International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2021; 7(1): 703-712
© 2021 IJOS
www.orthopaper.com
Received: 06-11-2020
Accepted: 27-12-2020

Dr. TM Ravinath
HOD orthopaedic, Dept Jjm Medical College, Karnataka, India

Shakeeb Mohammed Shariff
JJM Medical College Mcc B Block Davangere, Karnataka, India

Dr. Nilesh Agarwal
MS Ortho post graduate JJM medical college Karnataka, India

Dr. Pranav Rajendra
MS Ortho post graduate, JJM medical college Karnataka, India

Dr. Devashish Mendiratta
MS Ortho, JJM medical college Karnataka, India

Corresponding Author:
Shakeeb Mohammed Shariff
JJM Medical College Mcc B Block Davangere, Karnataka, India

A prospective study in surgical management of distal end radius fracture with variable angle locking compression plate

Dr. TM Ravinath, Shakeeb Mohammed Shariff, Dr. Nilesh Agarwal, Dr. Pranav Rajendra, and Dr. Devashish Mendiratta

DOI: https://doi.org/10.22271/ortho.2021.v7.i1k.2562

Abstract
Background and Objective: The distal end of the radius is subject to many different types of fracture, depending on factor such as age, transfer of energy, mechanism of injury and bone quality i.e. Colle's, Smith's volar and dorsal Barton's fracture [1]. Fractures of distal end radius are the most common fractures of the upper extremity, encountered in all of the skeletal fractures and constitute 17% and 75% of forearm fractures and having incidence from 5.7 to 124.6 per 10,000 persons per year [2]. In Intra articular distal radius fracture's degree of anatomical reduction is directly related to the posttraumatic arthritis. Conservative treatment is usually unsuccessful, and it is fraught with complications, such as early osteoarthrosis, deformity, subluxation, and instability [3-5] The aim of treatment here is good reduction and immediate stability to achieve anatomic fracture union, which will allow the early mobilization of wrist and also to avoid the complications of fracture [6-8] Fracture healing decided by factors such as gap, stability and blood supply [9]. With locking compression plate the locking screw supports subchondral bone and resists axial forces. Compression of locking compression plate to bone is unnecessary and preserves periosteal blood supply [10]. The locking plate minimizes the compression exerted on the bone to achieve stability, impairment of blood supply, periosteal compression and along with that it allows screws to be angled around central axis of plate hole to match with the anatomy [11]. The motive of this study is variable angle locking compression plates in the treatment of distal end radius fractures and it's beneficial effects.
Materials and Methods: 20 patients with Distal End Radius fracture were selected admitted at Chigateri general hospital and Bapuji hospital attached to J.J.M. Medical College, Davangere during October 2018 to October 2020.The study will include patients with distal end radius fractures seen as both out-patient and in-patient fulfilling the inclusion criteria. The patients are assessed both clinically and radiologically. Other associated injuries are noted. The patients undergoing open reduction and internal fixation and application of variable angle locking compression plates for distal end radius fracture are reviewed post operatively, one month, three month, six month and after one year clinically and with x-rays.
Result: The study comprised of 15 male and 5 female patients aged from 18 to 72 years with the mean age of 42.2 years with most patient had injury to right side i.e. 11 out of 20 (55%) patients. The average duration from the date of injury to date of surgery was 3 days. The follow up ranged from 6 to 14 months. Using the Modified Cooney, Green and O'Brien functional score for wrist we had 50% excellent, 30% good, 15% fair and 5% poor results with only 3 out of 20 (15%) patients having complications like (arthritis, extensor pollicis longus tendon irritation, superficial skin infection)
Interpretation and Conclusion: Fixation of Distal End Radius Fracture with a Variable angle locking compression plate has acceptable outcome for both the patients and surgeon. Variable angle locking plates give acceptable results in the treatment of this type of fracture with better and faster recovery of functions and range of movements.

Keywords: Distal radius fracture; variable angle locking compression plate; open reduction and internal fixation

Introduction
There are different types of distal end fractures of the radius , depending on factor such as age, transfer of energy, mechanism of injury and bone quality like Colles', Smith's, volar and dorsal Barton's fracture [1].
Fractures of lower end radius are the most common fractures of the upper extremity, encountered in practice and make up 17% of all fractures and 75% of all forearm fractures.

Incidence rates vary from 5.7 to 124.6 per 10,000 persons per year [2] This fracture shows bimodal distribution of age with the fracture more commonly seen in children and elderly. The objectives of management for a distal end radius fracture should be restoration of range of motion and grip strength while facilitating the patient's early reinstallation to normal daily activities and minimizing the chances of post traumatic arthritis. In an intra articular distal radius fracture the degree of the anatomical reduction is directly related to the post traumatic arthritis. Conservative management for the same is usually unsuccessful, and it is also fraught with complications, such as early osteoarthrosis, deformity, subluxation, and instability [3-5].

