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Original Article

Clinical results of volar locking plate fixation in radius distal fractures

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Abstract

Aim: This study aimed to evaluate the results of 41 surgically treated radius distal fracture patients. Average follow-up time was 9.8 months (6-19) and mean age was 44.04 (20-81). All patients treated surgically with volar locking plate between the dates October 2010 and November 2018.

Material and Methods: There were 11 type A2 (26%), 10 type C2 (24%), 4 type A3 (9%), 3 type B1 (7%), 3 type B3 (8%), 6 type C3 (14%) and 4 type C1 (9%) fractures, respectively according to the AO Classification System. Stewart's radiological criteria and range of motion were used in clinical and radiological evaluation. QuickDASH-T and Gartland-Werley scores were used for functional assessment.

Results: Twenty-three patients (56%) had excellent, 14 patients (34%) had good and 4 patients (9%), respectively had moderate functional scores according to Gartland-Werley scoring scale. Thirty-four patients (83%) were excellent and 7 patients (17%) were good, respectively according to Stewart's radiological criteria. Average QuickDASH-T score was 5.92 (0-22.7) and average Gartland-Werley score was 3.26 (0-13). Two patients suffered reflex sympathetic dystrophy as a complication.

Conclusion: Volar locking plating in distal radius fractures is a reliable treatment method with successful results with careful preoperative planning, attentive surgical approach and systematical rehabilitation. It should be considered as treatment of choice for all but especially active and demanding patients.

Keywords: Distal radius fracture; volar locking plate; intra-articular fracture

INTRODUCTION

Distal radius fractures are one of the most common fractures. It can be seen in almost all age groups with different injury mechanisms. Since the wrist is one of the joints that have the most impact on human daily activities, the limitation to occur has the potential to cause patient dissatisfaction. The treatment of distal radius fractures has changed distinctively according to the expectations of the patients and the technology developed over time. According to study by Koval et al. (1) in 2008, the rate of surgically treated distal radius fractures increased from 42% to 81% from 1999 to 2007. In the treatment of distal radius fractures, extra-articular, which constitutes the majority of fractures today, can be treated with closed reduction and casting. On the other hand, surgical intervention should be considered according to criteria such as bone quality and activity level of the patient as the presence of intra-articular fragments and failure to achieve stable reduction. Even if closed reduction and percutaneous pinning (CRPP) is a widely used surgical modality for distal radius fractures with the advancing technology, prolonged life expectancy and increasing functional demands even in advanced ages, the popularity of treatment modalities such as volar plating that can achieve minimum functional loss with the anatomical reduction of the fracture and the initiation of early movement has gradually increased.

MATERIAL and METHODS

Patients who underwent open reduction and internal fixation surgery with volar locking plates for distal radius fractures between October 2010 and November 2018 were included in this study. Patient data related to inpatient stay, outpatient visits as well as readmissions were extracted from hospital records and analyzed retrospectively. The inclusion criteria for the study were distal radius fracture, surgical treatment decision, and no

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other ipsilateral upper extremity injuries. Exclusion criteria for the study were other treatment modalities except volar plating, insufficient radiological and clinical follow-up data and a follow-up period of less than 6 months. Forty-one patients out of 132 surgically treated patients met the inclusion criteria and evaluated for the study.

Surgical Decision

Standard wrist (AP (anterior-posterior) and lateral) X-rays were taken in the admission of each patient. Further imaging with CT (computed tomography) scan was performed on fractures in which wrist joint was involved. Fractures were classified regarding AO/OTA classification. Immediate closed reduction and short/long arm splint was applied for all patients depending on the fracture localization. Surgery or conservative treatment was decided on post reduction X-rays and CT scans for intraarticular involvement.

Surgical Technique

All patients were positioned in supine and were applied pneumatic tourniquet (Figure 1.A.). Sixteen patients (69.5%) were operated under general anesthesia and 7 patients under axillary block (30.5%). Prior to anesthesia 1 g cefazolin sodium I.V (or clindamycin 600 mg I.V. for the patients with penicillin allergy) was applied for prophylaxis. FCR tendon sheath was revealed by passing the skin-subcutaneous tissues through the longitudinal incision made immediately from the radial (Figure 1.B.) of the flexor carpi radialis (FCR) tendon. The radial artery was identified on the radial side of FCR tendon. The FCR tendon sheath was opened (Figure 1.C.). Dissection was deepened between radial artery (laterally) and FCR tendon (medially) through pronator quadratus (PQ) muscle (Figure 1.D.). The PQ muscle was sharply dissected along the lateral side of radius close to its insertion and elevated to reveal fracture (Figure 1.E.). After the open reduction of the fracture, K-wires are used for temporary fixation. A volar anatomical locking plate was positioned in the distal radius and stabilized with temporary K-wires (Figure 1.F.). After fluoroscopic control, one cortical screw was applied through the oval hole located proximal to the plate and fixed the plate to radial shaft. Then, distal locking screws were placed with caution not to exceed the dorsal cortex. The remaining shaft screws were then applied, and the stabilization was completed.

