



Original Article

Comparative Study of Ankle Fracture in Danis Weber Type-C Treated by Small Dynamic Compression Plate Vs 1/3rd Tubular Plate for Lateral Malleolus and 04 mm Cancellous Screw for Medial Malleolus

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Abstract

Introduction: Danis-Weber type-C ankle fractures challenge orthopaedic surgeons because of their instability, involving syndesmotom disruption and medial-sided injury. Open reduction and internal fixation (ORIF) are the standard treatment; however, the optimal implant choice between a small dynamic compression plate (DCP) and a one-third tubular plate remains debatable. This study compared the outcomes of Danis-Weber type-C ankle fractures treated with a small DCP versus a one-third tubular plate for the lateral malleolus with a 4 mm cancellous screw for the medial malleolus.

Methods: A quasi-experimental study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Bangladesh, from March 2018 to April 2020 and from April 2023 to September 2023. Forty-eight patients with closed Danis-Weber type C ankle fractures were divided into two groups: small dynamic compression plate (DCP) and one-third tubular plate. Functional outcomes were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale at 24 weeks.

Results: The mean age was 35.67 ± 10.5 years, with a male predominance (77%). Road accidents caused the majority of injuries (58%). Radiological union occurred at 15.20 ± 1.19 weeks in the DCP group and 14.62 ± 1.11 weeks in the tubular plate group ($p = 0.99$). The complication rate was 16% in the DCP group versus 12% in the tubular plate group ($p = 0.99$). Excellent or good AOFAS outcomes reached 83.33% in DCP and 91.67% of patients treated with DCP and tubular plates, respectively. No significant intergroup differences were observed (all $p > 0.05$).

Conclusion: No significant difference exists between small DCP and one-third tubular plate fixation for Danis-Weber type-C ankle fractures, although the tubular plate showed modest trends toward better outcomes and fewer complications.

Keywords: Danis-Weber type-C; ankle fracture; small dynamic compression plate; one-third tubular plate; AOFAS score.

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Introduction

Ankle fractures represent one of the most frequently encountered orthopaedic injuries, constituting approximately 9% of all fractures and contributing a substantial proportion to the trauma workload in accident and emergency departments^{1,2}. The incidence is reported at 184 cases per 100,000 population per year, ranking ankle fractures as the third most common fracture in elderly patients after hip and wrist fractures³. It is estimated that approximately 2% of the general population will sustain an ankle fracture during their lifetime⁴.

The ankle joint is a hinge-type synovial joint comprising a mortise formed by the distal ends of the tibia and fibula, which articulates with the talus. Stability is maintained by the ankle mortise, the tibiofibular syndesmosis and the medial and lateral ligamentous complexes^{5,6}. The syndesmosis is reinforced by the anterior and posterior inferior tibiofibular ligaments, the interosseous ligament and the transverse tibiofibular ligament, which collectively resist external rotatory and translational forces⁷. A bimodal age distribution has been described, with peaks occurring in males aged 15–24 years due to high-energy trauma and in older women above 75 years due to osteoporosis and falls⁸.

The Danis-Weber classification is among the most widely used systems for categorizing ankle fractures based on the level of fibular fracture relative to the syndesmosis⁹. Type-C fractures, occurring proximal to the syndesmosis, are the most severe variant, invariably associated with syndesmotic disruption, interosseous membrane tear and medial malleolus fracture or deltoid ligament rupture¹⁰. Such injuries are inherently unstable and mandate surgical intervention to restore anatomical alignment and joint congruity. Delayed or inadequate treatment leads to persistent pain, functional impairment and premature osteoarthritis¹¹.

Operative fixation options for the lateral malleolus include semi-tubular plate, one-third tubular plate, small dynamic compression plate (DCP), locking plates, intramedullary devices and tension band wiring. The medial malleolus is typically stabilized with cancellous lag screws [12]. Biomechanically, the small DCP confers superior bending stiffness and torsional stability compared to the one-third tubular plate. However, the DCP is bulkier, carries a greater risk of wound complications due to limited soft tissue coverage over the distal fibula and is more expensive. Conversely, the one-third tubular plate is thinner, offers better soft tissue accommodation and is more affordable, though it provides comparatively lesser mechanical rigidity¹³.

Despite several published comparative studies, no consensus exists regarding the optimal implant for lateral malleolus fixation in Danis-Weber type-C fractures^{14,15}. Evidence from Bangladesh remains

particularly sparse, despite an increasing incidence of ankle fractures attributable to rising road traffic accidents. Against this background, the present study was undertaken to compare functional and radiological outcomes of Danis-Weber type-C ankle fractures treated with a small DCP versus a one-third tubular plate for the lateral malleolus, with 4 mm cancellous screw fixation for the medial malleolus.

