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Review Article

Recent Trends in Treatment of Malunited Fracture Distal Radius (Systematic Review)

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Abstract

The Aim of this Study: Review recent trends and different modalities as well as recent plates either locking or none locking that used in management of malunited distal radius fractures.

Methods: Online search was done using the Medline database on pubmed, google scholar and science direct from 2001to 2018; all the English language published studies will be identified with the search keywords of, malunited distal radius and treatment of malunited distal radius. Literature search database on pubmed showed 399 studies, after choosing English language, excluding other topics not related to search goals, excluding cadaveric studies and duplicates, and lack of functional outcome and case reports, 11 studies were included. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) flow diagram for study selection was used.

Conclusion: The volar approach and locking plate, without necessarily the use of bone grafting, is an effective technique for addressing symptomatic and severe deformities of the distal radius and should be preferred in elderly patients.

Keywords: *Distal Radius; Locking Plate; Malunion*

Introduction

The most common complication following distal radial fractures is malunion, especially when treated with closed reduction and cast immobilization [1]. Malunion occurs when a fracture heals with improper alignment, articular incongruity, incorrect length, or a combination of these elements [2].

Major complications resulting from malunion include; pain, loss of motion, radio carpal arthrosis and loss of grip strength. Median neuropathy and tendon attrition or rupture can be late sequelae [3]. Treatment of malunited distal radius is Corrective osteotomy of the distal radius with significant malalignment to restore the functional anatomy of the wrist [3].

Two types of osteotomies are offering specific advantages and disadvantages. A closing wedge osteotomy allows direct bone-to-bone contact and often need shortening the ulna to maintain the distal radio ulnar joint. Opening wedge osteotomies are more popular to restore the radial length. This technique can also correct angular deformities in both the frontal and sagittal planes [4].

Malunion involving dorsal angulation was treated with a dorsal plate, and malunion involving volar angulation typically was treated with a volar plate. Standard T-plates and screws were commonly used in both circumstances. However, the use of fixed-angle plate design and the volar application of these constructs for both volar and dorsal deformities have revolutionized plating in the distal radius [5].

Aim of the Study

The aim of this study is to review recent trends and different modalities as well as recent plates either locking or none locking that used in management of malunited distal radius fractures.

Methods

Search strategy

Online search was done using the Medline database on pubmed, google scholar and science direct from 2001to 2018; all the English language published studies will be identified with the search keywords of, malunited distal radius, treatment of malunited distal radius, osteotomy of malunited distal radius, open wedge osteotomy of malunited distal radius, volar angle fixed plate in malunited distal radius.

Literature search database on pubmed showed 399 studies. Primary screening: 295 studies were excluded due to language other than English language and other topics not related to search goals. Secondary screening: Title or abstract review 78 studies excluded due to cadaveric studies and duplicates. Tertiary screening: Full text review was done and 15 articles were excluded due to lack of functional outcome and case reports, 11 studies were included.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) flow diagram for study selection was used.

The investigated criteria included range of motion, grip strength, pain relief (VAS), and X-ray findings. The indications for corrective osteotomy were symptomatic, malunited, palmarly or dorsally displaced fractures of the distal radius rather than the degree of radiologic malposition. The preoperative patients' complaints were loss of range of motion, especially limited forearm supination, loss of grip strength, and pain, mostly on the ulnar side of the wrist, as well as cosmetic deformity.

Inclusion criteria: Studies which are included in our systematic review met the following guidelines:

(1) They provided levels I to IV evidence in one of the 3 areas of interest or more outlined previously.

(2) Human examinations and treatment.

(3) They included measures of functional and clinical outcome.

Exclusion criteria:

(1) Non English papers.

(2) Non-human trials.

(3) Articles with no clinical data.

Statistical analysis: Data was analyzed by Microsoft Office 2010 (excel) and Statistical Package for Social Science (SPSS) version 20.

Results

Our search revealed 11 studies accounting for total of 263 patients included in the final analysis. Number of males are 112 (42.6%) and females are 151 (57.4%) from 2001 to 2018. The mean age is 45.8. Dorsal deformity seen in 164 (62.4%) and volar deformity seen in 99 (37.6%) pt. with average follow up time is 30 months (Table 1 and 2).

In this review 214 were initially treated by closed reduction, 25 treated by K Wire, 4 initially treated by External Fixator, 6 by open reduction and internal fixation and 14 were neglected without any interference so the majority of malunion is seen with closed reduction (Table 3).

