Original Article

Evaluation of the Result of Small Locking DCP Fixation in Danis-Weber Type-C Ankle Fracture

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ABSTRACT

Introduction: *In traditional techniques, it is very difficult to align and stabilize the Danis-Weber type C ankle fracture. Small locking Dynamic Compression Plates (DCP) showed good result for other long bone fracture management. Here, we evaluated the functional outcome of fibula fixation in Weber type C fracture with small locking DCP.* ***Methods and Materials:*** *This was a quasi-experimental study carried out in National Institute of Traumatology & Orthopedic Rehabilitation (NITOR), Bangladesh from July 2014 to July 2016. Twenty patients with Danis-Weber type C ankle (closed) fracture purposively selected and treated with small locking DCP by extra periosteal bridging. The patients' outcome evaluated functionally with the use of American Orthopedic Foot and Ankle Society Score (AOFAS).* ***Results:*** *The mean age of the patients was 36.75 (±8.93). Majority of the patients 15 (75%) were male, and the commonest 14 (70%) cause of fracture was RTA. The mean time interval between operation and injury was 12.25 (±5.12) days and mean duration of the operation was 77.37 (±22.36) minutes. Majority of the patients, 13 (65%) had no post-operative complications. All fractures healed without displacements. The mean AOFAS score was 83.25 (±7.30). Patients had*

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mostly 18 (90%) satisfactory (AOFAS score ≥75) outcome following surgery. A time interval of ≤ 14 days between surgery and operation (p= 0.016), duration of operation ≤120 minutes (p= 0.005), and radiological healing time <16 weeks (p= 0.021) were significantly associated with satisfactory post-operative outcome. ***Conclusions:*** *Overall, post-operative outcome of plating by bridging technique with small locking DCP in Danis-Weber type C ankle fracture was satisfactory. This technique can be an effective method for treating such fractures. However, generalization must be with caution owing to the limitations of the sampling methods and small sample size.*

Keywords: *Ankle joint, ankle fracture, Danis-Weber type C fracture, AOFAS, Dynamic compression plate.*

INTRODUCTION

Ankle fractures are one of the most common type of injuries treated by orthopedic surgeons. Approximately 1 in 7-ankle fracture is accompanied by a distal tibiofibular syndesmotic disruption [1]. Most are low-energy fractures of one or both malleoli, usually caused by a twisting mechanism [2].

Ankle fractures have been the subject of numerous studies and articles regarding the mechanism of injury, classification and treatment modalities [2–6]. A thorough understanding of the ankle anatomy, mechanism of the injury, interpretation of the radiographs and adherence to basic principles of fracture management are the basis for a good results in cases of ankle fracture [3]. The ankle is a mortise joint formed by the lower end of the tibia and fibula articulating with the talus. The muscles and ligaments around the joint, the ankle syndesmosis, and the ankle mortise articulation with the talus body all contribute to the stability of the ankle joint [4]. The lateral and medial columns make up the ankle. The fibula, syndesmosis, and lateral ligaments make up the lateral column. The medial malleolus and the medial collateral ligament, also referred to as the deltoid ligament, make up the medial column [7]. When the fracture is above the syndesmosis, then it is a Danis-Weber type C fracture. The anatomy of the joint often makes the Weber type C fractures unstable [4,7]. The deforming force in this type of fractures (pronation abduction, pronation-external rotation) is translational rather than rotational. The medial structures fail first, and the fibula fracturing last. This usually results in occurrence of a transverse fracture line that is consistent with bending failure, about 5 cm proximal to the joint with lateral comminution [8]. Unstable fractures of Danis-Weber type C type needs surgical management.[3,4] In the operative treatment of displaced ankle fracture, anatomical reduction especially of the lateral malleolus is essential [9]. Reducing and maintaining the talus anatomically within the ankle mortise is the goal of treating ankle fractures [7]. This goal is usually achieved through restoring normal relationship of the ankle mortise, making the weight bearing alignment of the ankle must be at right angle to the longitudinal axis of the leg and smoothening the contour of the articular surface as much as possible. For unstable type C fractures, surgically the best results are obtained by open reduction and internal fixation [3,10].

