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Unstable distal radius fractures fixation with a 2.4 mm volar variable-angle locking plate: radiological and functional assessment

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ABSTRACT

Background: The main objective of this observational study was to evaluate the functional and radiological outcome of variable angle volar plates in intra-articular distal end radius fractures.
Methods: Patients with distal end radius fractures (AO type 3C) treated operatively between Jan 2020 and Dec 2020 and then followed up for at least 12 months. A total of 32 patients (11 men and 21 women) with a mean age of 51.9 years were included in the study. The functional outcome was assessed by using modified Mayo wrist score (MMWS), disabilities of the arm, shoulder, and hand (DASH) score, wrist range of motion (ROM) and grip strength relative to the uninjured side and radiological assessment of radial height, volar tilt, and radial inclination.
Results: MMWS and DASH scores improved postoperatively over time. Signs of radiographic union started around 12 weeks after surgery. The most common complication observed was finger and wrist stiffness, which was resolved with active wrist and finger movements. Non-union or hardware-related complications/ late complications such as tendon irritation/attrition were not observed with variable angle volar locking plates.
Conclusions: Distal end radius fracture fixation with variable angle plate gives favourable radiological and clinical outcomes. These results can be owed to features such as low profile, variable locking, anatomical design and implant biomechanics. The surgeon determined angulation of the distal row of screw fixation may decrease the incidence of joint penetration and improve fixation of radial styloid and lunate facet stability.

Keywords: Distal radius fracture, ORIF, Plating, Variable angle

INTRODUCTION

Distal end radius fractures are among the most common fractures encountered in emergency room. As life expectancies increases and the prevalence of osteopenia climbs, it is estimated that the incidence of these injuries will continue to increase over the coming decades.[1] Anatomic restoration of the distal radius articulation is of paramount importance to avoid the development of post-traumatic arthritis, wrist instability, residual pain, joint stiffness and deterioration of wrist functions. There are various methods for the management of distal radius fractures ranging from close reduction and casting to operative intervention by external fixators, K wires, buttress plates, locking fixed angle constructs and variable angle locking plates.

The anatomical geometry of the lunate facet area causes it to be inadequately supported by conventional fixation modalities leading to postoperative loss of reduction. To achieve sufficient stabilization by buttressing this fragment, conventional volar locked plates need to be placed distal to the watershed region. Distal fixation leads to plate prominence that may cause flexor tendon irritation. Furthermore, fixed angle devices placed distal to the watershed line lead to wrist joint penetration by distally

directed screws.[2] Normal radiographic findings of the distal radius include an average radial inclination of 23º, radial height of 11 mm, and volar tilt of 11º. Commonly accepted post-reduction parameters are: radial shortening less than 5 mm, radial inclination greater than 15º, between 15º dorsal and 20º volar tilt, and less than 2 mm of articular step-off.[3]

The 2.4 mm volar variable-angle 2-column distal radius plate (VA-DRP) system by GPC medical Ltd™ is designed to accommodate variable fracture geometry patterns involving distal radius including placement of plate distal to the watershed line. The VA-DRP system offers 15^0 off-axis placement of variable angle screws allowing fragment-specific capture in addition to avoiding intra-articular placement of screws

In this study, we examined the hypothesis variable angle volar locking plates could improve clinical outcomes, complications, and loss of correction in the short term for patients with intra-articular distal radius fractures

Biomechanics of implant and plate design

The 2.4 mm volar VA- DRP by GPC medical Ltd™ was used to achieve fracture fixation in all the patients. VA-DRP is based on the restoration of three column principle. Biomechanically distal radius and distal ulna form a three-column structure (Figure 1) and restoration of this is of utmost importance for the return of functionality of the traumatic limb.[6]

