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Original Article

Surgical versus conservative management of distal radius fracture with coronal shift; a randomized controlled trial

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Abstract: Background: Coronal shift is one of the most critical complications related to distal radius fracture (DRF), leading to instability in the distal radioulnar joint (DRUJ). Nevertheless, there is no unified approach for the managing DRF with coronal shift; therefore, the current study aims to compare the surgical versus conservative approach for the coronal shift due to DRF treatment. Methods: This is a randomized clinical trial conducted on 50 patients with distal radius fracture (type 1 based on Fernandez Classification of Distal Radius Fractures) with a coronal shift in 2014-17. The patients were randomly allocated to treatment conservatively (n=25) by a long arm casting or surgically (n=25) using a volar plate fixation. The patients were followed for 24 months, and primary outcomes included a functional score on the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire; pain score based on the Visual Analogue Scale (VAS), and handgrip strength (HGS) measured via a dynamometer were assessed and compared. Results: Both approaches led to significant improvement in range of motion, pain complaint, DASH scores, and HGS at the end of the two-year follow-up (*P*-value <0.05). The comparison of the trend of changes in the two groups generally revealed a remarkable better range of motions, VAS, and HGS among the operated cases (*P*-value <0.05); however, DASH score did not differ (*P*-value >0.05). Conclusion: The long-term outcomes of volar plate fixation for DRF management (bending fracture of metaphysis) plus coronal shift are notably superior to the conservative treatment; however, due to the limited information in this regard, further evaluations are strongly recommended.

Keywords: Distal radius, distal radioulnar joint, joint instability, radius fractures

Introduction

Distal radius fractures (DRF) are one of the most common types of orthopedic injuries [1, 2], accounting for 15% of all fracture-related referrals to emergencies [3, 4]. This type of fracture has a bimodal age rate curve with an increased incidence rate in children and the elderly [5].

Most DRFs are managed conservatively with closed reduction and plaster cast immobilization, while unstable ones require surgical fixation [6, 7]. Closed reduction with cast immobilization is not appropriate for the elderly, as they are at increased risk for displacement and prone to poor function recovery [8].

DRF may frequently cause injury to the distal radioulnar joint (DRUJ) and lead to symptomatic instability after the bone union. This instability can cause ulnar-sided wrist pain, limitation and painful forearm rotation, weakness in grip strength, and osteoarthritis. The stability of distal radioulnar joint (DRUJ) is dependent on the combination of four elements, including "1) the triangular fibrocartilage complex (TFCC), 2) the bony articulation underlying between the ulnar head and radius sigmoid notch and beyond the fibrocartilaginous rim, 3) distal interosseous membrane (DIOM) and 4) the pronator quadratus", among which TFCC, the radioulnar ligaments in particular, and then, DIOM are the major stabilizers of DRUJ [9, 10].

By assessing DRUJ injuries due to DRF, it is assumed that the intact DIOM plays the most significant role, as TFCC is frequently injured. DIOM plays the stabilizer role in the forearm by its resting tension [9]. An anatomical study demonstrated that DIOM originates palmar and proximal on the ulna and extends to the dorsal and distal part of the radius. Therefore, it functions as resistance in the dorsal translation of the radius while supinating [11].

The coronal shift also known as radial translation is defined as the coronal shift of the proximal fractured part of the radius to the ulna that causes significant complications such as a decrease in DIOM tension and increased laxity because of narrowing occurrence in the radioulnar distance proximal to the site of DRF [12, 13]. A cadaveric study by Dy and colleagues presented a considerable increase in DRUJ instability in cases with coronal shift due to DRF, even as small as 2 mm [12]. Therefore, the appropriate anatomical reduction of this fracture leads to re-tensions on DIOM, consequently causing contact pressures and, eventually, the ulnar head seats within the sigmoid notch. Together, these conditions help the patient achieve an appropriate wrist function [11, 14, 15].

Despite what was mentioned above, information about DRF management with the coronal shift is limited. The classical assessment of DRF management consists of five items of ulnar variance, radial inclination, articular congruity, a dorsal tilt of less than 10°, and carpal malalignment; however, recently, the attention has been deviated toward including coronal plane shift reduction in the above criterion due to the significance of DRUJ stability [16]. Therefore, in the current study, we are aimed to assess the DRF conservative management versus volar plate fixation in a 24-month follow-up study of patients with DRF plus coronal shift.