Lateral comminution of the fibula makes the operative treatment of this type of ankle fracture challenging [8]. Traditional sub-periosteal plating procedures remove the soft tissue that remains around a fracture, making it very difficult to align and support the fragments with a lateral plate. However, using the bridging approach by small locking Dynamic Compression Plate (DCP), the soft-tissue attachments to the fragments of fracture are kept in site, which keeps blood flowing to aid in healing and helps achieve the reduction [11]**.** This bridging with small locking DCP that effectively preserve the periosteum, have been used for the treatment of other long bones [8]. Here, in this scientific endeavor we attempted to find out the functional outcome of DCP fixation for Danis-Weber type C ankle fracture.

MATERIALS AND METHODS

a. Design, place and participants:

This 24 months long quasi-experimental study was conducted in National Institute of Traumatology & Orthopedic Rehabilitation (NITOR), the largest orthopedic hospital of Bangladesh situated in the capital Dhaka. All the patients with ankle fracture presented in the facilities were initially classified with Danis-Weber fracture classification criteria.[4,7] The patients aged between 18-60 years, with no other associated fractures around ankle joint (previous or new), diagnosed with closed type C ankle fracture within 3 weeks of initial assessment were approached for inclusion. An informed written consent that explained the nature and purpose of the study clearly, obtained from each patient included in the study. Twenty-four patients were primarily selected for the study; however, four were lost to follow-up. Therefore, final analysis included data from 20 samples.

b. Assessments and follow-ups:

During the first initial assessment a detailed history including time passed since injury, cause of injury was taken. A through general and physical examination was also completed. The patients underwent small locking DCP fixation by a team of experienced orthopedic surgery team from NITOR. For this study, patients had their follow-up at 12,14,16 and 18 weeks following surgery. All the physical, clinical and radiological assessments confirmed in each of the four follow-ups. Any relevant complications noted. Patient's whose fracture had not healed and/or were displaced after 4th (18 weeks) follow-up, was marked as non-healed and/or displaced healing. The AOFAS score calculated at the final 18th weeks follow-up. The AOFAS score originally first published in 1994 is a valid and reliable tool to determine the functional and clinical condition of the ankle-hind foot.[12,13] In the AOFAS score, ankle health is rated from 0 to 100, with a score of 100 for healthy ankles. For pain, there is 40 points, for functionality (activity, limitations, support) 50 points and for alignment, 10 points are distributed in the score.[12] Pain is reported by patients, and doctors evaluate alignment. To finish the functional portion, the patient and doctor collaborate.

RESULTS

In ***Table I*** the demographic variables and the cause of fracture is presented. Road traffic accident (RTA) was found to be the major cause of the Weber type C fracture, accounting for 14 (70%) of all the cases, followed by twisting fall (15%), sport (10%) and other (5%). The commonest age

group was 28-37 years (45%) with mean age of 36.75 (±8.93) years and most of the cases (75%) were male. Right-sided (60%) injury was more common than that of left sided (40%).

Table I: Demographic characteristics, side and cause of injury in respondents (n=20)

Variables	Frequency (n)	Percentage (%)
Age (year)		
18-27	4	20
28-37	9	45
38-47	5	25
48-57	2	10
Mean age (±SD)	36.75 (±8.93)	
Gender		
Male	15	75
Female	5	25
Side of injury		
Right	12	60
Left	8	40
Cause of injury		
RTA	14	70
Twisting fall	3	15
Sport	2	10
Others	1	5

Among the intra-operative characteristics displayed in ***Table II***, the mean time interval between injury and surgery was 12.25 (±5.12) weeks and half of the respondents had 7-14 weeks' time interval between injuries to surgery. Fifteen (75%) of the patients had syndesmosis screw fixed. Majority of the respondents had 60-90 minutes of operation (90%) and mean duration of operation was 77.37 (±22.36) minute.

Table II: Distribution of preoperative findings of respondents (n=20)

Variables	Frequency (n)	Percentage (%)
Time interval between injury and surgery (days)		
0-7	7	35
7-14	10	50
14-21	3	15

Mean time interval (days)	12.25 (±5.12)	
Syndesmosis screw fixation		
Screw fixed	15	75
Screw not fixed	5	25
Duration of operation		
60-90 min	18	90
90-120 min	1	5
>120 min	1	5
Mean duration of operation (minutes)	77.37 (±22.36)	

