ORIGINAL RESEARCH PAPER

Orthopaedics

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FUNCTIONAL AND ANATOMICAL OUTCOME IN INTRA-ARTICULAR DISTAL RADIUS FRACTURES TREATED BY VOLAR-LOCKING PLATING

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ABSTRACT

Distal end radius fractures are the most common fractures of the upper extremity. There are various modalities for treatment like close reduction and cast application, external fixators, ORIF with plate and screw etc.
In this study ORIF with volar Lcp(Volar approach)was done in 21 patients (22 male and 13 female) of distal end radius fractures depending on inclusion and exclusion criteria was performed. Fractures were classified according to frykman classification and AO classification. The functional and anatomical outcomes were measured. Out of 21 patients, according to Green and O'Brien 18(86% had excellent results), 6 had good results (29%), 4 had fair results (18%),1 had poor result(5%).According to Lidstorm's criteria anatomical outcome was 12 patients (57%) had excellent, 5 good (23.8) and 2 patients (9.5%) had fair outcome while 2 patients (9.5%) had poor outcome.We opined volar plating for treatment of fracture distal end radius is good method with excellent outcomes.

1. Introduction

Distal radius fractures are most common fractures of upper limb presenting at emergency rooms, compromising of more than 16% of all fractures. Distal radial fractures have a bimodal type of age distribution with high-energy trauma contributing in younger and low energy trauma in elderly population. Females are more liable to distal radius fractures when compared with males mainly because of more severe osteoporosis and a higher liability of elderly women to falls[1] compared to the age - matched men. The metaphyseal widening of the distal radius is a zone predisposed to fractures because of a lower amount of strong cortical bone and higher amount of weaker cancellous bone. The major risk factors are low bone mineral density (BMD) and a tendency to fall. Consequently, a fracture of the distal radius is typically the result of a fall on the outstretched arm in a postmenopausal woman, where a functionally active person suffers a trauma on an osteoporotic bone. Until about 60 years ago, it was general notion that most distal radial fractures could be treated conservatively with satisfactory results. Only 2 recently, it was clinically proved that intra-articular step-off and radial shortening corrected by surgery had improved patient outcome. [2]. Malunion, secondary loss of reduction, stiffness, reflex sympathetic dystrophy, residual deformity are the potential complications possible in cast treatment.[3] In case of intra-articular step in conservative management there are chances of limitation of movements and early arthritis of radio-carpal and radio-ulnar joints.[4] The goals of surgical treatment of distal radius fractures are to provide articular congruity [5,6], maintain alignment, and regain motion early in the postoperative period. Though various fixation options are available, the most commonly practising technique are closed reduction and External fixation and Open reduction and internal fixation with locking compression plate.

The advantages of volar locking plates over dorsal plates and external fixators have been described in recent literature [7,5].

External fixators oblige immobility across the joint, which may result in potential muscle atrophy, disuse osteopenia, and tightening of the joint capsule. This complicates rehabilitation and functional outcome, especially for those patients with osteoporosis. Dorsal plates carry the risk of tenosynovitis and tendon rupture due to the proximity of the plate to the extensor tendons. These complications have been reported to necessitate the removal of the dorsal plate in 11 to 33% of cases [8,9, and 10]. Volar plates diminish the aforementioned risks and have improved the outcome in treating distal radius fractures. Furthermore, and critical to reaching the goal of safe, early postoperative range of motion, volar locking plates introduce improvement in the stability of the fracture repair compared to non-locked volar plates.

The aim of the present study is to evaluate the functional and radiographic results of volar plates for treating fractures of the distal end of the radius.

2. Material And Methods

This study was conducted on patients with intra articular distal radius fractures in Department of Orthopaedic Surgery in kempegowda institute of medical science and research centre, Bangalore, Karnataka from March 2016 to December 2018, VV Puram, Bangalore. A total of 21 of aged ≥ 18, years were in this study.