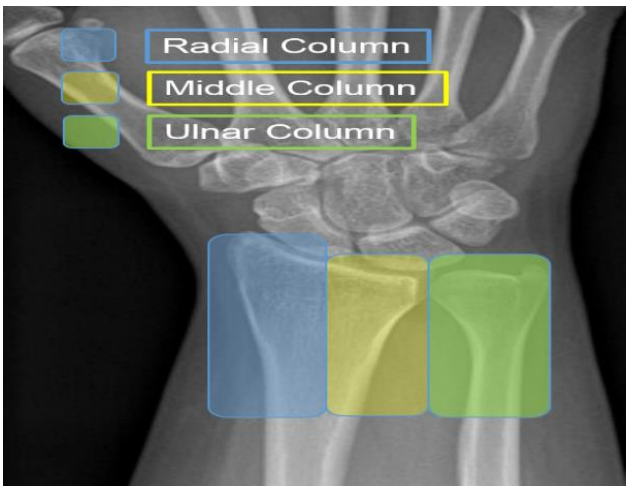

Figure 1: Lateral radial column constituting lateral radius with scaphoid fossa and the styloid process. Intermediate radial column (middle column) is formed by the medial part of the distal radius, with lunate fossa and sigmoid notch. Medial ulnar column is formed by the distal ulna, triangular fibrocartilage (TFCC) and distal radioulnar joint.

The anatomical design along with the variable locking mechanism allows dual-tiered support to the articular surface (Figure 2) and prevents loss of stability in the early postoperative period.

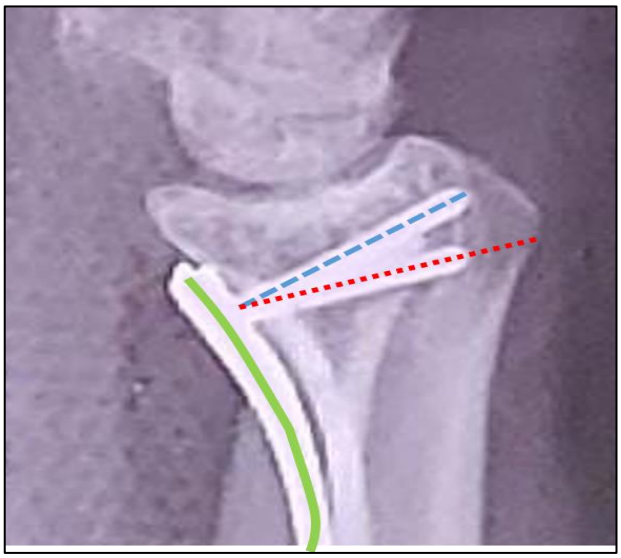

Figure 2: Plate design allows support of subchondral bone at lunate fossa by two rows of the screw and bicortical purchase can hold dorsal cortex.

Variable locking design is attributed to the clover leaf-shaped holes in the head portion of the plate.

Special variable angle screws with 2.4 mm rounded head to facilitate variable angle locking. These VA screws can be angled within a 30° cone around the central axis of the variable angle screw hole as demonstrated in Figure 3. This feature makes the plate a surgeon-determined fixed-angle construct.

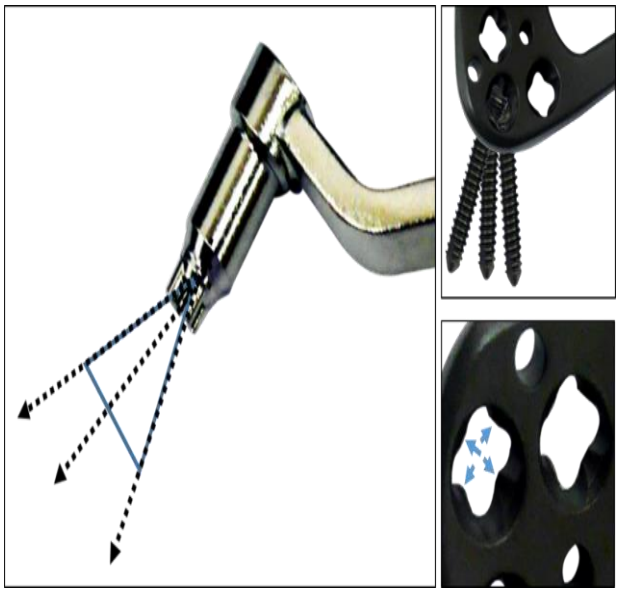

Figure 3: Four points of threaded locking between the VA-DRP and the VA locking screw marked with four solid blue arrows in the image of VA DRP hole, 15º Off-axis drilling using a cone sleeve.