The goal of treatment here is good reduction and immediate stability to achieve anatomic fracture union, which will help to get the early mobilization of the wrist and also to avoid the complications of fracture [6-8]. Fracture healing depends on the following factors: gap, stability, and blood supply[9]. The locking plate decreases the compressive forces exerted on the bone to achieve stability, which prevents associated impairment of blood supply [11] and periosteal compression and which is favored for fracture healing.

Various surgical techniques have been reported in the literature [11-16] like percutaneous pinning, external fixators and internal fixation with a locking compression plate among which open reduction and internal fixation using a locking plate system is currently advocated for the treatment of distal end fractures, resulting in good reduction and providing immediate stability [3, 4, 17, 18]. When adequate fracture reduction cannot be achieved with closed techniques, internal fixation can restore anatomy and improve functional outcomes.

With locking compression plate the locking screw supports subchondral bone and resists axial forces. Compression of locking compression plate to the bone is unnecessary and preserves periosteal blood supply [10] Primary stability achieved with locking screw in a plate prevents secondary displacement irrespective of the bone enabling good result in osteoporotic bones and young patients [19].

The variable angle locking plate decreases the compressive forces exerted on the bone to achieve stability, which prevent associated impairment of blood supply and periosteal compression and which is favored for fracture healing and another advantage of variable angle is that it allows screws to be angles around the central axis of plate hole to match anatomy [11].

The purpose of this study is to evaluate the functional outcomes and assess the complications of patients with distal end radius fractures treated with a variable angle locking compression plate.

Objectives

To study advantages of variable ANGLE locking compression plate over other methods of treatment of Distal end radius fractures.

To assess the complications associated with the variable angle locking compression plate in distal end radius fractures.

To study the functional outcome of distal end radius fracture treated by variable angle locking compression plate.

Methodology

Twenty adult patients with distal radial fractures treated at Bapuji Hospital and Chigateri General Hospital, Davangere, Karnataka state between October 2018 to October 2020 under the Department of Orthopedics, J.J.M. Medical College, Davangere, were included in this study.

Inclusion criteria

1. Adults over 18yrs of age, both male and female with volar Barton fracture (AO Type B3) with or without other associated injuries.
2. Patients medically fit for surgery
3. Patients willing for surgical treatment and have given informed written consent.

Exclusion Criteria

1. Patients below 18 yrs of age.
2. Patients medically unfit for surgery.
3. Compound fracture associated with vascular injuries.
4. Patients not willing for surgery.

There were 15 (75%) males and 5 (25%) females between the age group of 18-72 years with mean of 42.2 years. 11 (55%) patients had right side involvement (dominant wrist) and 9 (45%) had left side involvement.

Of the 20 cases, injury occurred due to road traffic accident in 15 (75%) patients and fall on the out stretched hand in 5(25%) patients.

Immediate Management

Following admission to the hospital, a careful history was elicited from the patients and / or attendants to reveal the mechanism of injury and the severity of trauma.

All patients were thoroughly examined. Their general condition associated systemic diseases and associated injuries were noted. All the findings were duly recorded in the patient proforma.

All patients presented with the involved elbow flexed and the wrist supported by the other hand. Careful inspection of the deformity, swelling and echymosis were done.

Clinically tenderness, bony irregularity, crepitus and the relative position of radial and ulnar styloid process were elicited. Movements of the wrist and forearm were checked and found to be painful and limited. Distal vascularity was assessed by radial artery pulsations, capillary filling, pallor and paraesthesia over finger tips.

The involved forearm was immobilized in a below elbow POP slab and kept elevated. Pain and inflammation were managed using analgesics like diclofenac sodium 50mg twice daily.

Pre-operative planning

Routine examination of blood was done for hemoglobin percentage, total and differential WBC counts, fasting blood sugar, blood urea, serum creatinine, bleeding and clotting time, HIV and HbsAg. Examination of urine was done for presence of albumin and sugar. Blood pressure and ECG were recorded in all patients. Preparation of the part was done on the day of surgery. Tetanus toxoid injection and intravenous antibiotic were given to all patients pre-operatively.

Physician fitness was obtained for all patients. Consent for surgery was taken and patients were operated after a pre-anesthetic checkup.

Radiographic Examination

Standard radiographs in PA and lateral views were taken for confirmation of the diagnosis and also to know the type of fracture. Oblique views were also taken in a few patients who had complex comminuted fractures. The fracture fragments were analyzed and involvement of radiocarpal and distal

radioulnar joints were assessed and classified according to the Frykman's and AO classification.

Surgical Procedures
The duration from the date of injury to date of operation ranged from 1-7 days (average 3.5 days).

Anesthesia
The operations were performed under general anesthesia in all cases and brachial block in 3 cases.
Position and tourniquet:
The patient was placed supine on the operating table. The affected limb was elevated for 2-3 minutes and exsanguinated. Then a mid-arm pneumatic tourniquet was applied.
The limb was placed on a side arm board by abducting the shoulder so that operating surgeon and assistant can sit either side of the hand table and can operate comfortably. The position of limb should allow complete imaging in the frontal and sagittal plane of the distal radius.
Forearm and hand were thoroughly scrubbed, painted with betadine and spirit and draped.