Study Design: Prospective open label observational study
Study Location- kempegowda institute of medical science and research Centre, Bangalore, Karnataka (10)
Study Duration: November 2016 to November 2018.
Sample size: 21 patients.
Sample size calculation -
Analysis: A priori: Compute required sample size

Input: Tail(s) = Two
Effect size dz = 0.70
α err prob = 0.05
Power (1-β err prob) = 0.80

Output: Noncentrality parameter =3.0512293
Critical t =2.1009220
Df =18
Total sample size =19
Actual power =0.8225473

The sample size has been estimated using the software GPower v. 3.1.9.2
Considering the effect size to be measured (dz) at 70%, power of

the study at 80% and the margin of the error at 5%, the total sample size needed is 19. The total is rounded off to 20.

Hence, the sample size will comprise of 20 samples in the group.

Subjects & selection method:
The study population was drawn from patients with intra articular fractures who presented to kempegowda institute of medical science and research centre, Bangalore, between October 2016 to May 2018.

Inclusion criteria:
1) Patients in the age group >18 years
2) Patients with distal radius fractures with intra-articular extension following road traffic accident or slip or fall on outstretched hand or assault
3) Closed fractures
4) Comminuted fractures with or without bone loss

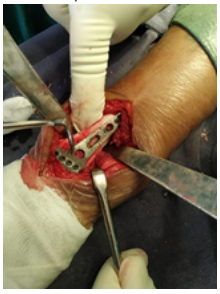
Exclusion criteria:
1) Open fractures
2) Patients with head injuries and who are comatose
3) Associated ulnar diaphyseal fractures or carpal bone fractures
4) Associated neurovascular injuries

Procedure methodology
After written informed consent was obtained, All cases presenting to the outpatient and emergency department fulfilling the above mentioned criteria will be taken up for study.

Patients subjected to surgery will be followed up at regular intervals with clinical and radiological data. Assessment will be done based on a proforma containing all necessary information regarding.
- Personal details: age, sex, address and occupation
- Type of fractures: A.O classification and frykmann classification
- Surgical procedure carried out
- Initiation of mobilization
- Range of movements achieved post operatively by way of periodic follow-up.
- Development of intra-operative and post-operative complication.

PRE-OPERATIVE INVESTIGATIONS-
Along with radiograph of affected and normal wrist AP and Lateral views, all investigations required for pre anaesthetic check-up were performed.

SURGICAL PROCEDURE-
(Volar approach) -Surgery was performed under appropriate anaesthesia i.e. either general anaesthesia or axillary or supra clavicular block under tourniquet control. Open reduction and internal fixation was done using modified Henry approach between the flexor carpi radialis and radial artery. The pronator quadratus was sharply taken off the radial aspect of the radius and reflected ulnarly to facilitate exposure of the fracture. Under direct visualization and the aid of fluoroscopy, the fracture was then reduced. Depending on the difficulty in achieving the reduction, provisional fixation with k-wires can be occasionally utilized. The plate and screws were placed and the provisional fixation (in use) was removed. The plate was initially secured proximally with a 3.5-mm cortical screw. Upon confirming adequate placement of the plate, a second screw proximal to the fracture was used to firmly secure the hardware. Distal fixation with locking screws was then performed while maintaining the fracture reduced. The remaining proximal fixation was then completed. [11]



Patients were encouraged limb elevation and active finger mobilization exercises in immediate post op period. Distal neurovascularity was assessed regularly and intravenous antibiotics were given for 3 days and after that changed to oral antibiotics till suture removal. Suture removal was done for all the cases between 10 to 12 days from post op. After suture removal the slab was removed and gentle active wrist mobilization exercises were started. Resisted exercises were started about 6 weeks after surgery.

