

Outcome of Volar Locking Plate Osteosynthesis for Volar Barton's Fractures

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ABSTRACT

Background: Volar Barton's fracture is intra-articular fractures of distal radius with volar luxation of the carpus. This severely affects wrist functions, leads to significant disability and high economic impact. Fortunately, the incidence is very low (only 1.2-4.2% of distal radius fractures). These fractures are inherently unstable, require fixation. In practices, various instruments are used for the operative management. Volar locking plate provides buttressing and stable fixation even in comminuted or porotic bone. This locking system also reduces soft tissue complications. Overall, allow early mobilization, and rapid recovery and improved wrist functions.

Aim of the study: The aim of the study was to assess the outcome of volar locking plate osteosynthesis in volar Barton's fracture (AO type 2R3-B3).

Methods: Quasi experimental study conducted at National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, from July, 2021 to June, 2023. Patients with volar Barton's fractures (2R3B3) meeting the selection criteria were the study population. Total 26 patients were included in the study. All cases were evaluated by clinical features, X ray, and Green and O'Brien score and Sarmiento's criteria. Minimum 6 months follow up was done with clinical, functional and radiological assessment.

Result: The mean age was 34.46 ± 9.90 years with male (69.2%) and right side (57.7%) predominance. Most of fractures were of 2R3B3.2 (65.4%) and were due to motor vehicle accidents (69.2%). The mean duration of injury to operation was 8.31 ± 3.17 days. All cases achieved radiological union. Mean loss of volar tilt was 2.88 ± 4.50 (range: 0-16) degree, loss of radial inclination was 3.88 ± 4.08 (range: 0-18) degree, and radial shortening was 2.04 ± 2.89 (range: 0-12) mm. Maximum patients had no pain (88.5%), normal range of motion and grip power (69.2% each), and subsequently return to normal employment (84.6) at final follow up. Overall, both radiological and functional satisfactory and unsatisfactory outcomes were 88.5% and 11.5% respectively. Most of the satisfactory outcomes were observed in B3.2 and unsatisfactory outcomes in B3.3 sub-type. Most of the poorer results occurred in older age groups. These associations were not statistically significant. Complications were minor and rate (15.4%) was fairly low.

Conclusion: Volar locking plate osteosynthesis can efficaciously be used to treat volar Barton's fractures, in terms of radiological and functional outcomes.

Keywords: Volar Barton's fracture, distal radius, volar locking plate, functional outcome, radiological outcome.

I. INTRODUCTION

The wrist is the most differentiated section of the musculoskeletal system. Distal parts of the radius and ulna, eight carpal bones, and proximal parts of the five metacarpals compose the wrist which serves as a bridge between the hand and forearm [1]. Distal radius fracture (DRF) refers to the fracture within 3 cm of the articular surface of the distal radius [2]. These fractures are one of the most common skeletal injuries of the wrist attending the emergency and outpatient departments, accounting for 14–18% of all fractures and 75% of all forearm fractures in adults [3]. But several factors are considered to be responsible for the increasing rates including lifestyle and environmental factor, rise in life expectancy, increased obesity in childhood, and osteoporosis rate in elderly population [4]. Distal radius fractures are of two types either volar or dorsal (Barton's fractures) depending on volar or dorsal shifting of the fragment along with subluxation of the carpus, the former being more common [5,6]. Barton's fractures affect a wide population range and show a bimodal age distribution. These fractures usually affect the elderly population, predominantly females, of more than 50 years old following low energy trauma. They are often osteoporotic and most common mechanism of injury is falling on the outstretched hand. However, a considerable number of cases occur in young adults (age 19-49 years), predominantly in males, from