Methods and material

Study design

This is clinical trial was conducted on 50 patients with distal radial fracture plus radius coronal shift referred to the Kashani Hospital affiliated at Isfahan University of Medical Sciences from March 2014 to April 2017.

The Ethics Committee of Isfahan University of Medical Sciences approved the study protocol primarily (Ethics code: IR.MUI.MED.REC.1398.054). This study is also approved by the Iranian Registry of Clinical Trial (IRCT) with the code of: IRCT20200604047653N1. After that, the patients were informed about the study protocol, they were reassured about the confidentiality of the information, and written consent for participation in the study was obtained.

Inclusion and exclusion criteria

The inclusion criteria of this study were age between 18-55 years, diagnosis of distal radius fracture (type 1 based on Fernandez Classification of Distal Radius Fractures: bending fracture of metaphysic [17]), having over 2 mm coronal shift and signing the written informed consent to participate in this study. The Fernandez classification aimed to provide a system that primarily focused on the mechanism of injury to classify injuries to standardize treatment accurately. Type 1 of this classification is recognized as a bending fracture of the metaphysic [18].

The non-entry criteria were open fractures, multiple fractures, medical conditions such as diabetes, osteoporosis, cerebral palsy, poliomyelitis and stroke, and malalignment of the upper extremities before the fracture incidence.

The exclusion criteria were improper follow-up and over 20% defects in patient's medical records.

Study population

The patients who met the inclusion criteria were included in the study until the desired number of patients was allocated to each DRF management approach. The approaches included volar locking plates or conservative non-operative casting.

Procedures

A posteroanterior (PA) radiograph was obtained primarily to distinguish radial translation. In this term, a reference line along the ulnar aspect of the radial diaphysis distally across the carpus was depicted, and over 2 mm of

proximal radius shift in coronal plane toward ulna plus less than 70% of lunate width remaining ulnar to the reference line were considered as coronal shift [16].

Then, the fractures were primarily reduced, and a sugar tongue splint was administered. Following the close reduction, radiography with a similar protocol as the previous one was taken to observe if the coronal shift remained.

After that, cases whose coronal shift was preserved were randomly allocated to be treated conservatively or surgically using Random Allocation software. Therefore, each patient was provided with a particular number, if even giving them to the conservative treatment and if odd to the volar locking plate fixation.

Conservative approach

For the patients who underwent conservative treatment, a standard long arm cast in a neutral position using the molding technique in three points was taken for six subsequent weeks.

Surgical approach

To apply to the distal part of the radius anteriorly, the Henry approach was administered. Therefore, after the exposure of the fractured parts, a retractor was placed within the interosseous space, and the ulnar-shifted proximal part of the radial was moved toward the anatomical place. Then, a pin was used to fix the distal and proximal portions to each other provisionally. After that, a locking plate (3.5 mm) was placed on the volar surface and fixed to both proximal and distal parts using screws. In the next step, by the fixation of the volar plate, the pin was removed. By the end of the procedure, the tourniquet was removed, a drain was embedded, and the subcutaneous and cutaneous tissues were restored. A standard long arm splint in a neutral position was taken for two subsequent weeks.

Outcome assessments

Patients were followed for 24 months after surgeries and regular visits were conducted at 3, 6, 12 and 24 months. During these visits, primary variables were assessed in all cases. The study's primary outcomes included the wrist function in different directions, including flexion, dorsiflexion, pronation, supination, ulnar deviation, and radial deviation. These variables were measured using a goniometer. We also measured the subjective functional outcomes presented by the patients using the functional score on the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, pain score based on the Visual Analogue Scale (VAS), and handgrip strength (HGS) measured via a dynamometer.

All of the measurements were performed by a skilled orthopedist to prevent the probable interobserver bias.

Wrists function in different directions

The supination and pronation range of motion was measured while a patient took a pencil by each of the hands; the elbows were 90 degrees flexed and wholly attached to the body. Then, the patient was requested to rotate the hands internally and externally. The degree between the pencil and the perpendicular line to the desk surface was defined as the degrees of supination and pronation.

The other directions were measured when the elbow was 90 degrees flexed and wholly attached to the body, the wrist was neutrally positioned, and the fingers were released. Then the patient was requested to perform each of the motions, and the activities were measured using a goniometer again.