FOLLOW UP -
Patients were recommended for follow up at 6 weeks, 3 months, 6 months and 12 months interval and routine x-rays were taken to assess the fracture healing. Patients were followed up using the green and O'Brien score for functional outcome. Radiologically we assessed in terms of residual dorsal angulation, radial shortening and loss of radial inclination and the results were graded according to the Lid Strom Criteria. These parameters were assessed throughout the follow up of the patient to assess the standard of reduction and the ability of the technique to keep up the reduction. Postoperative radiographs were evaluated in accordance with the Lidstrom anatomical-radiological classification.

3. RESULT
In our study 21 patients, were treated with volar locking compression plate. The average follow up among LCP group was 11.26 months with maximum follow up for 16 months and minimum follow up for 6 months. We had analysed the functional outcome as per Green and O'Brien scoring system modified by Cooney ET. al a. The anatomical outcome was measured with according to Sarmiento's modification of Lidstorm's criteria

The study comprised a total of 21 patients of intra articular fractures of the distal radius were considered according to inclusion and exclusion criteria for the final evaluation of results during May 2016 to October 2018. The youngest patient being 21 years and the oldest being 65 years. There were 9 female patients (43%) and 12 male patients (57%). Mode of trauma due to fall 11(52%) is more as compare to RTA 10 (48%). dominant side 14 (67%) is involved more as compare to non-dominant 7 (23%). Out of 21 patients 7 (33%) had type C1 fracture. 11 (52%) had type C2 and 3 (15%) had type C3 fracture.

Functionally 10 patients (46%) had excellent, 15 well (43%) and 4 patients had satisfactory (11%) restoration of functions.

Anatomically 12 patients (57%) had excellent, 5 good (23.8) and 2 patients (9.5%) had fair outcome while 2 patients (9.5%) had poor outcome.