high energy trauma like traffic accidents (RTAs) and sports injuries [2,4,7]. Various treatment modalities, including close reduction with plaster cast immobilization or percutaneous Kirschner wire (K-wire) fixation, open reduction and internal fixation (ORIF) with volar (non-locking) plates, volar locking plates or intramedullary distal radius nail, and joint-spanning external fixation, have been described for the management of these fractures [2,5,8]. The residual deformity of wrist adversely affects wrist motion and hand function by interfering with the mechanical advantage of the extrinsic hand musculature may cause pain, limitation of forearm motion, and decreased grip strength as a result of arthrosis of the radiocarpal and distal radioulnar joints [9]. Open reduction and internal fixation (ORIF) using a volar plate system provide good reduction and stability of the articular surface. Early mobilization of the wrist can be given; and results in rapid recovery of the patient and improved restoration of the function [10]. Operative treatment with a volar locking plate (VLP) was introduced in the early 2000s, and since then the procedure has rapidly gained wide popularity as they have some special advantages along with those provided by non-locking plates [8,11]. The wrist and hand are highly functional structures with a wide range of motion. Distal radius fractures often impair function, affecting daily activities and livelihood. Volar Barton's fractures are unstable, requiring internal fixation. Open reduction with a volar locking plate provides stable fixation, preserves blood supply, ensures articular reduction, and allows early wrist mobilization, reducing stiffness and osteoarthritis risk. So, the study aims to assess the outcome of volar locking plate osteosynthesis in volar Barton's fracture (AO type 2R3-B3).

II. METHODOLOGY & MATERIALS

This prospective quasi-experimental study was conducted at the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Sher-e-Bangla Nagar, Dhaka, Bangladesh a tertiary hospital specializing in orthopedic and trauma care. The study was carried out over a period of two years, from July 2021 to June 2023. The protocol was developed and ethically approved before data collection. Patients with radiologically confirmed closed volar Barton's fractures (AO type 2R3-B3) were enrolled during the study period. A purposive sampling method was applied to select available cases. Data were collected, analyzed, and compiled upon completion of the study. The study aimed to evaluate the functional and radiological outcomes of volar locking plate osteosynthesis in volar Barton's fractures (AO type 2R3-B3).

Inclusion Criteria:

- Radiological proven volar Barton's fracture (AO type 2R3-B3).
- Fracture less than 14 days.
- Age: 18 to 50 years.

Exclusion Criteria:

- Open fracture.
- Infected fracture.
- Pathological fracture.
- Unhealthy overlying skin.

Ethical Consideration

Prior permission was taken from Institutional Review Board (IRB), National Institute of Traumatology and Orthopedic Rehabilitation (NITOR), Dhaka, Bangladesh to conduct this study. Keeping compliance with Helsinki Declaration for medical research involving human subject 1964, the study subjects were informed verbally about the study design, the purpose of the study and right for withdrawing themselves from the project any time, for any reason, whatsoever. Patients were informed about the procedure of treatment, anticipated results, possible advantages, disadvantages, complications etc. Individuals who gave informed written consent to participate voluntarily in the study were included as study sample.

Data Collection

Data were collected using a pretested structured questionnaire (Appendix-VI) and a data sheet designed for the study. Information on demographic variables (age, sex, occupation), baseline variables (side involved, cause of injury, mechanism of injury, fracture sub-type), peri-operative variables (time interval from injury to surgery, complications), and outcome variables (radiological and functional outcomes) was systematically recorded. Patients were assessed preoperatively and postoperatively, and all collected data were documented to evaluate outcomes using the Sarmiento radiological score and Green and O'Brien functional score. Accuracy and completeness of data were ensured throughout the study.

Statistical Analysis

Data were processed and analyzed using software program SPSS version 25.0. At 5% level of significance and confidence interval (CI) of 95%, and p value was taken.