Three variable positions in which the screw can be potentially placed in the head portion of the plate.

The main objective of this observational study was to evaluate the functional outcome of variable angle volar distal radius plate in intra-articular distal end radius fractures by using MMWS, DASH score, wrist range of motion (ROM) and grip strength relative to the uninjured side and radiological assessment of radial height, volar tilt, and radial inclination.[4,5] The mentioned clinical data and functional scores is to objectively demonstrate that the newer implant design help in achieving good functional outcome measures.

METHODS

Study was conducted by author and resident of department of orthopaedics at Maharaja Agarsen hospital, Punjabi Bagh (Delhi, India) after institutional approval from the ethics committee fully abiding to Helsinki declaration. Patients with intra-articular distal end radius fractures (AO type 3C) who were treated operatively between Jan 2020 and Dec 2020 at Maharaja Agarsen hospital, Punjabi Bagh (Delhi, India) and then followed up for at least 12 months. All the patients who agreed to participate in the study signed a written consent form.

The inclusion criteria for the study were as follows: 1. Patients aged 18 to 65 years with displaced isolated closed intra-articular distal end radius fractures (AO type 3C) willing to undergo the operative procedure. 2. No previous history of ipsilateral limb orthopaedic pathologies such as fracture, inflammation or osteoarthritis.

The exclusion criteria for the study were: 1. Patient with associated limb fractures, 2. Patient with bilateral wrist fractures. 3. Open fractures, 4. Patients with delayed presentation (>2 weeks), 5. Pathological fracture, 6. Associated injuries/diseases that impair limb function or rehabilitation like severe head injuries, spinal cord injury, uncontrolled diabetes, and chronic smoking and 7. Pregnant females.

A total of 32 patients fulfilled the inclusion criteria to be included in the study. The 32 patients consisted of 11 men and 21 women, with a mean age of 51.9 years (range 19-73). Dominant hand involvement was seen in 25 patients and 7 patients had a fracture in non-dominant hands. The mode of injury was a road traffic accident in 14 patients, slip and fall on the ground in 12 patients, and sports-related injuries leading to fracture in 6 patients.

All of the surgeries were performed by a single orthopaedic consultant (Author S.C) under tourniquet control. Volar henry's approach was undertaken for fracture fixation.[7]

Open reduction and internal fixation with a 2.4 mm variable-angle locking distal radius plate (GPC medical Ltd., India) were done as shown in Figure 4.

Figure 4: Pre-operative images of AO type 3C fracture distal end radius and C arm fluoroscopic image of fracture fixation using 2.4 mm volar VA-DRP by GPC medical Ltd.™ (New Delhi, India) with restoration of anatomical configuration.

Post-surgery, the wrist was immobilized in a below-elbow plaster splint for one week. Patients were encouraged to active finger movements in the immediate postoperative period. The splint was removed at the first follow-up postoperative day 7. Active range of motion exercises for the wrist and fingers were started after the removal of the splint.

The radiographic assessment included anteroposterior and lateral views taken in the immediate postoperative period, at six weeks and then at monthly intervals till fracture union or in case of patient complaints.

Criteria for fracture union were no subjective complaint like pain, no objective finding like tenderness at the fracture site and radiologically when the fracture line was not visible.

Functional assessment of the affected limb was based on the following parameters wrist extension, palmar flexion, radial and ulnar deviation, forearm supination-pronation, and grip strength. MMWS, DASH score at 3 months, 6 months and 12 months postoperatively.

Radiological assessment of radial height, volar tilt, and radial inclination was done in the postoperative period.