Table 1 – Age distribution of patients

Age	Male	Female
20-30	3	1
30-40	4	3
40-50	2	3
50-60	2	1
60-70	1	1

Table 2- Sex distribution of patients

SEX	NO
MALE	12
FEMALE	9

Table 3- mode of injury of sustaining the fracture

MODE OF INJURY	NUMBER
RTA	10
SELF FALL	11

Table 4 and chart 1- Distribution according to dominance of the fractured side

	NUMBER
DOMINANT	14
NON DOMINANT LIMB	7

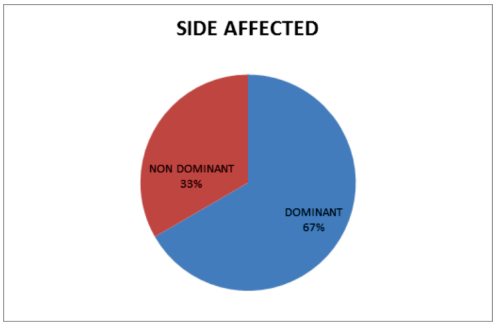


Table 5- comorbidities present in the patients

COMORBIDITY	NUMBER
PRESENT	5
ABSENT	16

Table 6 and chart 2 – Distribution according to Frykmann classification

Frykman classification	
Type	**Number**
3	5
4	1
5	0
6	1
7	7
8	7

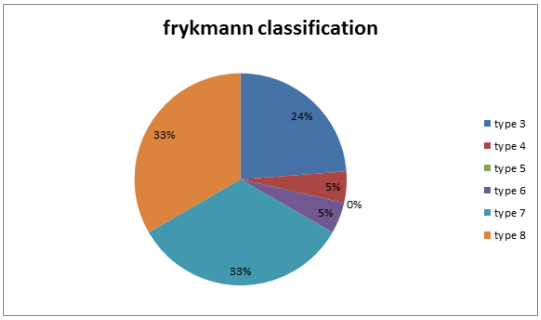


Table 8 and chart 3 – Distribution according to AO classification

AO classification	
Type	**Number**
C1	7
C2	11
C3	3

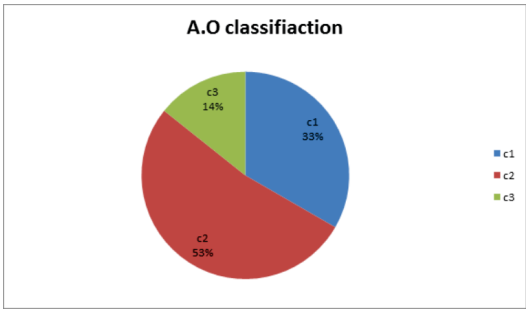


Table 9- Residual pain in patients at 6 months follow up

Pain	
Intensity	**Number**
No pain	7
Mild	9
Moderate	3
severe	1

Table 10 and chart 4- Recovery of range of motion at 6 months post operatively

RANGE OF MOTION (%)	NUMBER
100	7
75-99	9
51-74	4
0-50	1

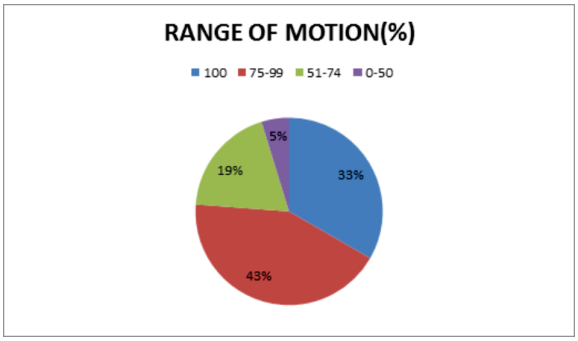


Table 11 and chart 5- Return to work at 6 months post-operative follow up

RETURN TO WORK	NUMBER
REGULAR	18
RESTRICTED	2
ABLE TO WORK	1
UNABLE	0

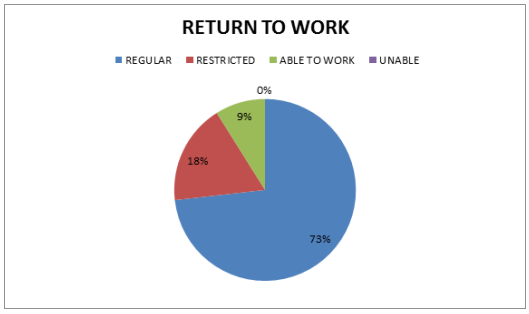


Table 12 and Chart 6 – Percentage of grip strength at 6 months follow up

GRIP	
% OF OPPOSITE SIDE GRIP	**NUMBER**
100	7
75-99	9
50-74	4
0-49	1

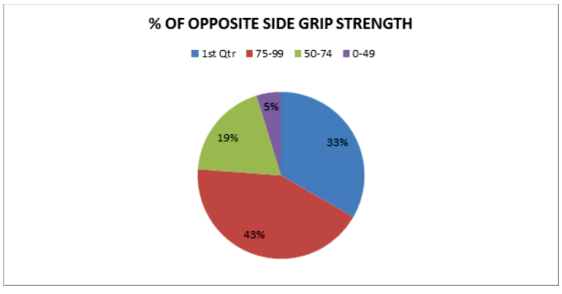


Table 13 and Chart 7 – Functional outcome

FUNCTIONAL OUTCOME	
EXCELLENT	**10**
GOOD	6
FAIR	4
POOR	1

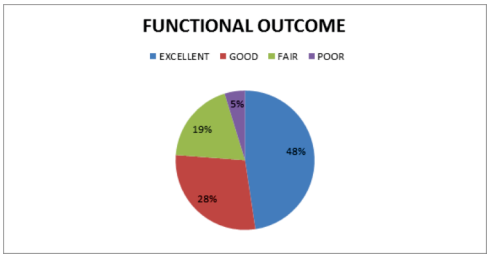


Table 14 and Chart 8 – Residual deformity in patients

RESIDUAL DEFORMITY	
NIL	**16**
SLIGHT	2
MODERATE	2
SEVERE	1

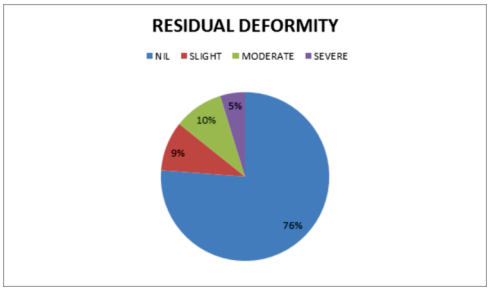


Table 15- Radiological outcome of various parameters

COMPARISON OF MEAN VALUES OF DIFFERENT PARAMETERS BETWEEN OPERATED [FOLLOW-UP] AND NORMAL SIDE USING STUDENT PAIRED T TEST						
Parameters	Sides	N	Mean	SD	Mean Diff	P-value
Radial Length	Follow-up	21	9.10	1.61	-2.14	<0.001*
	Normal	21	11.24	0.89		
Volar Tilt	Follow-up	21	9.29	1.82	-1.90	<0.001*
	Normal	21	11.19	0.98		