Procedure
All cases are treated with a variable angle locking compression plate using a modified volar Henry approach.

ORIF with plating
Approach: With the forearm in supination, make a longitudinal incision over the interval between the brachioradialis and the flexor carpi radialis muscles. Identify and protect the sensory branch of radial nerve, which lies beneath brachioradialis muscle. Carefully mobilize and retract medially the flexor carpi radialis and the radial artery and vein. The flexor digitorum sublimis, FPL, and pronator quadratus muscles are exposed. Beginning at the anterolateral edge of radius, elevate subperiosteally the flexor pollicis longus and the pronator quadratus and strip them medially.

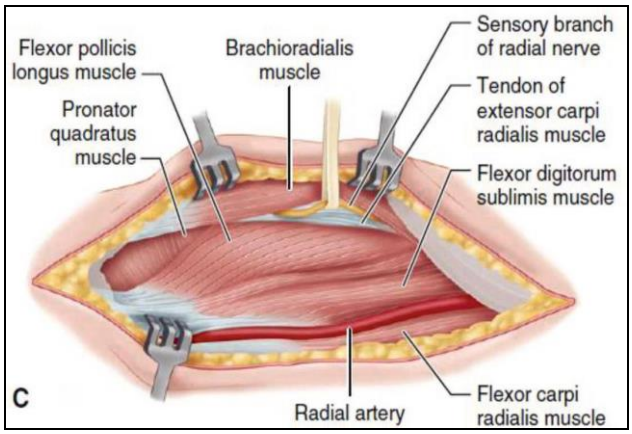


Fig 1: Volar henry approach for distal radius

The fracture line is now clearly visualised and reduced by manipulation and ligamentotaxis. Provisional k-wires may be used to maintain reduction. The appropriate plate with 3.5mm cortical and 4mm cancellous screws is applied. It is safer to check the screw size in fluoroscope to prevent later complications. Pronator quadratus sutured covering the distal end of plate to prevent tendon irritation. The plate functions in two ways – buttress the distal fragment and maintains metaphyseal reduction.

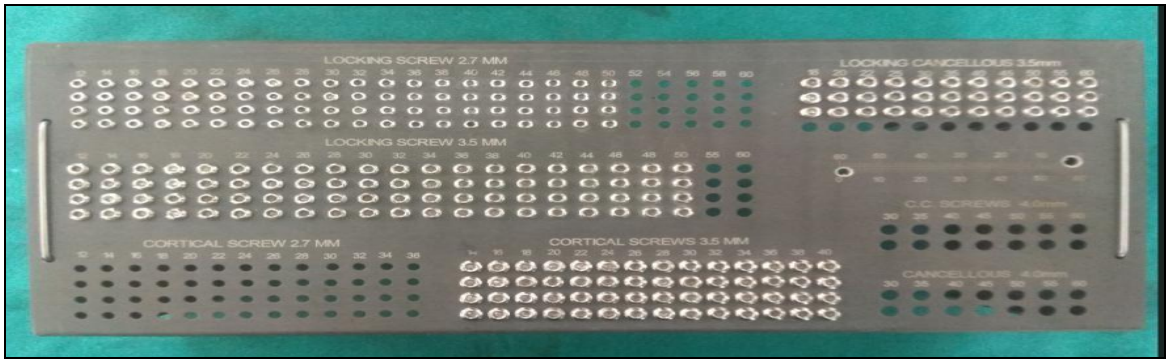
Implant Features
The two column volar distal radius variable angle locking compression plates combines the advantages of locked plating with Variable angle locking Holes which allow up to 15° off-axis screw angulation in all directions in order to address the individual fracture patterns providing fracture fragment specific fixation [8].
Strictly subchondral screw placement avoiding intra-articular misplacement of the screw remains sometimes challenging, due to the fixed angle of the locking screw. Which has been overcome by variable angle locking screws technique.
The plate system allows for the creation of construct that resists angular collapse and also functions as an effective fracture reduction aid.
The precise screws trajectories, anatomic contour and variable angle locking capabilities of the volar distal radius variable locking compression plates provide a stable construct for predictable reconstruction of complex fractures of distal radius.
VA-LACP Two column volar distal radius plate 2.7mm provide various locking screw options in the head of the plate to optimally support the articular surface [21].
Radial screws for the radial column
Ulnar screws for the intermediate column

Plate: The VALCP distal radius plate is a 2.7 mm low profile stainless steel and titanium plate with a 26° distal volar tilt that allows for optimal anatomic fracture reduction and restoration of radial inclination [10, 19, 20].

The distal articular end of the plate consists of 4 locking holes for 2.7mm locking screws angled at 15°.
The shaft of the plate consists of combiholes for insertion of 3.5mm locking or cortical screws [20, 21].

- The plates are available in 2, 3, 4, 5, 6, hole shaft length.