Clinical assessment of all patients was done by a single orthopaedic surgeon (Author AG). Clinical assessment is a part of routine hospital standard of procedure and data is collected and charted. The ROM was measured using an 8-inch stainless steel goniometer, and the grip strength was measured using a baseline Camry digital hand dynamometer.

Radiological assessment of all patients was done by a single musculoskeletal-trained radiologist (Author MG).

RESULTS

The 32 patients with intra-articular distal end radius fractures (AO type 3C) operated during the study period were considered for the study. Statistical analysis was performed with the SPSS, version 21 for Windows statistical software package (SPSS inc., Chicago, IL, USA). All patients were operated on within 10 days of the injury. The minimum follow-up period was 12 months. The mean operative time for all cases was 53.9 minutes (35-74). Demographic details of the patients along with operative time and time of radiographic union is shown in figure 5 and figure 6. All the cases were performed under tourniquet control and hemostasis was achieved before the closure of the wound.

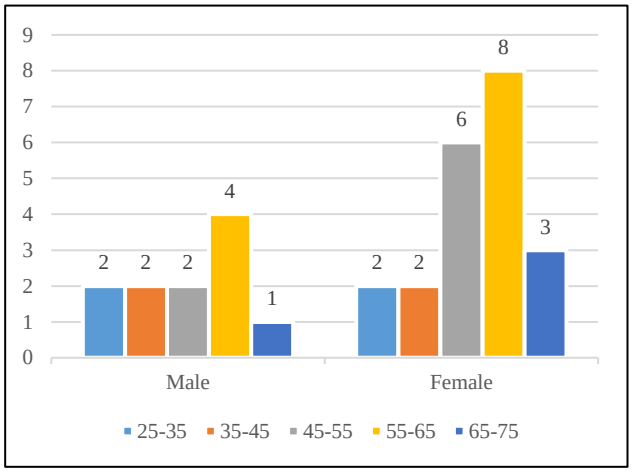

Figure 5: Demographic details of patients in the study.

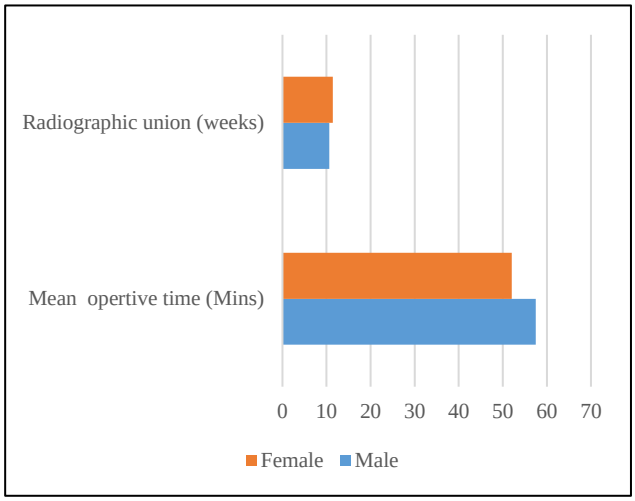

Figure 6: Average operative time (mins) and average radiographic union (weeks) comparison between two genders in the study.

In this study mean palmar flexion, dorsiflexion, radial deviation, ulnar deviation, supination, pronation, and grip strength at 12 months was 73-degree, 71-degree, 18 degrees, 38 -degree, 84degree, 80 degrees and 29.45 kg respectively.

MMWS, DASH score observed at follow-up is shown in Figure 7.