Materials & Methods

This was a quasi-experimental study conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-E-Bangla Nagar, Dhaka, Bangladesh. The study was conducted in two phases: March 2018 to April 2020 and April 2023 to September 2023. The study population comprised adults aged 18–60 years of either sex presenting with acute, closed Danis-Weber type-C ankle fractures. Sample size was calculated using the two-group comparison of means formula based on AOFAS score data reported by Ahn et al. (2021), where the mean final AOFAS scores were 83.9 (SD 14.3) and 89.4 (SD 9.5) in the DCP and tubular plate groups respectively. At 95% confidence level and 80% power, the estimated sample size was 24 per group; accounting for a 10% dropout, 30 patients were initially planned per group. The final analyzed cohort comprised 48 patients (24 per group) following purposive sampling.

Study Procedure

Eligible patients were allocated on a consecutive case-by-case basis to one of two groups: the small DCP group or the one-third tubular plate group (24 per group). All patients with acute injury were initially managed with analgesics and a short-leg posterior slab. Preoperative assessment included demographic data collection, clinical examination and plain radiography. Following adequate soft tissue preparation and resolution of fracture blisters, definitive surgical treatment was undertaken by open reduction and internal fixation (ORIF). Lateral malleolus fixation was performed with either a small DCP or a one-third tubular plate according to group allocation, while the medial malleolus was fixed with a 4 mm partial-threaded cannulated cancellous screw in all patients. All operations were performed by the same surgical team following a standardized technique.

Postoperative follow-up was conducted at 6, 12 and 24 weeks, with clinical, functional and radiological assessments recorded at each visit. Functional outcome was assessed using the AOFAS ankle-hindfoot scale, which evaluates pain (40 points), function (50 points) and alignment (10 points), with a maximum total score of 100. Outcome categories were: excellent (90–100), good (80–89), fair (60–79) and poor (<60).

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, Bangladesh, before commencement of the study. Written informed consent was obtained from each participant after explaining the study objectives, procedures, potential risks and benefits in the participant's preferred language. All patients were informed of their right to withdraw at any stage without consequence to their clinical care. Patient confidentiality was maintained throughout the study and all data were anonymized for analysis.

Statistical Analysis

Data were processed and analyzed using SPSS version 23.0. Categorical variables were expressed as frequencies and percentages. Continuous variables were presented as mean $\pm$ standard deviation (SD). The chi-squared test was used for categorical comparisons between groups and the Mann-Whitney U test was applied for non-normally distributed continuous variables. A p-value of less than 0.05 was considered statistically significant.

Results

The study shows that the study population ranged from 19 to 57 years of age. The majority of patients belonged to the 31–40 years age group (38%, $n = 18$) and the mean age was 35.67 ± 10.5 years. Males predominated, comprising 77% ($n = 37$) of all participants. Road traffic accident was the most frequent mechanism of injury (58%, $n = 28$), followed by twisting injury (38%, $n = 18$) and sports injury (4%, $n = 2$). Right-sided ankle injury was more common, accounting for 75% ($n = 36$) of cases.

Table I: Demographic and baseline characteristics of the study population ($n = 48$)

Variable		Frequency	Percentage
		(n)	(%)
Age Distribution (years)			
<20		1	2.1
21–30		14	29.2
31–40		18	37.5
41–50		13	27.1
51–60		2	4.2
Mean ± SD		35.67 ± 10.5	
Sex	Male	37	77.1
	Female	11	22.9
Cause of Injury			
Road Traffic Accident		28	58.3
Twisting Injury		18	37.5
Sports Injury		2	4.2
Site of Injury			
Right		36	75.0
Left		12	25.0

Table II: Duration interval between injury and definitive surgery ($n = 48$)

Duration (days)	Small DCP	1/3rd Tubular Plate
	n (%)	n (%)
09–13	4 (16.7)	3 (12.5)
14–18	12 (50.0)	12 (50.0)
19–21	8 (33.3)	9 (37.5)
Total	24 (100.0)	24 (100.0)
Mean $\pm$ SD	16.37 ± 1.341	16.91 ± 1.227

Table II shows that mean duration from injury to surgery was 16.37 ± 1.341 days in the small DCP group and 16.91 ± 1.227 days in the one-third tubular plate group. The majority of patients in both groups underwent surgery in the 14–18 days interval (50% each group).