Variable angle LCP plates of various lengths



Locking and cortical screws set

Screws

- The screws are 2.7mm stainless steel and titanium self-tapping and locking screws.
- Cup shaped Threaded head locks securely into the threaded holes in the plate to provide angular stability.

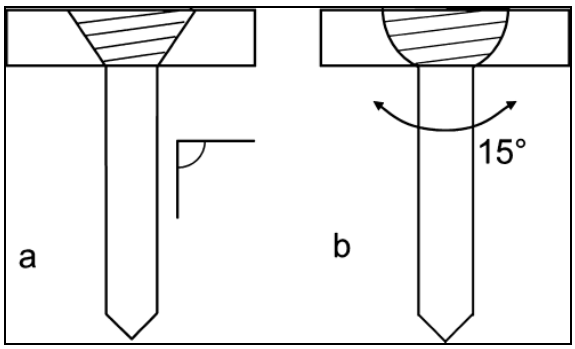
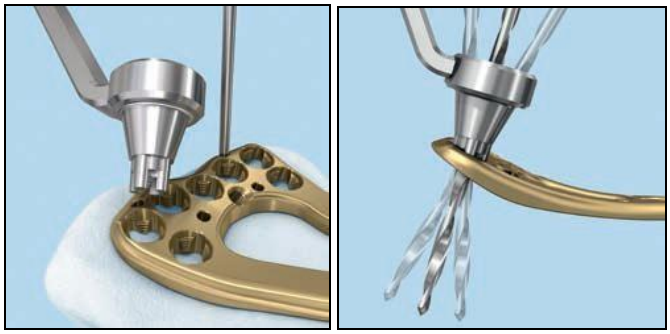


Fig. Schematic view of a) fixed angle b) variable angle locking screw

- The conical shape of the threaded head of fixed angle locking screws allows screw fixation only orthogonal to the plate hole ,where as the cup shaped threaded head of variable locking screws allows screw insertion in a variable angle up to 15° inclination [8].
- Locked screws allow unicortical screw fixation and load transfer to near cortex [22].
- Available in 6mm to 30mm lengths (2mm increments)



Variable angle technique

To drill variable angle holes up to 15° deviation from the nominal trajectory of the locking hole, the tip of the VA-LCP drill sleeve and key inserted into the cloverleaf design of the VA locking hole.

Using funnel-shaped end of the VA-LCP drill sleeve variable angle holes are drilled at the desired angle Alternatively, we use the freehand VA-LCP drill sleeve and insert it fully into the VA locking hole and Drill variable angle holes at the desired angle [23].

Drill Bit

- A 2mm regular drill bit is used for all the cancellous locking screws [21].
- 2.8mm regular drill bit for all the cortical locking and non locking screws

Variable Locking Compression Plate

The conventional fixed angle locking screws will provide stable Locking in the plate hole if inserted with in less than 5°of the precise perpendicular direction to the hole [8, 24].

Fixed angle locking screw applications are limited to the use of a drill sleeve correctly fixed in the threads of the plate hole. without the use of the drill sleeve the correct screw insertion angle could not be maintained. This lead to the development of variable angle locking plate designs which enables to strategically place the locking screws at various desired angles.

Strictly subchondral screw placement avoiding intraarticular misplacement of the screw remains challenging due to fixed angle of the locking screw.these difficulties have led to the development of variable angle locking screws which permit an inclination of the screw insertion angle up to 15°.

The variable angle locking screws have Cup shaped Threaded head which locks securely into the threaded holes in the plate to allow screw insertion into plate upto 15° inclination. Within this range of inclination a locking strength comparable to fixed angle locking screws inserted in 0° inclination is provided.

The conical shape of the threaded head of fixed angle locking screws allows screw fixation only orthogonal to the plate hole, where as the cup shaped threaded head of variable locking screws allows screw insertion in a variable angle up to 15° inclination.

Advantages of Variable Angle Locking Compression Plating

VA-LCP volar column plates have the following attributes:

- It enables the surgeon to address individual fragments separately
- Anatomical reduction depending on the pattern of fracture may be done and stabilization may be provided by using k-wires temporarily as the plate is applied.
- Plates are provided with elongated holes that make it convenient to make adjustments in the position of the plates.

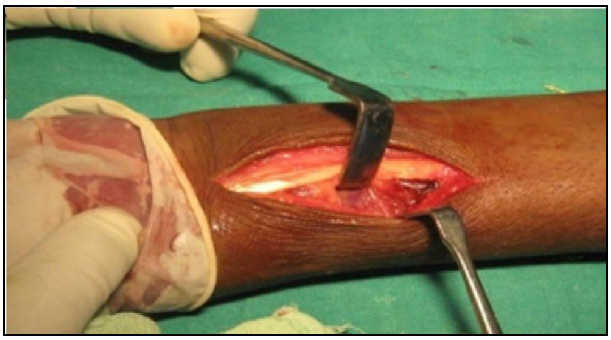
1. Universal anatomical shape eliminates need for anatomical contouring of plate based on variations in bone anatomy.
2. **Stable Fixation:** As the system is versatile, it allows stabilization of even complex fractures. In complex fractures treated based on the three column theory, radius and ulnar fragments may be separately dealt with. Also there are a variety of locking options which is beneficial in fractures near distal radio- ulnar joint where additional screws may be used to support the styloid process [25, 26].
3. **Preservation of Blood Supply:** The plates are specifically designed with a low profile cross sectional design with undercuts and rounded edges reducing chances of soft tissue irritation and ensuring good periosteal blood supply.
4. **Early Mobilization:** A combination of AO technique during surgery and the plate when used allow faster healing and early mobilization[26].
5. **Operative Photographs**