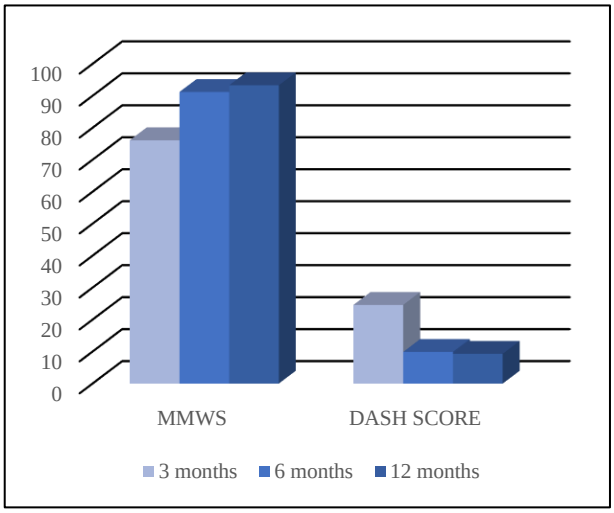

Figure 7: Demonstrates MMWS, DASH score at follow-up visits.

Signs of radiographic union started around 12 weeks postop and follow-up radiographs were taken at monthly intervals till bony union is achieved. No incidence of non-union was seen in the patients.

Radiological outcome at 6 months was found by calculating mean radial height, volar tilt and radial inclination as 10.1 mm, 10.2 degrees and 20.17 degrees respectively.

The most common cation observed was finger and wrist stiffness at 1 month follow-up, which was resolved with active wrist and finger movements. No incidence of superficial or deep infections was noted in our study.

Hardware-related complications/ late complications such as tendon irritation/attrition were not observed with variable angle volar locking plates. Active finger movements were encouraged from day 1 and early mobilization of the wrist with intensive physiotherapy ensured no cases of causalgia in our study. No case underwent a secondary surgical procedure. No additional plates were used for the fixation of the radial styloid fragment.

DISCUSSION

Distal radius fractures are commonly encountered fractures with variable fixation options. Numerous internal fixation plate design have come over the years. Volar plates have largely surpassed dorsal plates and the current design of variable locking plates have documented benefits over other fixed angle distal radius plates.[8-14]

AO type C3 distal radius fractures are the most unstable fractures and require anatomical restoration.

Distal row of screws support the central subchondral bone and transmit the axial force from the subchondral bone to the intact diaphyseal bone and proximal screws transferred the dorsal articular load to the implant and the diaphyseal bone.[15] Transmission of these forces help in maintenance of anatomical reduction of the lunate facet. Stanbury et al showed the superiority of a variable-angle locking plate for capturing a distal radial styloid compared with a fixed-angle plate in biomechanical study.[16] Along with radial styloid fixation this construct thus achieves good clinical outcomes.

Some authors have reported flexor tendon rupture after volar plate fixation, Flexor pollicis longus tendon is ruptured in these cases owing to the distal placement of volar plate.[17-18] In earlier designed volar fixation plates anatomical reduction of severe intra-articular fractures required placement of plate distal to the watershed line.[17] Plate prominence at the watershed line, where the flexor tendons lie closest, is a contributing factor to this complication.[20] Variable locking allows the plate to sit proximal to the watershed line and capture the isolated fragments by allowing surgeon-guided screw angulation.

VA-DRP system is an effective alternative to conventional plates for the fixation of radius fractures distal to the watershed region.

O'Shaughnessy et al reported 20% (5/25) of patients with an average follow-up of nine months required the removal of hardware secondary to flexor tendon irritation.[21] Low profile with anatomically contoured design along with highly polished surface leads to a lower incidence of flexor tendon irritation with VA DRP plate.

Gruber et al in their case series of comminuted distal end radius fracture fixation with fixed angle plates, noticed a statistically significant loss in parameters like the radial inclination and volar tilt with the use of volar fixed-angle plates.[22] Similar results have also been reported by other authors in earlier studies.[23-24] In numerous fracture patterns, the use of additional dorsal and straight plates or K wires is at times required with fixed angle locking plates.

With the use of variable angle locking plates, no additional implants either K wire/plates were used. The VA plate design allows adequate fixation of radial and intermediate columns.