Used questionnaires

DASH is a thirty-item validated outcome questionnaire measuring the physical function of the upper extremity disability on the basis and symptoms. DASH score includes a questionnaire that examines symptoms (such as pain, weakness, etc.) and the patient's ability to perform some physical activity, and patients answer all the questions according to their health status. The DASH consists mainly of a 30-item disability/symptom scale, scored 0 (no disability) to 100 [19].

The severity of pain was subjectively represented by the patients using the VAS. Based on VAS, the patient's pain was scored from 0 (no pain) to 10 (most severe pain) [20].

Handgrip strength

HGS is conducted to measure the maximum isometric strength of the hand and forearm

Table 1. The comparison of demographic information between non-operative treatment versus volar plated fixation treatment

Variable		Type of management		*P*-value
		Non-operative management	Volar plated fixation	
Age (years), mean ± std		33.72±6.74	37.68±9.18	0.08*
Follow-up postoperation interval (months), mean ± std		16.32±4.10	16.56±3.62	0.70**
Gender, n (%)	Male	14 (28%)	16 (32%)	0.56£
	Female	11 (22%)	9 (18%)	

*T-test; **Mann-Whitney; £Chi-square.

muscles by a dynamometer. To perform this test, the patient squeezes the dynamometer with maximum isometric effort, maintained for about 5 seconds. The best score of the patient is recorded as HGS. It is indicated that an HGS of more than 64 kg is an excellent result, and HGS between 44-47 kg is below the average, and HGS of below 40 kg is considered a very poor result [21, 22].

Statistical analysis

The obtained data were entered into the Statistical Package for Statistical Sciences (SPSS) version 23. The descriptive data were presented in mean, standard deviation, absolute numbers, and percentages. For the analytics, Chi-square, independent T-test, and Mann-Whitney were used. *P*-value of less than 0.05 was considered a significant level.

Results

Study population

The eligibility of 60 patients was assessed for participation in the current study. Two refused to participate, five did not meet the inclusion criteria, and 53 patients were allocated to the treatment approaches. One of the cases in the conservative treatment group and two patients in the latter group did not refer for referral visits and were excluded. Eventually, 50 patients, including 25 ones in the conservative treatment approach and 25 patients in the surgical volar plated fixation group, fulfilled the study.

Demographic data

The age range of the study groups was 18-55 years old, and they were followed for 12-24 months postoperatively. The comparison of two studied groups in terms of age (*P*-value =0.08), gender (*P*-value =0.70), and follow-up interval (*P*-value =0.56) revealed insignificant differences. Detailed information is demonstrated in **Table 1**.

Pain and limb function

The comparison of the two groups in terms of the range of motions, DASH score, VAS score, and handgrip strength has been demonstrated in **Table 2**. Based on this table, both approaches led to significant changes in better range of motion in different directions, less pain severity based on VAS, better DASH scores, and improved handgrip strength at the end of the two-year follow-up.

Wrist function

The comparison of the trend of changes in the two groups by the end of the 24 months revealed a remarkable better range of motions among the operated cases (*P*-value <0.05) except for flexion (*P*-value =0.11). In addition, the trend of changes in the VAS score (*P*-value <0.001) and HGS statuses (*P*-value <0.001) was significantly better in the patients who underwent volar plated fixation, but the DASH score changes showed non-significant differences (*P*-value =0.06).

Discussion

The current report is a controlled randomized trial comparing two methods of conservative versus volar plate fixation for the management of DRF (type 1 based on Fernandez Classification of Distal Radius Fractures) plus coronal shift. The other strong point of this study is its long-term follow-up period accounting for 24 months postoperatively. Our results insisted on the efficiency of both approaches for the management of DRF; however, the comparison of the two groups strongly favored the surgical approach compared to conservative management. In this clinical trial, the trend of changes

Table 2. The comparison of the wrist function between Volar plated fixation versus non-operative management