For the after operation outcomes the brief is presented in the ***Table III***, all of which but radiological healing time represents findings after 18th week. Post-operative flexion movements (both dorsi and planter) had moderate improvements, as majority of the respondents had 0-12 degree of dorsi-flexion (80%) and had 0-40º planter flexion (65%). Most of the patients had moderate pain perception (70%). However, 13 (5%) of them could walk at least four or more blocks without support and only 4 (20%) needed walking aid post-operatively. Among the sample, 17 (85%) had no difficulties in any walking surface, 16 (80%) respondents had mild hind foot restriction, 19 (95%) had stable ankle hind foot and 18 (90%) had good or fair foot alignment. For majority (55%) it took 14 weeks for radiological healing mean radiological healing time was 14.85 (±2.99) weeks. The procedure largely had no post-operative complication (65%). However, 3 (15%) patients had delayed union, 2 (10%) had superficial infection, 1 (5%) had deep infection and 1 (5%) had Talar shift.

Table III: Distribution of post-operative findings of respondents (n=20)

Variables	Frequency (n)	Percentage (%)
Dorsi-flexion		
0-10º	2	10
0-12º	16	80
0-14º	2	10
Planter flexion		
0-20º	4	20
0-40º	13	65
0-50º	3	15
Pain perception		
Mild	4	20
Moderate	14	70
Severe	2	10
Walking distance in blocks		
> 6	4	20
4-6	9	45

1-3	5	25
< 1	2	10
Walking aid		
Yes	4	20
No	16	80
Walking surface		
No difficulties in any surface	17	85
Some difficulties in uneven surface	2	10
Severe difficulties in uneven surface	1	5
Hind foot motion		
Mild restriction	16	80
Moderate restriction	3	15
Marked restriction	1	5
Ankle hind foot stability		
Stable	19	95
Unstable	1	5
Alignment of foot		
Good	15	75
Fair	3	15
Poor	2	10
Radiological healing time		
12 week	4	20
14 week	11	55
16 week	2	10
>18 week	3	15
Mean week (±SD)	**14.85 (±2.99)**	
Complication		
Non-healing	0	0
Displacement	0	0
Superficial infection	2	10
Deep infection	1	5
Delayed union	3	15
Talar shift	1	5
None	13	65

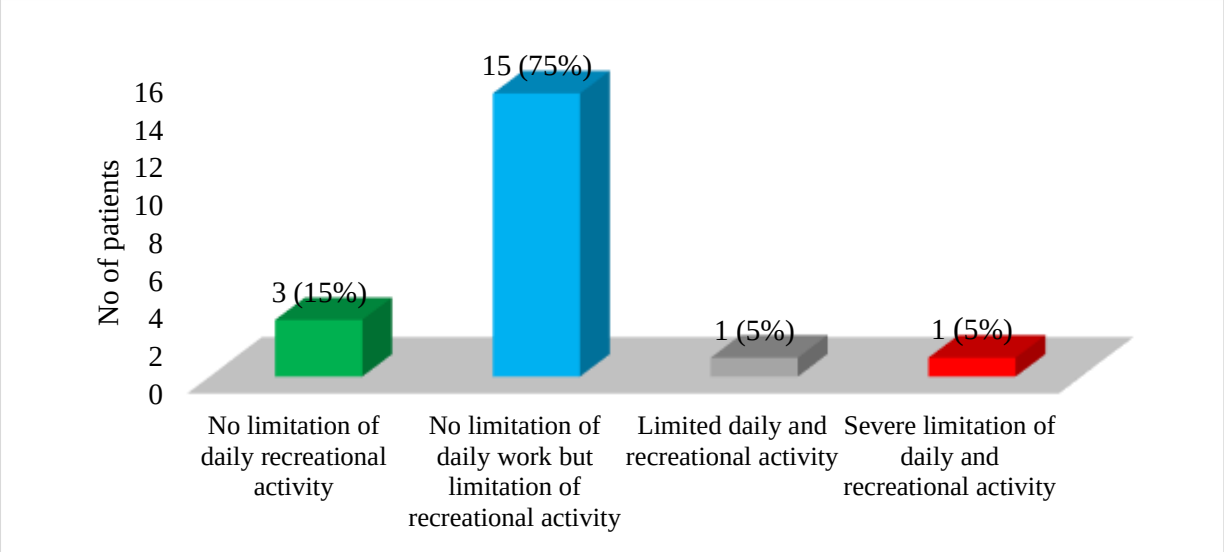

Figure 1: Distribution of functional activities of respondents (n=20)

Among all respondents, post-operatively at 18th week, 18 (90%) had satisfactory level of daily activity as, 3 (15%) had no limitations at any daily activity, while 15 (75%) had limitation only for recreational activity. However, 1 (5%) had limitation of daily and recreational activity and 1 (5%) had severe limitation of daily activity (**Figure 1)**.