Image 3: 3.5 and 2.7mm Locking and Cortical Screws

Image 4: Variable 3 Angle LCP

Image 5: Drill Set and General Instruments

(a): Painting and Draping of Distal Radius



(b) Modified Henry's Approch Distal Radius Incision

(c): Soft Tissue Dissection and Fracture Site Exposed

(d): 2.7 Mm Multilocking Plate Fixation

(e): Wash and Closure of the Operative Wound

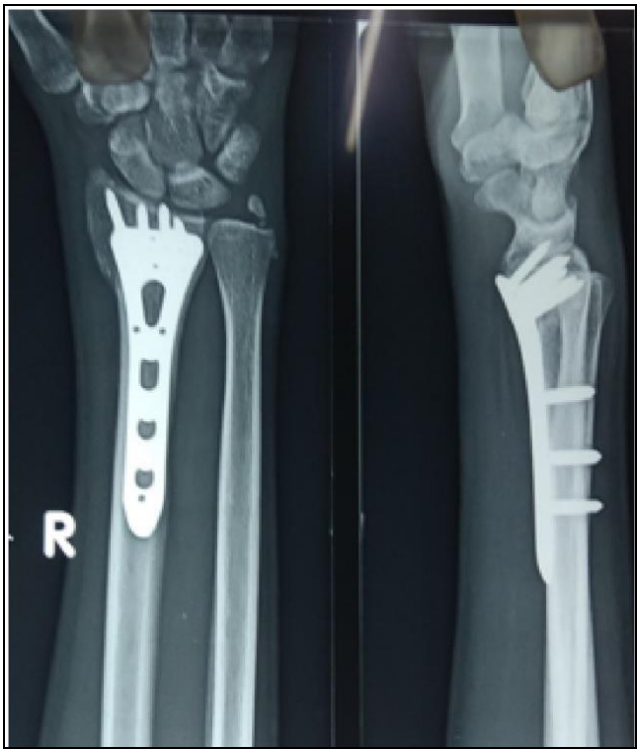
Clinical and X-ray Photographs

Dorsiflexion

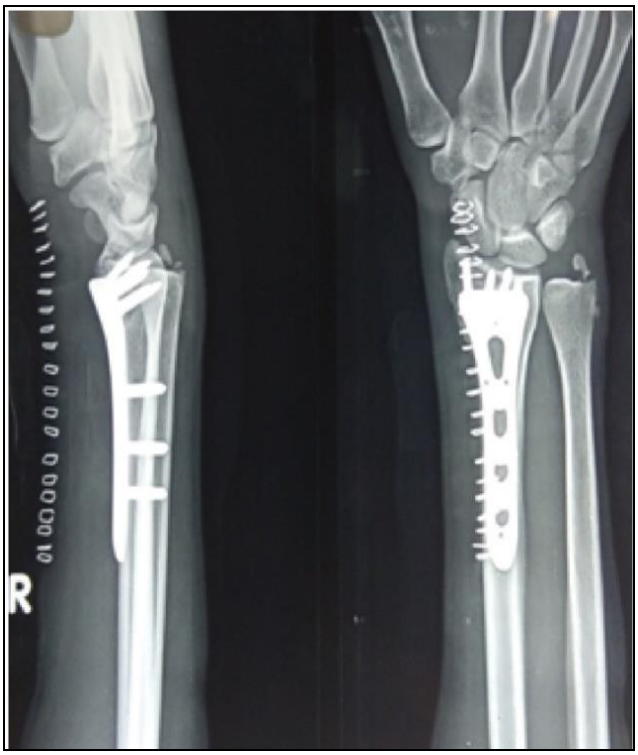
Ulnar Deviation & Radial Deviation

Case I: Excellent

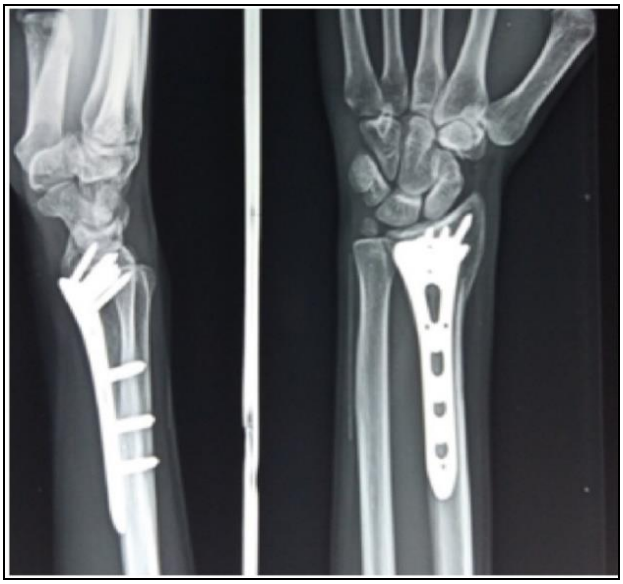
Pronation & Supination



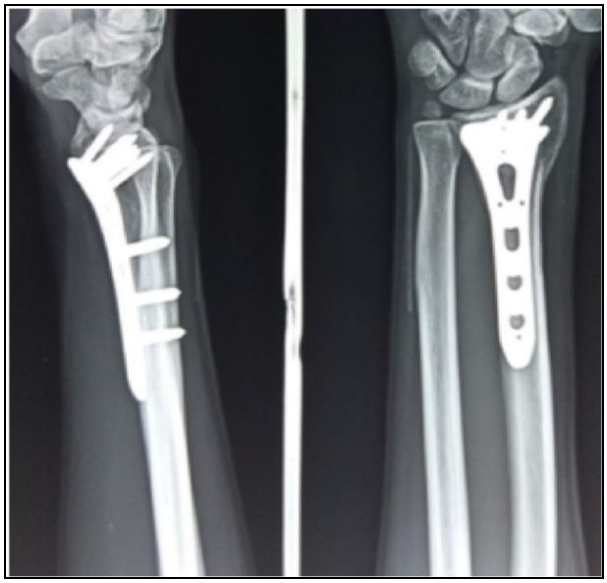
Immediate post-operative



1 month post-operative



6 months post operative



12 months post-operative

Result

The present study consists of 20 cases of distal radius fractures treated at Bapuji Hospital and Chigateri General Hospital, Davangere, treated between, october 2018 to october 2020. All 20 were closed fractures. All cases were followed up periodically during the period 2018 to 2020. The following are the observations made to the available data analyzed as follows.

Table 1: Age Incidence

Age in Years	No. of Cases	Percentage
< 20	2	10
21 – 30	2	10
31- 40	4	20
41 – 50	6	30
51 – 60	2	10
61 – 70	3	15
>70	1	5

In this series 2 (10%) patients were between 18-20 years, 2 (10%) patients were between 21-30 years, 4 (20%) between 31-40 years, 6 (30%) between 41-50 years, 2 (10%) between 51-60 years and 3 (15%) patients between 61-70 years and 1 (5%) patient was >70 years of age.

The age of the patients ranged from 18-72 years with an average of 42.2 years.

Table 2: Sex Incidence

Sex	No. of Cases	Percentage
Male	15	75%
Female	5	25%

Out of 20 patients, 15 (75%) were males and 5 (25%) were females, showing a male preponderance with the ratio being M: F - 3:1.

Table 3: Side of Involvement

Side	No. of Cases	Percentage
Right	11	55
Left	9	45

Right side (dominant wrist) was involved in 11 (55%) patients and the left side was involved in 9 (45%) patients.

Table 4: Mode of Injury