Fracture reduction, plate location and screw sizes checked with fluoroscopic imaging (Figure 2). The PQ muscle and FCR tendon sheet were repaired. After bleeding control, the wound was closed per planus with absorbable sutures. Short arm splint was applied with metacarpophalangeal joints were exposed.

Post-Operative Management

Patients were discharged on the postoperative second day. In all cases skin closure conducted via intradermal technique therefore no stitch removal needed. Follow-up visits were on first week for evaluation of soft tissue healing, third week for ending short-arm splint and passive range of motion (ROM) exercises, the sixth week for radiological and clinical evaluation of union and the assessment for requirement of physiotherapy/active ROM exercises, the third month for the evaluation of full recovery and the sixth month for ending follow-ups unless needed. Radiological controls were done with AP and lateral radiographs. Volar tilt angle, radial inclination, radial height and ulnar variance were measured and evaluated according to Stewart criteria on the sixth week postoperatively. Functional results evaluated according to the "Gartland-Werley" scoring system and "QuickDASH-T" survey on the third month postoperatively.

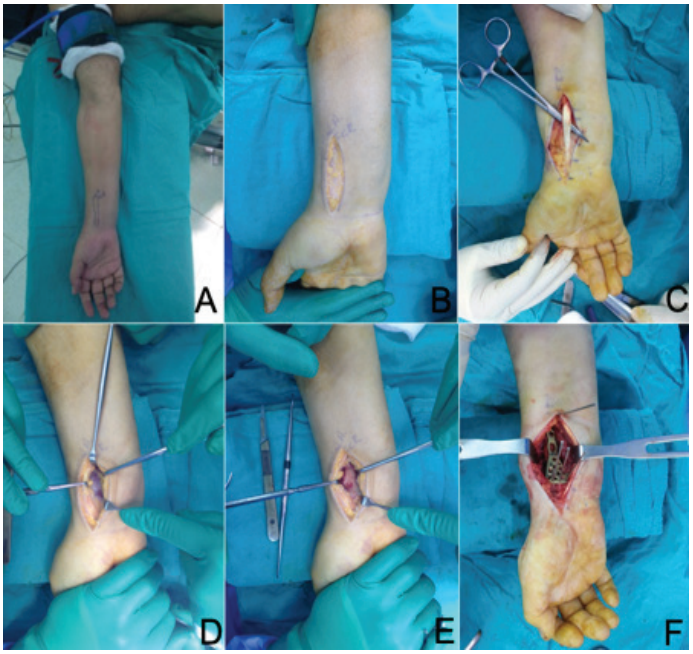

Figure 1. A. Position and skin marking of anatomical landmarks. B. Skin incision, revealing tendon sheath C. Exposure of FCR D. Exposure of pronator quadratus muscle E. Reduction F. Provisional fixation of plate

Figure 2. A. Pre-operative X-rays B. Intra-operative fluoroscopic views C. Early post-operative X-rays D. Follow-up (6 weeks) X-rays. E. Functional results (3rd month)

RESULTS

The mean age was 44.04 (20-81) years. The mean age of male patients was 36.4 (21-76), while the mean age of the female patients was 57.06 (25-81). 25 (60.9%) of our patients were male, 16 (39.1%) were female. 24 (59%) of the distal radius fractures included in our study were left, 17 (41%) were the right wrist. 19 (46%) of the injuries were on the dominant wrist. According to AO classification system 11 fractures were A2 (26%), 10 fractures C2 (24%), 4 fractures A3 (9%), 3 fractures B1 (7%), 3 fractures B3 (8%), 6 fractures were classified as C3 (14%) and 4 fracture as C1 (9%).

When the associated injuries were examined, there were ulna styloid fracture in 20 patients, ulna head fracture in 3 patients, subtrochanteric femur, contralateral olecranon, L-5 vertebral compression and sacrum fracture in 1 patient and contralateral perilunate fracture dislocation in 1 patient were existed. The average QuickDASH-T survey results were 5,92 (0-22.7), while average Gartland-Werley scores were found to be 3.26 (0-13).