Table III: Radiological union in both study groups (n = 48)

Duration of Radiological Union (weeks)	Small DCP n (%)	1/3rd Tubular Plate n (%)	p-value
12–15	16 (66.67)	19 (79.16)	0.99
16–19	5 (20.86)	3 (12.5)	
20–24	3 (12.5)	2 (8.3)	
Total	24 (100.0)	24 (100.0)	
Mean $\pm$ SD	15.20 $\pm$ 1.19	14.62 $\pm$ 1.11	

Table III shows that radiological union occurred earlier in the one-third tubular plate group than in the small DCP group. Mean radiological union time was 15.20 $\pm$ 1.19 weeks in the small DCP group and 14.62 $\pm$ 1.11 weeks in the one-third tubular plate group. The p-value was 0.99, which was not statistically significant. The majority of patients in both groups

achieved union within 12–15 weeks (66.67% DCP vs. 79.16% tubular plate).

Table 4 shows that complications were more frequent in the small DCP group (16%, n = 4) compared with the one-third tubular plate group (12%, n = 3), although the difference was not statistically significant (p = 0.99). The small DCP group had 2 superficial and 2 deep wound infections, whereas the tubular plate group had 2 superficial and 1 deep wound infection.

Table IV: Postoperative complications (n = 48)

Complication	Small DCP n (%)	1/3rd Tubular Plate n (%)	P-value
No complication	20 (84)	21 (88)	0.99
Any complication	4 (16)	3 (12)	
Superficial wound infection	2 (8)	2 (8)	
Deep wound infection	2 (8)	1 (4)	
Total	24 (100.0)	24 (100.0)	

Table V: Comparison of AOFAS functional sub-score parameters between groups at final follow-up (n = 48)

Parameter / Category		Small DCP n (%)	1/3rd Tubular Plate n (%)	p-value
Pain at last follow-up	No pain	12 (50)	13 (54)	1.0
	Mild pain	12 (50)	11 (46)	
Activity Limitation	No limitation	22 (92)	22 (92)	1.0
	Limitation in recreational activities	2 (8)	2 (8)	
Walking Distance (blocks)	4–6 blocks	21 (88)	22 (92)	1.0
	2–3 blocks	3 (12)	2 (8)	
Walking Surface	No difficulty on any surface	18 (75)	19 (79)	1.0
	Some difficulty on uneven surface	6 (25)	5 (21)	
Gait Abnormality	None or slight	24 (100)	24 (100)	1.0
Sagittal Motion	Normal or mild restriction	17 (71)	18 (75)	1.0
	Moderate restriction	7 (29)	6 (25)	
Hindfoot Motion	Normal or mild restriction	21 (88)	22 (92)	1.0
	Moderate restriction	3 (12)	2 (8)	
Alignment	Good	20 (84)	22 (92)	1.0
	Fair	4 (16)	2 (8)	

Table IV: Final AOFAS total score and functional outcome classification (n = 48)

AOFAS Score / Outcome	Small DCP n (%)	1/3rd Tubular Plate n (%)	p-value
Excellent (90–100)	12 (50)	13 (54.17)	0.99
Good (80–89)	8 (33.33)	9 (37.5)	
Fair (60–79)	4 (16.67)	2 (8.33)	
Poor (<60)	0 (0.0)	0 (0.0)	
Total	24 (100.0)	24 (100.0)	
Mean $\pm$ SD	89.125 $\pm$ 2.59	90.54 $\pm$ 1.98	
Satisfactory (Excellent + Good)	20 (83.33)	22 (91.67)	
Unsatisfactory (Fair + Poor)	4 (16.67)	2 (8.33)	

Table V shows that at the final 24-week follow-up, pain, activity limitation, walking distance, walking surface, gait abnormality, sagittal motion, hindfoot motion and alignment parameters were comparable between both groups. No statistically significant differences were observed across any of these parameters (all $p \geq 0.99$). All 48 patients (100%) in both groups demonstrated none or slight gait abnormality at last follow-up.

Table 6 shows that at the final 24-week follow-up, 12 (50%) patients in the small DCP group achieved an excellent outcome, 8 (33.33%) good, 4 (16.67%) fair and none poor. In the one-third tubular plate group, 13 (54.17%) achieved excellent, 9 (37.5%) good, 2 (8.33%) fair and none poor. The mean AOFAS score was 89.125 $\pm$ 2.59 in the small DCP group and 90.54 $\pm$ 1.98 in the tubular plate group. Satisfactory outcomes (excellent + good) were achieved in 83.33% and 91.67% of the small DCP and tubular plate groups respectively. The p-value was 0.99, which was not statistically significant.