Mechanism of Injury	No. of Cases	Percentage
Road traffic accident (RTA)	15	75
Fall on outstretched hand (FOOH)	5	25

In our study there were 15 (75%) patients with road traffic accidents and 5 (25%) patients fell on their outstretched hand

Table 5: Associated Injuries

Associated Injuries	No. of Cases	Percentage
Multiple abrassions	5	25
Contusional head injury	1	5
Total	6	30

Out of 20 cases, 6 (30%) patients had associated injuries.

Table 6: Duration of Operation From Date Of Injury

Duration	No. of Cases	Percentage
1-5 days	18	90
6-10 days	2	10

Surgery was done between 1-5 days in 18 (90%) patients as an elective procedure. Surgery was delayed up-to the 7th day in 2 (10%).

Table 7: Duration of Fracture Union

Time of Union	No. of Cases	Percentage
< 2-3 months	17	85
> 3 months	3	15

In the present study 17 (85%) patients had union in < 2-3 months and 03 (15%) patients had union in > 3 months.

Table 8: Range Of Motion

Movement (within normal functional range)	No. of Cases	Percentage
Dorsiflexion (min. 45°)	20	100
Palmar flexion (min 30°)	20	100
Pronation (min 50°)	20	100
Supination (min 50°)	20	100
Radial deviation (min 15°)	18	90
Ulnar deviation (min 15°)	19	95
Pain in distal radioulnar joint	1	5
Grip strength (60% or less than on opposite side)	1	5

In our study 20 (100%) patients had dorsiflexion within the normal functional range (minimum 45°), 20 (100%) had palmar flexion within the normal functional range (minimum 30°), 20 (100%) had pronation within the normal functional range (minimum 50°), 20 (100%) had supination within the normal functional range (minimum 50°), 18 (90%) had radial deviation within the normal functional range (minimum 15°) and 19 (95%) patients had ulnar deviation within the normal functional range (minimum 15°). 19(95%) patients had grip strength more than 60% compared to the opposite side. 1(5%) had significant loss of grip strength (< 60% compared to the opposite side). 1 (5%) patient had pain in the distal radioulnar joint. None of the patients had stiffness of the wrist.