According to Gartland-Werley scores, 23 of the patient's results were excellent (56%), good results were obtained in 14 (34%) and fair in 4 (9%). According to Stewart's radiological evaluation system 34 (83%) patients had excellent, 7 (17%) had good results.

In all of our patients we had clinical and radiological findings of complete fracture union at the post-operative sixth week. The results of wrist range of motion after treatment in this study was as follows: the average flexion was 55,36° (20-80°), the average extension 56,09° (10-80°), the average radial deviation 19,39 (15- 30°) and the average ulnar deviation was found to be 24,02° (15-40°). The evaluation of preoperative radiological measurements in this study was as follows: the average radial inclination was 9,80° (-20° -18°), the average radial height was 5,04 mm (-10mm-11mm) and the average volar tilt was -9,63° (-45° -32°). Post-operative radiological evaluation of the patients in this study showed that the mean radial inclination was 21,21° (18-25°), the mean radial height was 10,75 mm (8-13 mm) and the mean volar tilt was 11,09° (8-13°). Further evaluation of the pre and post-operative changes for the same parameters revealed that the average change in radial inclination was 11,41° (4-42°), the average change in radial height was 5,65 mm (0-21 mm), and the average change in volar tilt was 22,19° (3-57°), respectively.

DISCUSSION

The treatment of distal radius fractures was evolved since the time it was defined. However, a gold standard treatment modality has not yet been established. Although it is generally considered that closed reduction and cast immobilization is sufficient, this way of thinking has changed with the detailed description of the pathomechanics of the injury, advancement in treatment techniques and the increase in expected functional results (2).

Even if external fixation with various techniques described as sufficient and effective (3), immobilization duration and lack of fragment control limits it's use with almost only for multitrauma patients and open fractures. Although dorsal plating was first used according to the principles of open reduction internal fixation in distal radius fractures several problems limited its use including technical difficulties related to the complicated anatomical structure of the dorsal wrist, soft-tissue problems due to insufficient subcutaneous tissue, complications arising due to the close tendon contiguity of the implant. Dorsal plating is being replaced by volar plating with the development of volar locking plates that can provide stable reduction in a wide variety of fracture models due to the development of plate technologies (4,5).

Although the main criteria in the evaluation of reduction are radial height, radial inclination and volar tilt, the most important criteria to achieve good functional results is considered as anatomical restoration of the joint surface. In the determination of long-term functional results, the importance of these criteria investigated in many studies (6,7). It has been shown that the decrease in radial height leads to permanent increase in ulnar length. This increases the load on triangular fibrocartilage complex and is associated with pain and deformity. Insufficient reduction in radial inclination leads to a shift in the center of rotation during rotation movements and accelerates arthritic changes. Loss of volar tilt (> 10° dorsal tilt) is associated with decreased range of motion, loss of grip strength and limitation in daily activities (6).

The pre-operative radiological evaluation of the patients included in our study yielded an average radial inclination of 9,80° (-20°-18°), an average radial height of 5,04 mm (-10mm-11mm), and an average volar tilt of -9,63° (-45°-32°). The average radial inclination obtained from post-operative radiological evaluations is 21,21 ° (18°-25°), the average radial height is 10,75 mm (8-13 mm) and the average volar tilt 11,09° (8°-13°) values are similar to other studies in the literature and also evaluated within normal values (8,9).

One of the points to be considered during volar plating is the watershed line. It is an indication point for the plate placement that delimits the concave structure of the radius distal volar face (5,10). If volar plates applied distally to this point, may cause tendon complications due to the close tendon neighborhood and screw penetration into the joint in fixed-angle locked plate applications (5,8,11). We assessed that during surgery, besides provisional K-wire fixation through radial styloid, volar-distal to dorsal-proximal directional K-wires prior to plate application restores continuity of reduction and provides the most accurate plate placement. Another important point to be considered in the treatment of distal radius fractures with volar plating is the potential risk of dorsal cortex screw

penetration. Wall et al. (12) compared bicortical screws, unicortical screws and unicortical pegs in their in vitro biomechanical study. No significant difference was found between the groups in terms of stiffness under axial loading. In terms of two-millimeter displacement loads, no significant difference was found between bicortical screws and full length unicortical and 75% unicortical screws. In the light of this information, the authors suggested that the screws should be placed 2 mm shorter than the dorsal cortex if the dorsal cortex is intact and 4 mm shorter than the measured one if the dorsal cortex is intact to ensure adequate strength stabilization while preventing tendon irritation due to dorsal screw penetration. Riddick et al. (13), showed the sensitivity, specificity and accuracy of intra-operative skyline view (elbow 70° flexion, wrist 75° flexion, dorsal tangentially) is 83% and in ulnar side screws these values went up to 90%. In our study, none of the patients were found to have tendon irritation due to screw penetration from the dorsal cortex and need for removal of fixation material. During the surgery, care was taken to keep these complications in mind and to apply shorter screws than those measured and to control screw penetration by intraoperative imaging including tangential fluoroscopy and articular penetration was assessed by true AP and true lateral fluoroscopic imaging. Placing of watershed line K-wires was observed to prevent the intra-articular screw penetration in addition to providing the accuracy of the plate position since we had no need for change the positions and sizes of screws intraoperatively in any patients.