The mean AOFAS score 18th week after operation was 83.25 (±7.30). According to AOFAS scoring, majority of the respondents (90%) had satisfactory (excellent to good final outcome with excellent score among 1 (5%) and good score among 17 (85%) patients. Between the only 2 (10%) cases of unsatisfactory final score, 1 had fair and the other one had poor score. On this

regard, 18(90%) respondents had satisfactory outcome (**Table IV)**.

Table IV: Distribution of AOFAS scoring and final outcome of respondents (n=20)

Variables	Frequency (n)	Percentage (%)
AOFAS scoring		
Excellent (95-100)	1	5
Good (75-94)	17	85
Fair (51-74)	1	5
Poor (0-50)	1	5
Mean (±SD)	**83.25 (±7.30)**	
Final outcome		
Satisfactory (Excellent to good)	18	90
Unsatisfactory (Fair to poor)	2	10

We conducted Fishers Exact test to find out any significant association between the outcome and age, gender, side of the limb suffered the fracture, cause of fracture, whether syndesmosis screw fixed or not, time interval between operation and injury, duration of operation, and radiological healing time. Among these the last three variable found to be significantly

associated with final outcome with a respective p value of 0.016, 0.005, and 0.021 (**Table V**).

Table V: Association of demographic status and pre-operative findings of respondents with final outcome (n=20)

Variables	Final outcome		p value*
	Satisfactory n (%)	Unsatisfactory n (%)	
Age (year)			0.763
18-27	3(75)	1(25)	
28-37	8(88.9)	1(11.1)	
38-47	5(100)	0	
48-57	2(100)	0	
Gender			>0.05
Male	13(86.7)	2(13.3)	
Female	5(100)	0	
Side			0.495
Right	10(83.3)	2(16.7)	
Left	8(100)	0	
Cause of injury			>0.05
RTA	12(85.7)	2(14.3)	
Twisting fall	3(100)	0	
Sport	2(100)	0	
Others	1(100)	0	
Time interval between injury and surgery			0.016
0-7 days	7(100)	0	
7-14 days	10(100)	0	
14-21 days	1(33.3)	2(66.7)	
Syndesmosis screw fixation			>0.05
Screw fixed	13(86.7)	2(13.3)	
Screw not fixed	5(100)	0	
Duration of operation			0.005
60-90 min	18(100)	0	
90-120 min	0	1(100)	
>120 min	0	1(100)	
Radiological healing time			0.021
12 weeks	4(100)	0	
14 weeks	11(100)	0	
16 weeks	2(100)	0	
>18 week	1(33.3)	2(66.7)	

**Fishers Exact test done. Values expressed as frequency with percentage over row.*

DISCUSSIONS

In our experience and practice of orthopedics, ankle fracture, especially Danis-Weber type C fractures is not an uncommon problem. Because of the bending movement at the time of fracture, this specific fracture usually result in laterally comminuted fibular fractures. The resultant fragmented bone is challenging to align properly with maintaining satisfactory vascularity for fracture healing [11]. A classic direct open fracture reduction and rigid plate fixation will violate the soft-tissue attachments of the fragments. Such loss of soft tissue attachments and subsequent disturbance in the blood supply is associated with delayed healing. In addition, the surgical site is placed at risk for nonunion and infection [11-14]. During reduction and fixation with bridging technique leaves the comminuted fragment untouched [15]. This prospect of the vulnerable soft tissue left untouched at the site of fracture fragment was the basis to attempt small locking

DCP fixation in Danis-Weber type-C ankle fracture in our study.

In the final-outcome at 18th week post-operative, the excellent (≥95) to good (75-94) score of AOFAS was taken as satisfactory and any score below 75 (fair to poor) was considered as unsatisfactory. The mean AOFAS score was 83.25 (±7.30), and 90% of the surgery resulted in satisfactory outcome. In another study, that used AOFAS score in post-operative patients with ankle fracture the mean score was slightly higher at 87.3. However, that study measured the score two years after surgery [16]. In this study majority (75%) of the patients treated in our work were male. The finding of the mean age being 36.75 (±8.93), with a male predominance is in line with the expected epidemiology of ankle fracture at younger age is more common in male population [4,17] crush injuries due to traffic accident, twisting due to falling or sports activity are described as the commonest causes of such fracture,[4] and in our study those same traffic accidents, sports and twisting fall were the main causes of the injury. However, our result suggests any of the age, gender, side of fracture or cause of injury has no significant association with the post-operative satisfactory/ unsatisfactory outcome.