Table 9: Complications

Complications	No. of Cases	Percentage
Extensor pollicis longus tendon irritation	1	5
Arhtirtis	1	5
Infection	1	5
Total	3	15

1 (5%) patient had extensor pollicis longus tendon irritation because of long volar to dorsal screw. 1 (5%) patient had developed arthritis of the wrist joint due to improper reduction and articular step and 1 (5%) patient had developed superficial skin infection which was treated with antibiotics and got recovered.

None of the patient had median nerve complication. There were no intra operative complications.

Table 10: The assessment of results were made using the demerit score system of Modified Cooney, Green and O'Brien functional score for wrist based on objective and subjective criteria, residual deformity and complications

Results	No. of Cases	Percentage
Excellent	10	50
Good	6	30
Fair	3	15
Poor	1	5

Using score system of Modified Cooney, Green and O'Brien functional score for wrist we had 10 (50%) Excellent result, 6 (30%) Good result, 3 (15%) Fair result and 1 (5%) had poor result.

Conclusion

The present study was undertaken to assess the functional outcome of operative management of Distal End Radius fractures in adults by a Variable Angle Locking Compression Plate and the following conclusions were drawn.

Distal End Radius fractures are more common in the 3rd to 5th decades. Male preponderance is due to their involvement in heavy manual labour, outdoor activities and riding vehicles. Most of the fractures in the younger individuals are due to motor vehicle accidents or high energy trauma. The fractures occurring in the older individuals will be due to trivial fall on outstretched hand causing fracture in the osteoporotic bone.

The mode of injury is either a road traffic accident or fall on the outstretched hand. Road traffic accidents were more common for young patients while self fall was common for older individuals.

According to many studies, locked plates provide successful results for the treatment of intra-articular unstable fractures of distal radius. variable angle Locking compression plate used in Distal End Radius fractures fracture for its effective anatomic reduction, allowing early joint motion because of its rigid fixation. Close placement to joint interface and screwing capability in different orders are its biomechanical superiorities. Modified Volar Henry approach provides both access with minimal surgical trauma on distal radius and fixation with a better adaptation to surrounding tissues.

In the subjects of our study, a successful anatomic alignment was acquired with modified volar Henry approach. The patients, who were young adults in majority, went back to their daily activities with 90% recovery.

We encountered some complications (15%) in our study. One is extensor tendon irritation, which was because of long screws projecting dorsally. Other one complication was arthritis in one patient which was because of improper reduction and articular step. One patient developed superficial skin infection of operative wound which was treated with antibiotics and recovered in 2 weeks. These complications can be prevented once the surgeon gets adapted to the procedure.

Use of variable angle locking compression plates in Distal End Radius fractures provide good to excellent results and are effective in the correction and maintenance of distal radius anatomy. By using these plates, joint motions and daily functioning is recovered in a shorter time and patient is able to go for his routine work and job in much shorter period of time comparative to other methods of fixation with almost complete normal functions of wrist. The study comprised of twenty cases of Distal End Radius fractures in adults.

All patients treated with open reduction and internal fixation with a variable angle locking compression plate. The follow-up ranged from 9-18 months. The average age was 42.2 years with the fracture being more common in the 3rd to 5th decades. Males were predominant with right wrist affection more than left. All fractures were either due to road traffic accidents or fall on the outstretched hand, with road traffic accidents being more common of the two.

The average duration from the date of injury to the date of surgery was 3.5 days. All (100%) the patients had their range of motion within the normal functional range. None of the patients had wrist stiffness.

Complications were minimal. There was 1(5%) case of extensor pollicis longus tendon irritation. There was 1 (5%) case with an intra articular fracture developed grade I radiocarpal arthritis doing well with physiotherapy. And there was 1(5%) case with superficial infection of operative wound treated with antibiotics.

Using score system of Modified Cooney, Green and O'Brien functional score for wrist we had 10 (50%) Excellent result, 6 (30%) Good result, 3 (15%) Fair result and 1 (5%) had poor result.

Summary

The study comprised of twenty cases of DISTAL END RADIUS fractures in adults.

All patients treated with open reduction and internal fixation with a variable angle locking compression plate. The follow-up ranged from 9-18 months. The average age was 42.2 years with the fracture being more common in the 3rd to 5th decades. Males were predominant with right wrist affection more than left. All fractures were either due to road traffic accidents or fall on the outstretched hand, with road traffic accidents being more common of the two.

The average duration from the date of injury to the date of surgery was 3.5 days. All (100%) the patients had their range

of motion within the normal functional range. None of the patients had wrist stiffness.

Complications were minimal. There was 1(5%) case of extensor pollicis longus tendon irritation. There was 1 (5%) case with an intra articular fracture developed grade I radiocarpal arthritis doing well with physiotherapy. And there was 1(5%) case with superficial infection of operative wound treated with antibiotics.