III. RESULT

The mean age of patients was 34.46 ± 9.90 years. Most were male 69.20% and aged 31–40 years 34.60%. Motor vehicle accidents were the leading cause of injury 69.20%, and service holders were the most affected 26.90% demonstrates in (Table 1). In Figure 1 shows among the 26 patients, 57.7% had fractures on the right side, while 42.30% had involvement of the left side. Similarly, most fractures were of type 2R3B3.2 (65.0%), followed by 2R3B3.3 (23.0%) and 2R3B3.1 (12.0%) according to the AO classification illustrates in (Figure 2). The mean time interval between injury and surgery was 8.31 ± 3.17 days, with 57.70% operated within 8–14 days. Postoperative complications included wrist stiffness in 11.05% and superficial wound infection in 3.80% of cases highlights in (Table 2). Table 3 examines that 57.70% of patients had a loss of volar tilt $\leq 0^\circ$, 73.10% showed radial shortening < 3 mm, and 65.40% had radial inclination $\leq 4^\circ$, with mean values of $2.88^\circ \pm 4.50$, 2.04 ± 2.89 mm, and $3.88^\circ \pm 4.08$ respectively. Among the patients 65.4% of patients had excellent and 23.10% had good functional outcomes, while 7.70% were fair and 3.80% poor. Regarding pain, 88.5% reported no pain, 7.70% mild, and 3.08% moderate, with no cases of severe pain reveals in (Table 4). Table 5 indicates that 69.20% of patients achieved 100% normal wrist range of motion and grip strength, while 26.90% and 30.80% reached 99–75% of normal levels, respectively. Regarding functional status, 84.60% returned to employment, 11.50% had restricted work, and 3.80% were unemployed but able to work. The majority of excellent radiological outcomes were observed in 2R3B3.2 fracture subtype (66.70%) and in patients aged 31–40 years (38.90%). Poor outcomes were exclusively seen in the 2R3B3.3 subtype (100%), while fair outcomes were mainly found in patients aged 41–50 years (100%) shows in (Table 6).

Table 1: Demographic and clinical characteristics of patients with Volar Barton's Fracture (n = 26)

Variables	Frequency (n)	Percentage (%)
Ages (Years)		
< 20	3	11.50
21-30	7	26.90
31-40	9	34.60
41-50	7	26.90
Mean \pm SD	34.46 \pm 9.90	
Gender		
Male	18	69.20
Female	8	30.80
Occupation		
Service Holder	7	26.90
Businessman	5	19.20
Day laborer	3	11.50
Student	6	23.10
House wife	3	11.50
Other	2	7.70
Cause of Injury		
MVA (Motor Vehicle Accident)	18	69.20
Fall from standing height	5	19.20
Sports injury	3	11.50

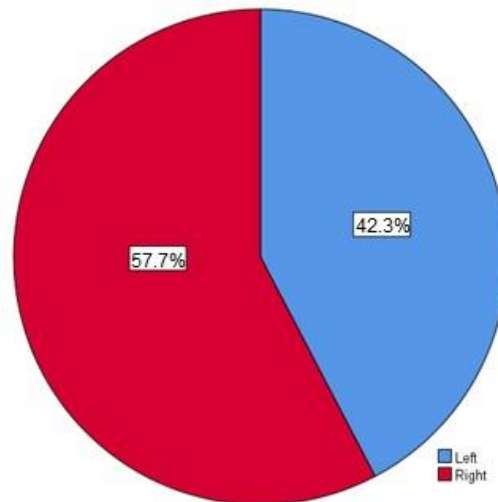


Figure 1: Distribution of the study patients by affected side (N=26)

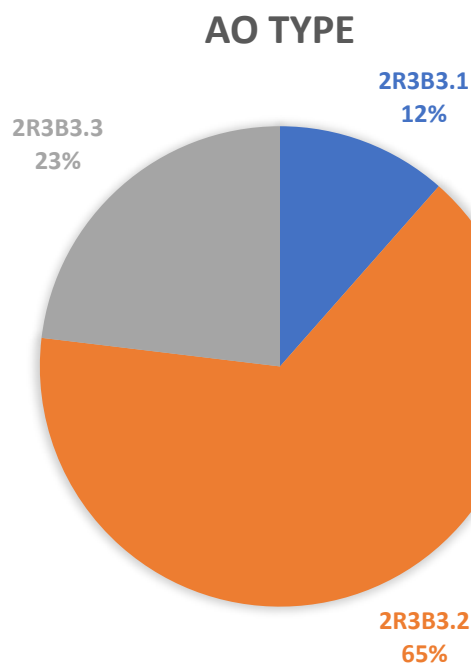


Figure 2: Distribution of fracture patterns according to AO classification

Table 2: Time interval between injury and surgery and postoperative complications