Radial Inclination	Follow-up	21	18.52	3.40	-3.58	<0.001*
	Normal	21	22.10	1.09		
COMPARISON OF MEAN VALUES OF ULNAR VARIANCE BETWEEN OPERATED [FOLLOW-UP] AND NORMAL SIDE USING WILCOXON SIGNED RANK TEST						
Parameters	Sides	N	Mean	SD	Mean Diff	P-value
Ulnar Variance	Follow-up	21	-0.48	0.75	0.66	0.001*
	Normal	21	-1.14	0.57		

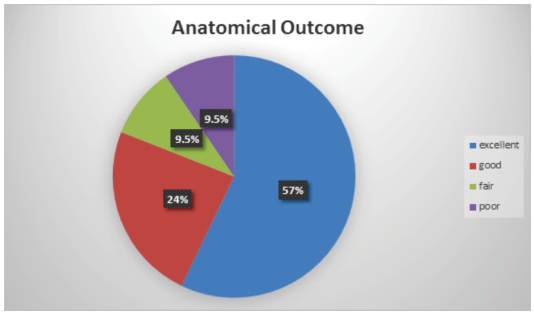
* - Statistically Significant

The test results demonstrated that operated side during follow-up period showed significantly lesser mean radial length [9.10 ± 1.61] as compared to normal side [11.24 ± 0.89] at P<0.001.

Similarly, the operated side during follow-up period showed significantly lesser mean Volar tilt [9.29 ± 1.82] as compared to normal side [11.19 ± 0.98] at P<0.001. And also the mean radial inclination on the operated side during follow-up period showed significantly lesser value [18.52 ± 3.40] as compared to normal side [22.10 ± 1.09] at P<0.001. But when the consideration is done clinically the mean decrease in radial height is part of acceptable reduction and a positive volar tilt (no dorsal tilt) and a deviation of 3.4 degrees of loss of radial inclination can be considered as an acceptable post-operative reduction

The test results demonstrated that operated side during follow-up period showed significantly higher mean ulnar variance [-0.48 ± 0.75] as compared to normal side [-1.14 ± 0.57] at P<0.001 but again they are clinically insignificant and unlikely to predispose to radiocarpal joint arthritis.

Chart 9 – Anatomical outcome according to LIdstorms's Criteria



4. Discussion

Intra-articular fractures of radius have a varied configuration and multiple factors that contribute to the functional outcome. Many complications of distal radius fracture treatment are the result of immobilization of the wrist joint for 4 to 6 weeks with either cast or external fixator. [12,13]. Volar plating with locking screw plate system, has the advantage of an easy surgical approach, no or relatively less period of immobilization of wrist and removal of plate is not mandatory.[14]. Dorsal plating is associated with a high complication rate mostly due to dorsal soft tissue irritation and tendon-related delayed problems hence almost always plate removal is required.