Using score system of Modified Cooney, Green and O'Brien functional score for wrist we had 10 (50%) Excellent result, 6 (30%) Good result, 3 (15%) Fair result and 1 (5%) had poor result.

References

1. Apley's system of orthopaedics and fracture 9th edition chapter 25 page 772.
2. Ark J, Jupiter JB. The rationale for prec ise management of distal radius fractures. The Orthopedic Clinics of North America 1993;24(2):205-10.
3. Jupiter JB, Fernandez DL, Toh CL, Fellman T, Ring D. Operative treatment of volar intra-articular fractures of the distal end of the radius. JBJS. 1996;78(12):1817-28.
4. Aggarwal AK, Nagi ON. Open reduction and internal fixation of volar Barton's fractures: a prospective study. Journal of Orthopaedic Surgery 2004;12(2):230-4.
5. Mehara AK, Rastogi S, Bhan S, Dave PK. Classification and treatment of volar Barton fractures. Injury. 1993;24(1):55-9.
6. Downey MS, Lawrence GA. Digital and Sesamoid Fractures. In: Southerland JT, ed. McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. 4th ed: Lippincott Williams & Wilkins; 2013;2:1634-1645.
7. Bradway JK, Amadio PC, Cooney WP. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. J Bone Joint Surg Am 1989;71(6):839-47.
8. Karlström G, Olerud S. Fractures of the tibial shaft a critical evaluation of treatment alternatives. Clinical Orthopaedics and Related Research®. 1974;105:82-115.
9. Greiwe RM, Archdeacon MT. Locking plate technology: current concepts. The journal of knee surgery. 2007;20(1):50-5.
10. Kilic A, Kabukcuoglu Y, Ozkaya U, Gul M, Sokucu S, Ozdogan U. Volar locking plate fixation of unstable distal radius fractures. Acta Orthop Traumatol Turc 2009;43(4):303-8.
11. Mehara AK, Rastogi S, Bhan S, Dave PK. Classification and treatment of volar Barton fractures. Injury. 1993;24(1):55-9.
12. Thompson GH, Grant TT. Barton's fractures-reverse Barton's fractures. Confusing eponyms. Clinical orthopaedics and related research 1977;(122):210-21.
13. Fitoussi F, Ip WY, Chow SP. Treatment of displaced intra-articular fractures of the distal end of the radius with plates. JBJS 1997;79(9):1303-2.
14. Wong KK, Chan KW, Kwok TK, Mak KH. Volar fixation of dorsally displaced distal radial fracture using locking compression plate. Journal of Orthopaedic Surgery 2005;13(2):153-7.
15. Kim RY, Rosenwasser MP. Internal fixation of distal radius fractures. AMERICAN Journal of Orthopedics-Belle Mead. 2007;36(12):2.
16. Dai M, Wu C, Liu H, Wang I, Yu C, Wang K *et al*. Treatment of volar Barton's fractures: comparison between two common surgical techniques. Chang Gung medical journal 2006;29(4):388.
17. Harness N, Ring D, Jupiter JB. Volar Barton's fractures with concomitant dorsal fracture in older patients. The Journal of hand surgery 2004;29(3):439-45.
18. Wright TW, Horodyski M, Smith DW. Functional outcome of unstable distal radius fractures: ORIF with a volar fixed-angle tine plate versus external fixation. The Journal of hand surgery 2005;30(2):289-99.
19. Crenshaw Andrew H. Jr. Fracture of shoulder, arm and forearm. Chapter-54 In: Campbell's operative orthopedics, Philadelphia: Mosby Inc. 11part XV;3447-3449.
20. Adani R, Tarallo L, Amorico MG, Tata C, Atzei A. The treatment of distal radius articular fractures through LCP system. Hand Surgery 2008;13(02):61-72.
21. Cooney W3, Dobyns JH, Linscheid RL. Complications of Colles' fractures. J Bone Joint Surg Am 1980;62(4):613-9.
22. Ring D, Prommersberger K, Jupiter JB. Combined dorsal and volar plate fixation of complex fractures of the distal part of the radius. JBJS 2004;86(8):1646-52.
23. Bradway JK, Amadio PC, Cooney WP. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. J Bone Joint Surg Am 1989;71(6):839-47.
24. Jupiter JB, Fernandez DL, Toh CL, Fellman T, Ring D. Operative treatment of volar intra-articular fractures of the distal end of the radius. JBJS 1996;78(12):1817-28.
25. Catalano III LW, Cole RJ, Gelberman RH, Evanoff BA, Gilula LA, Borrelli Jr J. Displaced intra-articular fractures of the distal aspect of the radius. Long-term results in young adults after open reduction and internal fixation. JBJS 1997;79(9):1290-302.
26. Fitoussi F, Ip WY, Chow SP. Treatment of displaced intra-articular fractures of the distal end of the radius with plates. JBJS 1997;79(9):1303-2.