Perhaps the greatest challenge in the treatment of distal radius fractures with volar plating is the patients' ability to adapt postoperative rehabilitation as Orbay et al. mentioned (5). Consistent with this, in our study, 3 of the 4 patients with fair functional outcome were older (mean 70, range 52-81). The other patient had multiple injuries as a result of falling from height as a suicide attempt. That patient had psychological problems prevented sufficient cooperation to adapt rehabilitation procedures. Brumfield et al. (14) examined the biomechanics of normal wrist and found that 10° flexion and 35° extension range allows the majority of daily activities. Normal range of motion for wrist described as 30° flexion, 45° extension, 15° radial and ulnar deviation and 50° pronation and supination. This range of motion is important to allow circumduction movement. In our study, we obtained average flexion of 55,36°, 56,09° extension, 19,39° radial deviation and 24,02° ulnar deviation values are almost at the limits of normal ROM and similar to other studies in the literature (8,15). The most effective factor for obtaining such ROM values as almost within normal values is evaluated as rigid and anatomic fixation allowing early mobilization.

Complications that are frequently reported in the surgical treatment of distal radius fractures with volar locking plate include extensor tendon irritation and rupture due to the use of long screws, flexor tendon ruptures especially flexor pollicis longus tendon due to the placement of the plate more distally than normal, penetration of the screws into the joint, median nerve compression / CTS (carpal tunnel syndrome), superficial and deep soft tissue infection, RSD (reflex sympathetic dystrophy), nonunion and malunion. Bentohami et al. (16) in their review, which included 33 studies that met the study criteria in 2014, on the complications that occurred after surgical treatment of volar-locked plate of distal radius fractures, found a total complication rate of 16.5% in a group of 1817 patients. Knudsen et al. (17) found the rate of complications as 18% in their study involving 165 patients and reported that these complications were most common complications were CTS and inadequate osteosynthesis and both seen in 12 patients.

In our study, there were no major complications identified as failure of fixation material, deep infection, tendon rupture, CTS, any condition requiring removal of fixation material, and malunion. While minor complications such as tendon irritation, neuritis, superficial infection and loss of reduction were not observed, RSD was observed in 2 patients. Most of the complications reported are seemed to be based on insufficient reduction, plate positioning and screw penetration. Depending on its nature, distal radius fractures can be reducted anatomically in every case with almost the same intraoperative reduction techniques. On the other hand, retaining of reduction depends on the implants that are used. Therefore, preoperative planning is essential for especially intraarticular and/or multifragmentary fractures. Fragment specific implants, rim plates or free micro-screws even if auto/allograft options should be considered for need when planning.

Retrospective design, lack of comparison with other treatment options and relatively small number of patients are our limitations.

CONCLUSION

Radius distal fractures can be seen in almost any age group due to different injury mechanisms and underlying causes (high energy trauma, low energy trauma in osteoporotic bone, etc.) and therefore treatment methods should be customized according to the patient. Regardless of the treatment method chosen, anatomic reduction is important due to the important place occupied by wrist functions in daily living activities.

Preoperative planning and a good understanding of fracture configuration is important, and computed tomography evaluation may help if necessary. It should be considered during pre-operative planning that the stabilization of the reduced fragment in fractures with very distal location (water shed line and distal) cannot be achieved only with volar plates. According to the results of the radiological evaluation criteria obtained in our study, almost complete anatomical reduction can be achieved with volar plates. It is important to perform careful surgical technique, keeping in mind the complications that may occur, especially due to the distal radius anatomy. It would be appropriate to prefer the shorter screws rather than the long ones, especially when applying the most distal screws during

surgery, and to use intraoperative radiological imaging including tangential radiography.

When the individual and mean functional results obtained in our study were evaluated, it was determined that stable fixation, early rehabilitation and systemic rehabilitation during patient recovery were effective on the functional outcomes. Frequent complications (tendon irritation / rupture, nerve compression, loss of reduction), should be kept in mind a possible in follow-up examinations.

Competing interests: The authors declare that they have no competing interest.

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Ethical approval: This study is a retrospective archive research.

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