In order to achieve good functional outcome in cases of volar fixation some surgical techniques are required to be followed like placement of distal locking screws as close to the articular surface as possible without entering the joint.[15]

In the series of Drobetz and Kutscha- Lissberg the outcome was excellent in 33%, good in 15%, Fair in 17% and poor in 5% of their cases.[15]Their series reported a high complication rate related to tendon ruptures (FPL, EPL) which was not encountered in our series probably due to better plate designs.

The series of Ho et al showed the incidence of median neuropathy after volar plating at 5.3% and that of carpal tunnel syndrome at 3.2%.[16] In our study we encountered one case of postoperative median neuropathy. Median nerve neuropathy has been postulated to be the result of scarring in the forearm surgical wound or retractor injury during surgery. This complication can be reduced by meticulous dissection and careful retraction.

The series of Vargaonkar evaluated the results of various treatment modalities of distal end radius fracture. [17] In this series, in the subgroup of patients treated with ORIF and plating, 67% had excellent results, 33% with good results and no fair or poor functional outcome. In our study we had 38% excellent result (n=8), 19% (n=4) good, 29 %(n=6) fair and 14 %(n=3) poor outcomes.

In study by chauvan 91% patients treated with volar locking plate had good to excellent outcomes while in our study 81% had well to excellent outcome. [18] They stabilized the fracture fragments with volar plate and screws in the management of the fractures of distal radius, which is an effective method to maintain the reduction till fracture is united and prevent collapsing of the fracture fragments, even when the fracture is grossly comminuted/intra-articular/unstable and/or the bone is osteoporosed.

Avoidance of malunion is important, since a poor anatomical result adversely affects recovery of Function since any particular step >2mm is said to hinder movement and predispose to radiocarpal joint arthritis. In study by Keating it was concluded that volar tilt was the most important single determinantof functional outcome and despite cases with malunion acceptable functional outcome was achieved. [19]

5. Conclusion

We conclude that intra-articular fracture of distal end radius can be effectively stabilized by a volar locking plate and screw system. The construct maintains the reduction till union and prevents collapse or re-displacement of fracture fragments. It allows early functional mobilization, thus overcoming the problems of long term immobilization with concurrent stiffness of wrist and hand.

6. Acknowledgements

I wish to acknowledge the patients eho participated in the study and without whose cooperation this study couldn't have been possible and the staff of kempegowda institute of medical sciences for all the help.

ILLUSTRATIONS

Figure 2- Pre Op Xray (Color Illistration)

Figure 3- Immediate post Op Xray (Colour Illustration)

Figure 4- 6 Month Follow up (Colour Illustration)

Figure 5- One Year Follow up (Colour Illustration)

Figure 6- Functional Outcome after 1 Year –Dorsiflexion (Colour Illustration)

figure 7- Functional Outcome after 1 Year –Plantarflexion (Colour Illustration)

Figure 8- Functional Outcome after 1 Year –Ulnar Deviation (Colour Illustration)

Figure 9- Functional Outcome after 1 Year –Radial Deviation (Colour Illustration)

Figure 10- Functional Outcome after 1 Year –Pronation (Colour Illustration)

Figure 11- Functional Outcome after 1 Year –Supination (Colour Illustration)

ANNEXURE 1

Green and O'Brien Score (Cooney modification) [11]

I. Pain (25 points)
- 25 None
- 20 Mild, occasional
- 15 Moderate, tolerable
- 0 Severe or intolerable

II. Range of motion (25 points): flexion + extension, percentage of normal
- 25 100
- 15 75-99
- 10 50-74
- 5 25-49
- 0 0-24

III. Grip strength (25 points), percentage of normal
- 25 100
- 15 75-99
- 10 50-74
- 5 25-49
- 0 0-24

IV. Activities (25 points)
- 25 Returned to regular employment
- 20 Restricted employment
- 15 Able to work but unemployed
- 0 Unable to work because of pain