Variables	Frequency (n)	Percentage (%)
Time Interval Between Injury and Surgery (Days)		
1-7	11	42.30
8-14	15	57.70
Mean ± SD	8.31 ± 3.17	
Complications		
No	22	84.60
Wrist Stiffness	3	11.50
Superficial wound infection	1	3.80

Table 3: Distribution of postoperative radiological measurements

Variables	Frequency (n)	Percentage (%)
Loss of Volar Tilt (in degree)		
$\leq 0^{\circ}$	15	57.70
$1^{\circ} - 10^{\circ}$	8	30.80
$11^{\circ} - 14^{\circ}$	2	7.70
$> 15^{\circ}$	1	3.80
Mean \pm SD	2.88 \pm 4.50	
Radial Shortening (in mm)		
< 3	19	73.10
$3 - 6$	5	19.20
$7 - 11$	1	3.80
≥ 12	1	3.80
Mean \pm SD	2.04 \pm 2.89	
Radial Inclination (in degree)		
$\leq 4^{\circ}$	17	65.40
$5^{\circ} - 9^{\circ}$	6	23.10
$10^{\circ} - 14^{\circ}$	2	7.70
$> 15^{\circ}$	1	3.80
Mean \pm SD	3.88 \pm 4.08	

Table 4: Distribution of patients according to functional and pain outcomes

Variables	Frequency (n)	Percentage (%)
Satisfactory		
Excellent	17	65.40
Good	6	23.10
Unsatisfactory		
Fair	2	7.70
Poor	1	3.80
Pain (Score)		
No (25)	23	88.50
Mild (20)	2	7.70
Moderate (15)	1	3.80
Severe (0)	0	0.00

Table 5: Distribution of patients according to wrist range of motion, grip strength, and functional status

Variables	Frequency (n)	Percentage (%)
ROM of Wrist (Score)		
100% of normal (25)	18	69.20
99-75% of normal (15)	7	26.90
74-50% of normal (10)	1	3.80
25%-49% of normal (5)	0	0.00
0-24% of normal (0)	0	0.00
Grip Strength (Score)		
100% of normal (25)	18	69.20
99-75% of normal (15)	8	30.80

74-50% of normal (10)	0	0.00
25%-49% of normal (5)	0	0.00
0-24% of normal (0)	0	0.00
Functional Status (Score)		
Returned to employment (25)	22	84.60
Restricted employment (20)	3	11.50
Able to work but unemployed (15)	1	3.80
Unable to work (0)	0	0.00

Table 6: Association between fracture sub-type, age group, and final radiological outcome

Variables	Final Radiological Outcome				p value
	Excellent	Good	Fair	Poor	
Fracture Sub-type					
2R3B3.1	3 (17.60)	0 (0.00)	0 (0.00)	0 (0.00)	0.340
2R3B3.2	12 (70.60)	4 (66.70)	1 (50.00)	0 (0.00)	
2R3B3.3	2 (11.80)	2 (33.30)	1 (50.00)	1 (100.00)	
Fracture Sub-type					
2R3B3.1	3 (16.70)	0 (0.00)	0 (0.00)	0 (0.00)	0.451
2R3B3.2	12 (66.70)	4 (80.00)	1 (50.00)	0 (0.00)	
2R3B3.3	3 (16.70)	1 (20.00)	1 (50.00)	1 (100.00)	
Age Group (Years)					
< 20	2 (11.10)	1 (20.00)	0 (0.00)	0 (0.00)	0.476
21-30	5 (27.80)	2 (40.00)	0 (0.00)	0 (0.00)	
31-40	7 (38.90)	1 (20.00)	0 (0.00)	1 (100.00)	
41-50	4 (22.20)	1 (20.00)	2 (100.00)	0 (0.00)	