Variables		Time				*P*-value**	*P*-value**
		Three months	Six months	12 months	24 months		
Flexion, (degrees)	Volar plated fixation	51.40±18.04	59.52±16.78	65.88±15.33	69.52±14.12	<0.001	0.11
	Non-operative management	54.64±17.92	59.20±17.39	65.28±15.80	68.01±15.15	<0.001	
P-value*		0.52	0.94	0.89	0.71		
Dorsiflexion, (degrees)	Volar plated fixation	49.04±16.63	51.56±15.44	60.92±14.16	63.33±13.17	<0.001	0.03
	Non-operative management	54.72±12.97	57.32±13.90	62.64±14.80	66.87±14.06	<0.001	
P-value*		0.18	0.17	0.67	0.37		
Radial deviation, (degree)	Volar plated fixation	17.87±8.03	17.96±7.08	19.56±7.90	20.72±6.10	<0.001	<0.001
	Non-operative management	16.16±5.82	19.36±6.25	22.44±5.85	25.16±6.018	<0.001	
P-value*		0.40	0.46	0.12	0.01		
Ulnar deviation, (degree)	Volar plated fixation	24.48±7.59	28.40±8.07	33.04±7.67	34.92±8.06	<0.001	0.001
	Non-operative management	29.08±6.19	31.36±5.80	37.52±6.16	38.32±5.72	<0.001	
P-value*		0.02	0.14	0.2	0.09		
Supination, (degree)	Volar plated fixation	67.60±10.16	78.88±9.34	80.48±8.87	81.32±8.19	0.01	<0.001
	Non-operative management	66.28±12.33	71.20±13.16	77.16±14.40	77.01±12.92	0.02	
P-value*		0.68	0.02	0.33	0.16		
Pronation, (degree)	Volar plated fixation	80.08±10.15	75.52±8.94	81.28±10.61	81.69±9.68	<0.001	<0.001
	Non-operative management	75.76±10.02	77.08±9.29	80.16±8.53	81.41±7.06	<0.001	
P-value*		0.14	0.51	0.68	0.91		
DASH score	Volar plated fixation	29.41±13.91	20.64±6.74	14.72±6.96	11.68±6.36	<0.001	0.06
	Non-operative management	40.40±12.46	26.76±6.18	20.72±5.98	16.84±5.38	<0.001	
P-value*		0.005	0.002	0.002	0.003		
VAS score	Volar plated fixation	2.24±1.20	2.96±1.30	1.96±1.67	1.24±1.20	<0.001	<0.001
	Non-operative management	4.24±1.30	2.84±0.89	3.48±1.41	2.48±1.29	<0.001	
P-value*		<0.001	0.70	0.001	0.001		
Handgrip strength	Volar plated fixation	17.12±6.71	16.44±6.75	27.20±8.10	30.60±8.17	<0.001	<0.001
	Non-operative management	15.81±6.65	20.80±7.15	25.76±7.11	29.16±6.77	<0.001	
P-value*		0.48	0.03	0.51	0.50		

*Independent Samples T-Test. **Repeated Measures. VAS = Visual Analog Scale. DASH = Disabilities of the Arm, Shoulder and Hand questionnaire.

in a different range of motion entities was remarkably better in the operated cases other than wrist flexion. Besides, the operated cases represented superior HGS and less severe pain than the latter ones. Surprisingly, the trend of subjective presentations of the patients about the outcomes using DASH revealed an insignificant difference between the groups, while the sole comparison of the two approaches at each of the assessment stages was in favor of the surgical procedure than the conservative one.

Most of the studies in the literature have not insisted on the significance of coronal shift incidence due to DRF. However, they agreed with our study regarding the superiority of surgical management compared to the conservative nonsurgical approach [23-25].

The outcomes of our study made us propose the theory about the necessity of determining the indications for each of the existing approaches in cases with DRF plus radial translation, conservative management, in particular, a point that has been presented by Ross and colleagues in a study assessing the use of volar locking plate for the management of DRFs with coronal shift [26]. Nevertheless, there is no protocol for the approaches used for the management of this condition. At the same time, it is well-clarified that the correction of the coronal shift should be prioritized in cases with DRF, as cadaver studies simulating coronal shift due to DRF have shown that radial translation for only 2 mm led to considerable DRUJ instability [12].

The studies in the literature have only recommended varieties of fixation techniques but have not been conducted on large numbers of patients. Ross and colleagues insisted on the excellent values of volar plate fixation for sagittal plane alignment with the restoration of volar tilt, while the nature of this technique cannot assist with the management of coronal shift; therefore, they proposed a technique of open