V. Final result
- 90-100 Excellent
- 80-89 Good
- 65-79 Fair
- <65 Poor

ANNEXURE 2

Lidstrom classification
Excellent
Insignificant deformity
- Dorsal angle greater than 0° (neutral) - Radial shortening less than 3 mm - Loss of radial tilt not more than 4°
Good
Small deformity
- Dorsal angle 1-10° - Radial shortening 3-6 mm - Loss of radial tilt 5-9°
Fair
Moderate deformity
- Dorsal angle 11-14° - Radial shortening 7-11 mm - Loss of radial tilt 10-14°
Poor
Severe deformity
- Dorsal angle greater than 15° - Radial shortening greater than 11 mm - Loss of radial inclination greater than 15°

7. REFERENCES

1. Mensforth RP, Latimer BM. Hamann-Todd Collection aging studies: osteoporosis fracture syndrome. Am J Phys Anthropol 1989;80(4):461-479.
2. Smith DW, Henry MH: Volar fixed-angle plating of the distal radius. JAm Acad Orthop Surg 2007;11:25-32.
3. Solgaard S. Function after distal radius fracture. Acta Orthop Scand 1988;59(1):39-42.
4. Altissimi M et al Long term results of conservative treatment of fractures of the distal radius. Clinical Orthopedics & Related Research, 1986; 206:202-210
5. Smith DW, Henry MH. Volar fixed-angle plating of the distal radius. J Am Acad Orthop Surg 2005; 13:28–36. [PubMed]
6. Trumble TE et al Factors affecting functional outcome of displaced intra-articular distal radius fractures. J Hand Surg 1994; 19:325–40. [PubMed]
7. Riggs BL, Melton LJ. The worldwide problem of osteoporosis: insights afforded by epidemiology. Bone 1995; 17:505S–11S. [PubMed]
8. Carter PR et al Open reduction and internal fixation of unstable distal radius fractures with a low-profile plate: a multicenter study of 73 fractures. J Hand Surg 1998; 23A:300–7. [PubMed]
9. Herron M, Faraj A, Craigen MA. Dorsal plating for displaced intra-articular fractures of the distal radius. Injury 2003; 34:497–502. [PubMed]
10. Ring D et al Prospective multicenter trial of a plate for dorsal fixation of distal radius fractures. J Hand Surg 1997; 22A:777–84. [PubMed]
11. Nana AD et al Plating of the distal radius. J Am Acad Orthop Surg. 2005; 13(3):159-71.
12. Doi K et al Intra-articular fractures of distal aspect of radius: arthroscopically assisted reduction compared with open reduction and internal fixation. J Bone Joint Surg (Am). 1999;81:1093-110.
13. Rader CP et al Internal fixation of the distal radius. A comparative, experimental study. Arch Orthop Trauma Surg. 1995; 114:340-3
14. Hove LM et al. Open reduction and internal fixation of displaced intra-articular fractures of the distal radius. Thirty-one patients followed for 3-7 years. Acta Orthop Scand. 1997; 68:59-63.
15. Drobetz H, Kutscha-Lissberg E. Osteosynthesis of distal radial fractures with a volar locking screw plate system. Int Orthop (SICOT). 2003;27:1-6.
16. Ho AWH, Ho ST, Koo SC. Hand numbness and carpal tunnel syndrome after volar plating of distal radius fracture. Hand. 2011; 6(1):34-8.
17. Vargaonkar G. Distal end radius fractures: evaluation of results of various treatments and assessment of treatment choice. Chinese J Traumatol. 2014; 17(4):214-9
18. Chavhan AN et al Functional and radiological outcome in distal radius fractures treated with locking compression plate. Int J Res Med Sci 2017; 5:574-82.
19. Keating JF et al .Internal fixation of volar- displaced distal radial fractures. J Bone Joint Surg. 1994; 76:401-40.