IV. DISCUSSION

Volar Barton's fractures are not common injuries [12]. Volar Barton's fracture is an unstable fracture of distal radius, commonly accompanied by subluxation or luxation of wrist joint [13]. Various forms of treatment have been described closed reduction and plaster application, percutaneous pinning, external fixation, and open reduction and internal fixation (ORIF) with plates and screws [14]. Operative treatment with volar locking plating restores articular congruity, joint stability, permits early wrist mobilization and return to normal activities or work [15]. Among present study population, the age ranged from 18 years to 50 years, with mean age was 34.46 ± 9.90 years. Maximum 34.60% patients belong to 31-40 years age group. According to Gogia et al. reported that mean age of the patients was 37 years, most of the patients were younger age group (less than 38 years of age) [16]. In this study there were male predominance. Out of the 26 patients 69.20% were male and 30.80% were female. Four studies examined that higher male predisposition of volar Barton's fracture could be attributed to a highly active work group with a higher involvement in high energy trauma and high velocity injuries of RTA [12,16,17]. Most of the patients of this study were service holders 26.90%, followed by student 23.10%, and lowest number of cases were from other occupations 27.70% in our study. Pillai et al. found such fractures to be more common in students 28.10% [18]. The study the most common cause of injury was MVA (motor vehicle accident) which was 69.20%. Other causes were fall from standing height on the ground 19.20% and sports injury 11.50%. Dai et al. stated causes of fracture included 56.50% motorcycle accidents, 21.70% fall on ground, 13.10% sports injuries and 8.7% falls from a height [19]. In present study highest 65.40% patients had B3.1 type, followed by 23.10% patients had B3.3 type and lowest 11.50% patients had B3.1 type fractures. According to Ali et al. B3.2 were 56%, B3.3 were 25% and B3.1 were 20%; and Madhukar et al. B3.2 were 64.29%, B3.3 were 28.57% and B3.1 were 7.14% [14,17]. Current study showed right predominance over left side in terms of affected sides of the fractures. Out of 26 cases 57.70% had right and 42.30% had left sided fractures. Four studies examined the same things [16-18, 20]. In this study, maximum 57.70% patients were operated in 2nd week (8-14 days), and rest 42.03% patients were operated in 1st week (1-7 days). The mean interval of injury to operation time was 8.31 ± 3.17 days, where minimum was 3 days and maximum was 14 days. Ali et al. contrary to this finding majority 60% of the patients were operated within the first week of injury in study series [14]. In present study, union was

achieved in all cases and most patients 84.60% had no complications. Only 15.40% patients developed complications. Among them 11.57% patients developed wrist stiffness and 3.80% had superficial wound infection. Infection was controlled by regular dressing with antibiotics. None of the cases developed non-union, median nerve damage, or hardware breakage. Similar to our study Ali et al. reported 11.60% complication in the form of somewhat restriction of wrist's ROM [14]. Radiological evaluation was done according to Sarmiento's modification of Lindstrom criteria. Loss of volar tilt of the distal radius were $\leq 0^\circ$ in 57.70%, 1° - 10° in 30.80%, 11° - 14° in 7.70% and $> 15^\circ$ in 3.80% case. Mean loss of volar tilt was 2.88 ± 4.50 degree (range: 0° - 16°). Radial shortening < 3 mm, $3 - 6$ mm, $7 - 11$ mm and ≥ 12 mm occurred respectively in 73.10%, 19.20%, 3.80% and 3.80% case. Mean radial shortening was 2.04 ± 2.89 mm, and range was $0 - 12$ mm. Loss of radial inclination $\leq 4^\circ$ occurred in 65.4%, $5^\circ - 9^\circ$ in 23.10%, $10^\circ - 14^\circ$ in 27.70% and $> 15^\circ$ in 3.80% case. Mean loss of radial inclination was 3.88 ± 4.08 degree with range of $0^\circ - 18^\circ$. Gogia et al. reported, similar to this study more than 60% patients had excellent to good result with regard to loss of volar tilt. All the patients (100%) in their study series had excellent to good results in term of radial shortening, which is slightly better than current study [16]. At final follow up radiologically excellent result were found in 65.40%, good in 23.10%, fair in 7.70% and poor in 3.80% case. Thus, overall satisfactory radiological outcome was seen in 88.50% and unsatisfactory outcome was seen in 11.50% cases. On the other hand, lower overall satisfactory outcomes were reported by Karthik et al. and Goud et al. - 77.50% and 76.60% respectively. Both of these studies had more 'good' results as compared to 'excellent' results. None of these had 'poor' radiological results [21,22]. In current study, functional outcome according to Green and O'Brien score was excellent in 69.20% patients, good in 19.20% patients, fair in 7.70% patients and poor in 3.80% patient at final follow up. Thus, overall satisfactory functional outcome was seen in 88.50% and unsatisfactory outcome was seen in 11.50% cases. Wrist functions as assessed by Green and O'Brien score showed satisfactory (excellent to good) results in 89.30% patients by Madhukar et al. which is comparable to our study [17]. Association between fracture sub-type with both final radiological outcome and final functional outcome were statistically insignificant. However, most of the satisfactory (excellent and good) radiological and final functional outcomes observed in 2R3B3.2 sub-type and most un-satisfactory (fair and poor) radiological and final functional outcomes observed in 2R3B3.3 sub-type. Almost similar to our study, Baldaniya and Doshi concluded that all the patients with poor outcome was of (2R3) B3.3 classification [15].