reduction and internal fixation during the surgical procedure for the correction of radial translation. After that, to confirm their recommended approach, they claimed that correction of coronal shift lessens the requirement for ulnar-sided surgical procedures [26], a fact presented by Saw and others [26], a fact that was presented by Saw and others, as well [27]. In this order, varieties of techniques during the use of volar plates have been represented. For instance, Raply and others presented that using a Gelpi retractor in the volar approach can help coronal shift correction. In this term, the Gelpi retractor is placed between the ulna and radius to spread adequate tension apart these bones until achieving appropriate tension or using an external fixator as an alternative for imposing the required tension. Another technique was the use of an Armye/Navy retractor inserted in the interosseous space and rotated for 90 degrees until the achievement of radius reduction [28]. The other suggested technique was to use a volar plate as the reduction tool represented by Moritomo and Omori [11]. Alternatively, Trehan and colleagues preferred a technique in which a Hohmann retractor was used to place on the ulnar metaphyseal flare. At the same time, a counter-pressure is applied to the radial styloid [16]. Senehi and colleagues suggested a maneuver during volar plate fixation of DRF so that the proximal plate is cheated in the ulnar direction while the intraarticular surface is reduced distally using the volar locking plate as a guide. By completing the intraarticular reduction, the proximal screw will be loosened, and the DRUJ will be reduced by the proximal plate radially translation [29]. The strength of this indirect reduction mechanism is the maintenance of pronator quadratus and interosseous membrane tension and, therefore, DRUJ stability [10].

The main limitations of this study were the restricted study population and including patients with type 1 distal radius fracture. It is believed that further research on larger populations and including other fracture types could reveal important data.

In summary, the current study compares the volar plate fixation approaches for the correction of DRF plus coronal shift versus conservative management in which the surgical approach was superior. There was no similar study comparing different approaches or even demonstrating the efficacy of each of the approaches. Still, they have recommended varieties of techniques for fracture correction in both sagittal and coronal planes [30, 31]. Therefore, further studies to achieve a proper approach for the management of DRF plus radial translation are strongly recommended.

Conclusion

The long-term outcomes of volar plate fixation for the management of DRF (bending fracture of metaphysic) plus coronal shift are notably superior to the conservative treatment; however, due to limited information, further evaluations are recommended in this regard to generalizing the outcomes.

Disclosure of conflict of interest

None.

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References

[1] Azad A, Kang HP, Alluri RK, Vakhshori V, Kay HF and Ghiassi A. Epidemiological and treatment trends of distal radius fractures across multiple age groups. J Wrist Surg 2019; 8: 305-311.

[2] Stirling ER, Johnson NA and Dias JJ. Epidemiology of distal radius fractures in a geographically defined adult population. J Hand Surg Eur Vol 2018; 43: 974-982.

[3] Court-Brown CM and Caesar B. Epidemiology of adult fractures: a review. Injury 2006; 37: 691-697.

[4] Andalib A, Etemadifar MR, Zadeh AR and Moshkdar P. Treatment of pilon fractures with low profile plates. Int J Burns Trauma 2021; 11: 486.

[5] Barrie KA and Wolfe SW. Internal fixation for intraarticular distal radius fractures. Tech Hand Up Extrem Surg 2002; 6: 10-20.

[6] Ayong S, Traore A, Postlethwaite D and Barbier O. Functional evaluation of unstable distal radius fractures treated with an angle-stable volar T-plate. Acta Orthop Belg 2014; 80: 183-189.

[7] Kiaei BA, Farsani DM, Ghadimi K and Shahali M. Evaluation of the relationship between serum sodium concentration and mortality rate in ICU patients with traumatic brain injury. Arch Neurosci 2018; 5.

