010; Gupta *et al*., 2010; Gao *et al*., 2009) In study, the mean age of 36 years is comparable to the studies. (Zelle *et al*., 2006) The age of the patient had no bearing on the time to union in their study. (Paluvadi *et al*., 2014) In study, the age of the patients ranged from 20 to 56 years with mean age of 36 years. Most of the patients (i.e. 35) were in the age group of 20 to 40 years. There were 35 male and 15 female patients included in the study. The mode of injury in the majority of the patients was road traffic accidents. The majority of the fractures operated in our study were extra-articular fractures, i.e. AO/OTA 43-A (90%). We also operated three (6%) partially articular AO-

OTA 43-B and two (4%) intra articular AO/OTA 43-C fracture in our study. 35 patients (70%) had a both bone leg fracture, with majority of the fibular fractures occurring at the level of the tibial fracture, suggesting a bending mechanism. Out of the 35 patients with an associated fibular fracture, only 8 patients needed fixation of the fibula (22.8%). Of these, 4 fractures were fixed with one third tubular plates and 4 with rush nails. The average duration between trauma and surgery was 4.36 days with a range of 0-12 days. Most of the cases were operated upon within 7 days of injury (86%). (Megas *et al*., 2003)

In study result reported that 66.66% of cases showed radiological union in12 - 20 weeks while in 33.34% it was in 20- 32 weeks. These results are quite comparable to other studies with mean duration of radiological union to be 20.7 weeks (range: 16- 28 weeks) in open and 17.96 weeks (range: 10- 36 weeks) in closed fractures. (Aksekili *et al*., 2012) While another study (Shrestha *et al*., 2011) reported an average duration of 18.5 weeks (range: 14- 28 weeks) for the fracture segment union. In another study, (Helfet *et al*., 1994) there was two stage procedures first they applied external fixator to convert open fractures to close fractures and in 2nd stage MIPO for the close fracture fixation. LCP plating using MIPO causes minimal soft tissue damage. Therefore, it has a biological advantage over ORIF in that it preserves the periosteal blood supply and as a result increases the chance of healing. (Borrelli *et al*., 2002) Collinge and Sanders (2000) have described indirect fracture reduction and percutaneous plating techniques as evolutionary steps in biological plating. Studies (Zelle *et al*., 2006; Perren, 2001) reported good results for MIPO using closed, indirect reduction and contoured dynamic compression plates for distal tibial fractures. (Mushtaq *et al*., 2009) In study, clinical results were evaluated according to the AOFAS score chronologically and at union. In other studies, all of the 50 patients had an AOFAS score of 90 or greater out of a possible 100 points. The mean score was 95.06. Collinge and Protzman (Collinge and Protzman, 2010) reported a good to excellent result with a mean AOFAS score of 85. In the study undertaken by Redfern *et al*. (2004) all patients returned to their pre-injury occupation or level of activity. The mean AOFAS score in the MIPO group of the study by Guo *et al*. (2010) was 83.9. In another study of minimally invasive plate fixation of the distal tibia reported excellent results in11 patients, good in 9, fair in 2 and poor result in one patient. (Vasu *et al*., 2007) On follow up, implant removal was needed in eight patients with symptomatic hardware in our study (16%), compared to 5%-92.7% in other studies. (Megas *et al*., 2003)

The use of distal tibial LCP to fix a spectrum of distal tibial fractures results in early healing of these injuries with minimal complications. Although studies include only a small number of cases, the clinical and radiological results are very encouraging. This technique allows for soft tissue recovery and has gained popularity, as complication rates with this strategy appear to be significantly improved. (Wenda *et al*., 1997; Olerud and Karlstrom, 1972)

Conclusion

The present case series shows that MIPO with LCP is an effective treatment method in terms of union time and complications rate for distal tibia fracture. The MIPO technique is a reliable fixation approach to fractures of the distal ttibia, preserving most of the osseous vascularity and fracture haematoma and thus providing for a more biological repair. The bone healing, though slightly delayed, was universal with this type of fixation. This technique can be used in fractures where locked nailing cannot be done like distal tibial fractures with small distal metaphyseal fragments, vertical split and markedly comminuted fractures. Due to preserved vascularity, there is lesser incidence of delayed union and non-union. There was reduced incidence of infection due to limited exposure. Infection can also be prevented by careful handling of soft tissues and by minimising the operating time.

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