Limitations of the study: This study had several limitations. It was conducted in a single center with a relatively small, non-randomly selected sample size, which may limit the representativeness of the findings. Fracture classification was based on X-ray evaluation rather than CT scan, which could affect the accuracy of fracture typing. Additionally, the follow-up period was limited to six months, preventing assessment of long-term outcomes. Therefore, the results of this study may not be generalizable to the broader population.

V. CONCLUSION

The study showed that operative treatment of volar Barton's fracture led to excellent to good radiological and functional result with uncomplicated recovery in majority of the cases. Lower and minor complications, and satisfactory outcome permit to say that volar Barton's fractures can efficaciously be treated with volar locking plate osteosynthesis, allowing rigid anatomic fixation and early mobilization.

Recommendations: Considering the clinical perspective, this study supports that different attention is needed from health care providers while managing patients of volar Barton's fractures. A multi centric and large-scale study with long term follow up should be performed on larger sample size. Thereby further comparative studies can also be done.

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Ethical approval: The study was approved by the Institutional Ethics Committee.

REFERENCES

- [1]. Eschweiler J, Li J, Quack V, Rath B, Baroncini A, Hildebrand F, Migliorini F. Anatomy, biomechanics, and loads of the wrist joint. *Life*. 2022 Jan 27;12(2):188.
- [2]. Liu Y, Waheed MZ, Wang D, Zhou J. Treatment of Distal Radial Fracture Fixation Using Volar Rim Distal Radius Plate: A Prospective Study.
- [3]. Huang YM, Chen CY, Lin KC, Tarn YW, Liao CY, Chang WN. Functional outcomes following fixation of a marginal distal radius fracture with two commonly used volar locking plates: a retrospective cohort study. *BMC musculoskeletal disorders*. 2022 Jan 3;23(1):18.
- [4]. Candela V, Di Lucia P, Carnevali C, Milanese A, Spagnoli A, Villani C, Gumina S. Epidemiology of distal radius fractures: a detailed survey on a large sample of patients in a suburban area. *Journal of Orthopaedics and Traumatology*. 2022 Dec;23(1):43.
- [5]. Dai M, Wu C, Liu H, Wang I, Yu C, Wang K, Chen C, Jung C. Treatment of volar Barton's fractures: comparison between two common surgical techniques. *Chang Gung medical journal*. 2006 Jul 1;29(4):388.