The frequently used 2-3 shaft screws for plate fixation owing to limited exposure required and adequate fixation achieved with 3 locking screws in shaft segment. A study by Weninger et al showed the biomechanical strength of four shaft screws vs three in a sawbones model and found superior mechanical properties in the group with the additional protection screw, demonstrating the importance of the shaft screws in the overall mechanical property of these plates.[25] However newer implant design have shown superiority in fixation with 2 shaft screws as shown by Jung et al.[26] In this study Jung et al used arix volar distal radius locking plate (JEIL medical, Seoul, Korea) design of the plate is similar to the one used in our study and stated dorsally comminuted, extra-articular, non-osteoporotic distal radius fractures, the minimum number of screws-four in the distal row and 2 in shaft-in volar locking plate fixation can provide sufficient stability. For osteoporotic patients 3 locking screws provide adequate stability.

In this study, 2.4 mm volar VA- DRP by GPC medical Ltd.™ (New Delhi, India) was used. Results were similar to the studies by Wong et al and Hakimi et al with the Stryker Variax plate, the study by Chen et al with variable-angle volar rim locking compression plate system (VA-LCP; Depuy-Synthes, West Chester, PA).[27-29]

There were several limitations to this study. We could not compare various internal fixation methods. This was a observational study; a prospective randomized controlled trial gives a better insight into the effectiveness of a procedure. A larger patient cohort and longer follow-up are necessary for the evaluation of results in a more meaningful manner.

CONCLUSION

We report favourable radiological and clinical outcomes using the VA-DRP system by GPC medical Ltd. These results can be owed to the superior implant features such as low profile, variable locking, anatomical design based on the biomechanics of distal radius. Along with options for change in angulation of distal row of screw fixation that may decrease the incidence of joint penetration and improve fixation of radial styloid and lunate facet stability. Implant design have leads to reduced incidence of complications and need of implant removal.

A long-term prospective study is needed to assess long-term clinical and radiographic outcomes of the 2.4 mm volar VA- DRP system.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Ismail AA, Pye SR, Cockerill WC. Incidence of limb fracture across Europe: results from the European Prospective Osteoporosis Study (EPOS). Osteoporos Int. 2002;13(7):565-71.
2. Kachooei AR, Tarabochia M, Jupiter JB. Distal Radius Volar Rim Fracture Fixation Using DePuy-Synthes Volar Rim Plate. J Wrist Surg. 2016;5(1):2-8.
3. Nana AD, Joshi A, Lichtman DM. Plating of the distal radius. J Am Acad Orthop Surg. 2005;13(3):159-71.
4. Cooney WP, Linscheid RL, Dobyns JH. Triangular fibrocartilage tears. J Hand Surg Am. 1994;19(1):143-54.

5. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand). The Upper Extremity Collaborative Group (UECG). Am J Ind Med. 1996;29(6):602-8.
6. Rikli DA, Regazzoni P. Fractures of the distal end of the radius treated by internal fixation and early function. A preliminary report of 20 cases. J Bone Joint Surg. 1996;78(4):588-92.
7. Henry AK. Extensile exposures. Edinburgh. Churchill Livingston. 1973.
8. Soong M, Van Leerdam R, Guitton TG, Got C, Katarincic J, Ring D. Fracture of the distal radius: Risk factors for complications after locked volar plate fixation. J Hand Surg Am. 2011;36:3-9.
9. Drobetz H, Bryant AL, Pokorny T, Spitaler R, Leixnering M, Jupiter JB. Volar fixed-angle plating of distal radius extension fractures: influence of plate position on secondary loss of reduction-a biomechanic study in a cadaveric model. J Hand Surg Am. 2006;31:615-22.
10. Seung C, Jai P, Hyung-Soo K, Soo-Tae C, Jeong-Hyun Y, Joo-Hak K, et al. Comparative Analysis of the Results of Fixed-angle versus Variable-angle Volar Locking Plate for Distal Radius Fracture Fixation. J Korean Fracture Society. 2012;25:197.
11. Stanbury SJ, Salo A, Elfar JC, Biomechanical analysis of a volar variable angle locking plate: the effect of capturing a distal radial styloid fragment. J Hand Surg Am. 2012;37:2488-94.
12. Marlow W, Singhal R, Dheerendra S, Ralte P, Ischer J, Waseem M. Distal radius volar locking plates: Does a variable angle locking system confer a clinical advantage? Acta Orthopaedica Belgica. 2012;78:309-16.
13. Kawasaki K, Nemoto T, Inagaki K, Tomita K, Ueno Y. Erratum to: Variable-angle locking plate with or without double-tiered subchondral support procedure in the treatment of intra-articular distal radius fracture. J Orthop Traumatol. 2020;15.
14. Regar C, Siddharath SP, Ramesh M, Sharma S, Jain J. A comparative study between variable and fixed angle volar locking plates in management of unstable intra-articular distal radius fractures. Int J Res Orthop. 2020;6:1222.
15. Figl M, Weninger P, Jurkowitsch J, Hofbauer M, Schauer J, Leixnering M. Unstable distal radius fractures in the elderly patient-volar fixed-angle plate osteosynthesis prevents secondary loss of reduction. J Trauma 2010;68(4):992-8.
16. Stanbury SJ, Salo A, Elfar JC. Biomechanical analysis of a volar variable-angle locking plate: the effect of capturing a distal radial styloid fragment. J Hand Surg Am. 2012;37(12):2488-94.
17. Drobetz H, Kutscha-Lissberg E. Osteosynthesis of distal radial fractures with a volar locking screw plate system. Int Orthop. 2003;27(1):1-6.
18. Valbuena SE, Cogswell LK, Baraziol R, Valenti P (2010) Rupture of flexor tendon following volar plate of distal radius fracture. Report of five cases. Chir Main. 2010;29(2):109-13.
19. Orbay J. Volar plate fixation of distal radius fractures. Hand Clin. 2005;21(3):347-54.
20. Soong M, Earp BE, Bishop G. Volar locking plate implant prominence and flexor tendon rupture. J Bone Joint Surg Am. 2011;93:328-35.
21. O'Shaughnessy MA, Shin AY, Kakar S. Stabilization of Volar Ulnar Rim Fractures of the Distal Radius: Current Techniques and Review of the Literature. J Wrist Surg. 2016;5(2):113-9.
22. Gruber G, Gruber K, Giessauf C, Clar H, Zacherl M, Fuerst F. Volar plate fixation of AO type C2 and C3 distal radius fractures, a singlecenter study of 55 patients. J Orthop Trauma. 2008;22(7):467-72.
23. Rozental TD, Blazar PE. Functional outcome and complications after volar plating for dorsally displaced, unstable fractures of the distal radius. J Hand Surg Am. 2006;31(3):359-65.
24. Orbay JL, Fernandez DL. Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient. J Hand Surg Am. 2004;29(1):96-102.
25. Weninger P, Schueller M, Drobetz H. Influence of an additional locking screw on fracture reduction after volar fixed-angle plating-introduction of the protection screw in an extra-articular distal radius fracture model. J Trauma. 2009;67(4):746-51.
26. Jung HS, Jung HS, Baek SH, Lee JS. How Many Screws Are Needed for Reliable Stability of Extra-articular Nonosteoporotic Distal Radius Fractures Fixed with Volar Locking Plates? Clin Orthop Surg. 2020;12(1):22-28.
27. Wong TC, Yeung CC, Chiu Y. Palmar fixation of dorsally displaced distal radius fractures using locking plates with Smartlock locking screws. J Hand Surg Eur. 2009;34(2):173-8.
28. Hakimi M, Jungbluth P, Gehrmann S. Unidirectional versus multidirectional palmar locking osteosynthesis of unstable distal radius fractures: comparative analysis with LDR 2.4 mm versus 2.7 mm matrix-smartlock. Unfallchirurgie. 2010;113(3):210-6.
29. Chen M, Gittings DJ, Yang S, Liu G, Xia T. Variable-Angle Locking Compression Plate Fixation of Distal Radius Volar Rim Fractures. Iowa Orthop J. 2019;39(2):55-61.

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