Discussion

This quasi-experimental study compared the radiological and functional outcomes of small DCP versus one-third tubular plate fixation for Danis-Weber type-C ankle fractures, with concurrent medial malleolus fixation using a 4 mm cancellous screw. Both implants yielded comparable outcomes across all measured parameters at a 24-week follow-up, with no statistically significant intergroup differences detected.

The mean age of study participants was 35.67 $\pm$ 8.85 years, with the majority concentrated in the 31–40

years age group. This finding aligns with that of Kim and Park, who reported a mean age of 37.2 years among patients with Danis-Weber type-C fractures¹⁶. The predominance of younger patients likely reflects increasing exposure to road traffic accidents, which constituted 58% of injury mechanisms in this study. Comparable trends have been reported by Manjur et al., who found that road traffic accidents accounted for 68% of the causal mechanism¹⁷.

Males constituted 77% of participants in the present study, which is consistent with published literature. Kim and Park similarly reported a male preponderance of 79%, reflecting the greater outdoor occupational and recreational activity exposure of male patients¹⁶. Right-sided ankle injury predominated (75%), which is broadly consistent with the finding of Péreza et al., who reported 64.5% right-sided involvement¹⁴.

The mean interval from injury to definitive surgery was 16.6 $\pm$ 3.03 days in this study. This delay is attributable to the standard practice of deferring surgical fixation until resolution of soft tissue swelling and formation of skin wrinkles, in order to minimize wound complications and optimize operative conditions⁵. Adequate soft tissue preparation is a recognized determinant of surgical success in periarticular ankle fracture fixation.

Regarding pain outcomes, 50% of the small DCP group and 54% of the tubular plate group were pain-free at final follow-up, with the remaining patients reporting only mild pain ($p = 1.00$). Péreza et al. reported a mean pain subscale AOFAS score of 36.76 out of 40, which was slightly superior to the present study; this difference is likely attributable to their longer follow-up period of 52 weeks [14]. Activity limitation was

equally distributed in both groups, with 92% of patients in each group experiencing no limitation at last follow-up, consistent with the findings of Manjur et al., who reported 96.4% activity-free patients in their single-implant DCP series¹⁷.

Walking capacity and surface tolerance showed no statistically significant intergroup differences. At 24 weeks, 88% of small DCP patients and 92% of tubular plate patients achieved a walking distance of 4–6 blocks, while 75% and 79%, respectively, reported no difficulty on any surface ($p = 1.00$). All participants in both groups demonstrated no or slight gait abnormality at final follow-up. Regarding range of motion, normal or mild sagittal restriction was present in 71% and 75% of the DCP and tubular plate groups, respectively ($p = 1.00$). Hindfoot motion was normal or mildly restricted in 88% and 92% of the respective groups, closely mirroring the findings of Ahn et al. (2021), who reported a normal range of motion in 85.7% of tubular plate patients¹⁸.

Postoperative complication rates were 16% ($n = 4$) and 12% ($n = 3$) in the small DCP and tubular plate groups, respectively ($p = 0.99$). Both groups exhibited comparable wound infection profiles, consistent with findings by Shih et al. (2020) and Manjur et al. (2023), who reported similarly low infection rates with either implant^{15,17}. The higher complication rate in the small DCP group, though not statistically significant, may reflect the reduced soft tissue coverage over the distal fibula when the bulkier DCP is employed.

Radiological union was achieved slightly earlier in the tubular plate group (14.62 ± 1.11 weeks) compared with the DCP group (15.20 ± 1.19 weeks), though no significant difference was found ($p = 0.99$). This is comparable to the findings of Manjur et al. and Ahn et al., who reported mean union times of 15.1 weeks and 13.34 weeks in tubular plate and DCP groups, respectively^{17,18}.

At the final follow-up, functional outcomes by AOFAS score were excellent or good in 83.33% of small DCP patients and 91.67% of tubular plate patients ($p = 0.99$). The mean AOFAS scores were 89.125 ± 2.59 and 90.54 ± 1.98 in the DCP and tubular plate groups, respectively, both reflecting near-excellent outcomes. Although no statistically significant intergroup difference was established, the tubular plate group demonstrated a consistent positive trend across

multiple domains, including pain, walking capacity, range of motion, alignment and complication rate. These findings are congruent with studies by Shih et al. and Manjur et al., all of which reported equivalent outcomes between DCP and tubular plate constructs for fibular fixation^{15,17}.

The follow-up period of 24 weeks limits assessment of long-term radiological and functional outcomes, including osteoarthritic progression. The study was conducted at a single tertiary center using purposive sampling, which may introduce selection bias and limit generalizability to the broader population.