[8] Blakeney WG. Stabilization and treatment of Colles' fractures in elderly patients. Clin Interv Aging 2010; 5: 337.
[9] Samani RE, Ebrahimi H, Zadeh AR and Safaee M. Evaluation of relative abundance of lymphedema after reverse axillary mapping in patients with breast cancer. Adv Biomed Res 2022; 11: 36.
[10] Kihara H, Short WH, Werner FW, Fortino MD and Palmer AK. The stabilizing mechanism of the distal radioulnar joint during pronation and supination. J Hand Surg Am 1995; 20: 930-936.
[11] Dehghani M, Fadaei B, Rastegar S, Zarezadeh A, Ghadimi K, Nikkhah R and Eslami S. Modified Camitz versus BRAND procedures for the treatment of severe carpal tunnel syndrome: a comparative trial study. Arch Bone Jt Surg 2020; 8: 420.
[12] Dy CJ, Jang E, Taylor SA, Meyers KN and Wolfe SW. The impact of coronal alignment on distal radioulnar joint stability following distal radius fracture. J Hand Surg Am 2014; 39: 1264-1272.
[13] Ross M, Di Mascio L, Peters S, Cockfield A, Taylor F and Couzens G. Defining residual radial translation of distal radius fractures: a potential cause of distal radioulnar joint instability. J Wrist Surg 2014; 3: 22-29.
[14] Moloney M, Farnebo S and Adolfsson L. Incidence of distal ulna fractures in a Swedish county: 74/100,000 person-years, most of them treated non-operatively. Acta Orthop 2020; 91: 104-8.
[15] Nypaver C and Bozentka DJ. Distal radius fracture and the distal radioulnar joint. Hand Clin 2021; 37: 293-307.
[16] Trehan SK, Orbay JL and Wolfe SW. Coronal shift of distal radius fractures: influence of the distal interosseous membrane on distal radioulnar joint instability. Hand Surg 2015; 40: 159-162.
[17] Fernandez D. Distal radius fracture: the rationale of a classification. Chir Main 2001; 20: 411-425.
[18] Wæver D, Madsen ML, Rölfing JH, Borris LC, Henriksen M, Nagel LL and Thorninger R. Distal radius fractures are difficult to classify. Injury 2018; 49 Suppl 1: S29-32.
[19] Hudak PL, Amadio PC, Bombardier C, Beaton D, Cole D, Davis A, Hawker G, Katz JN, Makela M and Marx RG. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder, and head). Am J Ind Med 1996; 29: 602-608.
[20] Ju JH, Jin GZ, Li GX, Hu HY and Hou RX. Comparison of treatment outcomes between nonsurgical and surgical treatment of distal radius fracture in elderly: a systematic review and meta-analysis. Langenbecks Arch Surg 2015; 400: 767-779.
[21] Soysal P, Hurst C, Demurtas J, Firth J, Howden R, Yang L, Tully MA, Koyanagi A, Ilie PC and López-Sánchez GF. Handgrip strength and health outcomes: umbrella review of systematic reviews with meta-analyses of observational studies. J Sport Health Sci 2021; 10: 290-295.
[22] Ramírez-Vélez R, Saez de Asteasu ML, Martínez-Velilla N, Zambom-Ferraresi F, García-Hermoso A and Izquierdo M. Handgrip strength as a complementary test for mobility limitations assessment in acutely hospitalized oldest old. Rejuvenation Res 2021; 24: 213-219.
[23] Orbay JL and Fernandez DL. Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient. J Hand Surg Am 2004; 29: 96-102.
[24] Diaz-Garcia RJ, Oda T, Shauver MJ and Chung KC. A systematic review of outcomes and complications of treating unstable distal radius fractures in the elderly. J Hand Surg Am 2011; 36: 824-835.
[25] Rozental TD, Blazar PE, Franko OI, Chacko AT, Earp BE and Day CS. Functional outcomes for unstable distal radial fractures treated with open reduction and internal fixation or closed reduction and percutaneous fixation. A prospective randomized trial. J Bone Joint Surg Am 2009; 91: 1837-1846.
[26] Ross M, Allen L and Couzens GB. Correction of residual radial translation of the distal fragment in distal radius fracture open reduction. J Hand Surg Am 2015; 40: 2465-2470.
[27] Saw N, Roberts C, Cutbush K, Hodder M, Couzens G and Ross M. Early experience with the TriMed fragment-specific fracture fixation system in intraarticular distal radius fractures. J Hand Surg Eur Vol 2008; 33: 53-58.
[28] Rapley JH, Kearny JP, Schrayer A and Viegas SF. Ulnar translation, a commonly overlooked, unrecognized deformity of distal radius fractures: techniques to correct the malalignment. Tech Hand Up Extrem Surg 2008; 12: 166-169.
[29] Senehi R, Luo TD, Marquez-Lara A, Aneja A, Beard HR and Carroll EA. Use of volar plate for indirect coronal plane reduction in an intraarticular distal radius fracture. J Orthop Trauma 2017; 31 Suppl 3: S39-S41.
[30] Eltorai AEM, Sobel AD, Thomas NP Jr, Daniels AH and Born CT. Current trends in the management of distal radius fractures. Orthopedics 2017; 40: 145-152.
[31] Tordjman D, Hinds RM, Yang SS and Capo JT. Radial shaft convergence in distal radius fractures: diagnosis and treatment. Tech Hand Up Extrem Surg 2018; 22: 19-25.