- [6]. Tang Z, Yang H, Chen K, Wang G, Zhu X, Qian Z. Therapeutic effects of volar anatomical plates versus locking plates for volar Barton's fractures. *Orthopedics*. 2012 Aug 1;35(8):e1198-203.
- [7]. Laghari AR, Mahar SA, Palh HB, Ahmed W, Bhutto AM, Hussain F, Keerio NH. Outcome of volar barton fractures treated with locking compression plates: a cross-sectional study: volar barton fractures treated with locking compression plates. *Pakistan Journal of Health Sciences*. 2022 Oct 31:142-6.
- [8]. Çalbiyik M, Ipek D. Use of volar locking plate versus intramedullary nailing for fixation of distal radius fractures: a retrospective analysis of clinical and radiographic outcomes. *Medical science monitor: international medical journal of experimental and clinical research*. 2018 Jan 30;24:602.
- [9]. Agrawal V. Randomized study of functional outcome of patients with lower end radius fracture treated with distal locking radius plate. *Original Research Article*. 2018;346(2):346-94.
- [10]. Madhukar SN, Pugazhendhi G, Vijayanarasimhan SA, Venkatachalam K. Functional outcome of volar Barton's fracture treated with volar plate osteosynthesis. *Sch Acad J Biosci*. 2016;4(3B):237-43.
- [11]. Hevonkorpi TP, Launonen AP, Raitio L, Luukkala T, Kukkonen J, Reito A, Sumrein BO, Laitinen MK, Mattila VM, NITEP-group. Nordic Innovative Trial to Evaluate Osteoporotic Fractures (NITEP-group): non-operative treatment versus surgery with volar locking plate in the treatment of distal radius fracture in patients aged 65 and over—a study protocol for a prospective, randomized controlled trial. *BMC Musculoskeletal Disorders*. 2018 Apr 5;19(1):106.
- [12]. Aggarwal AK, Nagi ON. Open reduction and internal fixation of volar Barton's fractures: a prospective study. *Journal of Orthopaedic Surgery*. 2004 Dec;12(2):230-4.
- [13]. Bhattacharya PK, Choudhury FA, Khanna A. TREATMENT OUTCOME OF LOCKING COMPRESSION PLATES IN VOLAR BARTON'S FRACTURE. *Int J Med Phar Sci| Vol*. 2015 Jan;5(5):1.
- [14]. Ali MN, Tahir AM, Ahmed ZU. Treatment of Volar Barton's Fractures of the Distal Radius with T-buttress Plates. *Pakistan J Med Heal Sci*. 2014;8:631-4.
- [15]. Baldaniya JS, Doshi KP. A study of functional outcome of volar Barton fracture treated with open reduction and volar plate fixation. *Int J Sci Res*. 2016;5(8):641-643.
- [16]. Gogia KK. MANAGEMENT OF VOLAR bARTON FRACTURE WiTh VOLAR PLATE OSTEOsYNThESis-PROSPECTIVE STUDY. *International Journal of Orthopaedics*. 2019 Dec;5(01):77-81.
- [17]. Madhukar SN, Pugazhendhi G, Vijayanarasimhan SA, Venkatachalam K. Functional outcome of volar Barton's fracture treated with volar plate osteosynthesis. *Sch Acad J Biosci*. 2016;4(3B):237-43.
- [18]. Pillai HB, Sankar S, Rawat SS, Arya S, Jadhav P. The functional outcome volar barton fracture treated by open reduction and internal fixation with T Plate-A prospective study. *J Contemp Med Res*. 2020;7(6):F7-11.
- [19]. Dai M, Wu C, Liu H, Wang I, Yu C, Wang K, Chen C, Jung C. Treatment of volar Barton's fractures: comparison between two common surgical techniques. *Chang Gung medical journal*. 2006 Jul 1;29(4):388.
- [20]. Al-Faily HO, Nasir HA, Mohammed TR, Al-Edanni M. Prospective Descriptive Study of Radiological and Functional Outcomes of Volar Barton's Fracture Fixed by Volar Locked Plate. *Open Access Macedonian Journal of Medical Sciences*. 2022 Feb 21;10(B):1271-5.
- [21]. Karthik SJ, Ethiraj P. Do variable locking plates provide better functional and radiological outcomes in volar Barton fractures?. *Cureus*. 2022 Nov 12;14(11).
- [22]. Goud V, Kanamarlapudi M. Correlation between functional and radiological outcome after surgical stabilization of volar Barton fracture with plating: a comparative study. *Int J Res Orthop*. 2020;6(4):666-670.