Conclusion

There is no statistically significant difference between small dynamic compression plate and one-third tubular plate fixation for Danis-Weber type-C ankle fracture at 24 weeks of follow-up. However, the one-third tubular plate group demonstrated a consistent trend towards superior functional outcomes and lower complication rates, suggesting it may be the preferred implant choice for this fracture type.

References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006 Aug 1;37(8):691-7.
2. Bugler KE, Clement ND, Duckworth AD, White TO, McQueen MM, Court-Brown CM. Open ankle fractures: who gets them and why?. *Archives of orthopaedic and trauma surgery*. 2015 Mar;135(3):297-303.
3. Bariteau JT, Hsu RY, Mor V, Lee Y, DiGiovanni CW, Hayda R. Operative versus nonoperative treatment of geriatric ankle fractures: a Medicare Part A claims database analysis. *Foot & ankle international*. 2015 Jun;36(6):648-55.
4. Arastu MH, Demcoe R, Buckley RE. Current concepts review: ankle fractures. *Acta Chir Orthop Traumatol Cech*. 2012 Jan 1;79(6):473-83.
5. Bowyer G. Injuries of the ankle and foot. In Apley & Solomon's System of Orthopaedics and Trauma 2017 Aug 29 (pp. 937-963). CRC Press.
6. Golanó P, Vega J, De Leeuw PA, Malagelada F, Manzanares MC, Götzens V, Van Dijk CN. Anatomy of the ankle ligaments: a pictorial essay. *Knee surgery, sports traumatology, arthroscopy*. 2010 May;18(5):557-69.
7. Ebraheim NA, Taser F, Shafiq Q, Yeasting RA. Anatomical evaluation and clinical importance of

- the tibiofibular syndesmosis ligaments. *Surgical and Radiologic Anatomy*. 2006 May;28(2):142-9.
8. Daly PJ, Fitzgerald RH, Melton LJ, Llistrup DM. Epidemiology of ankle fractures in Rochester, Minnesota. *Acta Orthopaedica Scandinavica*. 1987 Jan 1;58(5):539-44.
 9. Kennedy JG, Johnson SM, Collins AL, DalloVedova P, McManus WF, Hynes DM, Walsh MG, Stephens MM. An evaluation of the Weber classification of ankle fractures. *Injury*. 1998 Oct 1;29(8):577-80.
 10. Reddyreddy S, Stead T, Mangal R, Lopez-Ortiz C, Wilson J, Ganti L. Lateral Malleolar Fracture. *Orthopedic Reviews*. 2022 Nov 30;14(4):37619.
 11. Xie L, Xie H, Wang J, Chen C, Zhang C, Chen H, Zheng W. Comparison of suture button fixation and syndesmotic screw fixation in the treatment of distal tibiofibular syndesmosis injury: a systematic review and meta-analysis. *International Journal of Surgery*. 2018 Dec 1;60:120-31.
 12. Singh R, Kamal T, Roulohamin N, Maoharan G, Ahmed B, Theobald P. Ankle fractures: a literature review of current treatment methods. *Open journal of Orthopedics*. 2014;4(11):292-303.
 13. Manoharan G, Singh R, Kuiper JH, Nokes LD. Distal fibula oblique fracture fixation using one-third tubular plate with and without lag screw—A Biomechanical study of stability. *Journal of orthopaedics*. 2018 Jun 1;15(2):549-52.
 14. Herrera-Pérez M, Gutiérrez-Morales MJ, Guerra-Ferraz A, Pais-Brito JL, Boluda-Mengod J, Garcés GL. Locking versus non-locking one-third tubular plates for treating osteoporotic distal fibula fractures: a comparative study. *Injury*. 2017 Nov 1;48:S60-5.
 15. Shih CA, Jou IM, Lee PY, Lu CL, Su WR, Yeh ML, Wu PT. Treating AO/OTA 44B lateral malleolar fracture in patients over 50 years of age: periarticular locking plate versus non-locking plate. *Journal of Orthopaedic Surgery and Research*. 2020 Mar 20;15(1):112.
 16. Kim GB, Park CH. Hybrid fixation for Danis-Weber type C fractures with syndesmosis injury. *Foot & Ankle International*. 2021 Feb;42(2):137-44.
 17. Manjur M, Rahaman MS, Ahmed AD, Uddin MN. Prospective study of radiological healing and functional outcome after ORIF of Danis-Weber Type-C closed ankle fracture. *Med Res Chronicles*. 2023;10(1):122-131.
 18. Ahn JH, Cho SH, Jeong M, Kim YC. One Third Tubular Plate Remains a Clinically Good Option in Danis Weber Type B Distal Fibular Fracture Fixation. *Orthopaedic surgery*. 2021 Dec;13(8):2301-9.