In this present work, 7 (35%) patients were operated within the 1st 7 days, 10(50%) patients were operated on the 2nd week, and only 3(15%) patients were operated on the 3rd week. The mean interval between injury and plate fixation was 12.25 (±5.12) days. To minimize complications, to expedite care, and to achieve optimal outcomes, it is important to choose the best time for surgical treatment. When happened, the delay to surgery was often due to blisters or soft tissue injury. Definitive treatment (surgery) also deferred for several days for those cases for whom the leg was needed to be elevated so that the swelling could subsided. Soft tissue condition of the injured site determined the perfect time for operation. The mean duration of surgery in this work was 77.37 (±22.36), and only two patients needed an operation extending more than 90 minutes. A notable statistically significant finding here is, respondents with satisfactory post-operative outcome in terms of AOFAS score had less than 14 days of time interval between injury and surgery. In addition, duration of operation less than 90 minutes was significantly associated with satisfactory outcome. Foe ankle fracture, this association of unsatisfactory result and delayed surgery was also reported in other works.[16,18] In their work De Las Heras Romero et al.[16] found that even a waiting time to surgery of more than a day-affected outcome in general and according to Pilskog et al. [18] operation done after 7 days was associated with unsatisfactory result. However, the findings of this research although agrees that delayed intervention can leads to unsatisfactory end, yet the window was longer than 14 days in our work. This may be due to the potential superiority of the DCP fixation technique. For syndesmotic screw fixation during the procedure for 1 (5%) patients we did not use screw (surgeons choice), and this had no association with final outcome.

A large proportion (80%) of the patients in the present study reported moderate to severe pain at least at one point of the follow-ups. However, we consider the pain

was mainly due to irregular physiotherapy and stiffness in the most of the patients, as pain subsided by taking NSAID`S, physiotherapy and moist hot compression. Walking distance without support (65% at least 4 blocks), difficulty associated with walking surface (95% with no difficulty or minimal at uneven surface), restriction in hind foot movement (only 20% with moderate to marked restriction), hind foot stability (95% stable), alignment (90%-good to fair) and limitation in daily activity (90% with no limitation to limitation only in recreational activity)- in all the aspects patients' post-operative measures were mostly on the better side.

In the current study 4 (20%) patients had radiological evidence of healing at 12 weeks, 11(55%) had healing evidence at 14 weeks. In 2 (10%) patients it was at 16 weeks, and in 3(15%) patients the radiological evidence of healing was at or more than 18 weeks. All respondents with radiological healing time for 12 week, 14 week and 16 week had satisfactory outcome. Only 2 respondents with more than 18 weeks of healing had significant unsatisfactory outcome. The excellent healing in time probably augmented due to placing of plate in bridging technique. Cortical bone gets its nutrition from periosteal vessels.

During the course of the study 13 (65%) of the patients had no complication developed. None of the patient have had non-union or implant failure. All of the 2 (10%) superficial infections subsided by local dressing and antibiotics. Only one of the two patients that developed deep infection that needed debridement and prolong specific antibiotics and no need to remove implants. The fracture ultimately healed. This minimal proportion of complications are noteworthy considering, in the work of Ahmad Hafiz et al.[19] showed 12 of their cases (15%) developed superficial infection, 2 cases (2.5%) developed deep infection leading to non-union and 1 (1.2%) developed joint stiffness.

CONCLUSION

We found that, overall, post-operative outcome of plating with small locking DCP in Danis-Weber type C ankle fracture was satisfactory. This bridging technique can be an effective method for the stabilization of Danis-Weber type-C ankle fractures with minimal post-operative complications. The technique allows for mostly satisfactory reduction of the fracture fragment. A reduction earlier than two weeks and operative time as much as minimum is recommended. However, due to the limitations like selection biases, lack of control group and small sample size generalization should be with caution. Yet, the study findings could be a reference for the country during protocol development for ankle surgery and further research works on the same.

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