No	Author	No of Patients	Age (Average)	Sex	Time of Intervention (Average)	Type of Deformity	Follow up Time
1	Prommersberger K-J., *et al*. 2001	20	43y	M: 14 F: 6	22m	Dorsal: 2 Volar: 18	18m
2	Prommersberger K-J., *et al*. 2002	49	47y	M: 19 F: 30		Dorsal: 29 Volar: 20	18m
3	Wieland AWJ., *et al*. 2005	47	66y	M: 6 F: 41	4m	Dorsal: 35 Volar: 12	56m
4	Riccardo Luchetti 2004	6	50y	M: 4 F: 2		Dorsal: 6 Volar: 0	33 m
5	E. El-karef 2005	26	42y	M: 7 F: 19		Dorsal: 10 Volar: 16	54m
6	M. Mahmoud., *et al*. 2012	19	31y	M: 17 F: 2	10m	Dorsal :19 Volar: 0	18m
7	Rothenfluh., *et al*. 2013	22	45y	M: 12 F: 10		Dorsal: 8 Volar: 14	12m
8	A. Elmi, *et al*. 2014	14	42.5y	M: 12 F: 2		Dorsal: 14 Volar: 0	24m
9	Fok *et al*. 2015	12	42y	M: 5 F: 7		Dorsal: 12 Volar: 0	43m
10	Luigi Tarallo., *et al*. 2014	20	40y	M: 12 F: 8		Dorsal: 20 Volar: 0	50m
11	Kunihiro Oka., *et al*. 2018	28	55.5y	M: 4 F :24	13m	Dorsal: 9 Volar: 19	12m
Total	11 study from 2001 to 2018	263	45.8y	M:112 F:151	12m	Dorsal: 164 Volar: 99	30m

Table 1: *Showing list of papers, no of patients, time to surgery, mean follow up time and age and sex of patients, and type of deformity.*

Study	Initial ttt	Approach	Implant	Bone Graft	Immobilization Time (Average)	Healing	Time of Union	Complication	Sec Surgery
1	CR:9 KW:6 E F:2 OR:3	Radio palmar Y Shaped	-Volar T plate -Dorsal T plate	Iliac Crest	3 w	H :19 Non:1		1- Hematoma 2- TS 3- Non-Union	1- evacuation of hematoma 2- CT Release 3- Revision
2	CR:27 KW17 E F:2 OR:3	Radio palmar Y Shaped	-Volar T plate -Dorsal T plate	Iliac Crest	3 w	H :48 Non:1		1- Hematoma 2- CTS 3- Tendon irritation 4- DRUG pain	1- evacuation of hematoma 2- CT Release 3- implant removal 4- DRUG Repair

3	CR	Volar: 12 Dorsal: 35	-Volar T plate -Dorsal T plate	NO	2 w	Healed	12 w	1- CTS 2- Tendon Rupture 3- DRUG pain	1- CT Release 2- implant removal 3- DRUG Repair 4- Tendon Repair
4	CR	Dorsal	K Wire-	Hydroxyapa-tite		Healed	10 w	No	
5	CR:24 KW:2	Volar: 16 Dorsal: 10	-Volar T plate -Dorsal T plate	Iliac Crest	6 w	Healed		Temporary Radial n Neuritis	
6	CR	Volar	-Volar angle fixed plate	NO	3 w	Healed	10 w	1- Median n neuritis 2- CRPS 3- Ulnar impaction	Ulnar shortening
7	CR	Volar: 14 Dorsal: 8	-Volar angle fixed plate -D 3.5 P	Iliac Crest	2 w	Healed		1- Tendon irritation 2- Dislocation of distal fragment	1- Implant removal 2- Revision
8	Neglected	Dorsal	-Dorsal T plate	Iliac Crest	2 w	Healed	11.5 w	DRUG Pain	DRUG Repair
9	CR	Less Invasive dorsal	-Fixed angle D Nailplate	Iliac Crest	2 w	Healed	5.5 w	No	No
10	CR	Volar	-Volar angle fixed plate	No	2 w	Healed	16 w	Sensory n neuritis	No
11	CR	Volar: 19 Dorsal: 9	-Volar angle fixed plate -Dorsal Plate	-Iliac Crest (14) -Artificial bone (14)	2 w	Healed	11 w (14) pt. Delayed (14) pt.	Tendon irritation	Plate Removal

***Table2**: Showing no of study, initial treatment, Approach, Implant, bone graft, union, time of healing, immobilization time, complication, and secondary surgery.*

	Initial ttt	
	N	**%**
CR	214	81.4%
KW	25	9.5%
EF	4	1.5%
OR	6	2.3%
Neglected	14	5.3%

***Table 3:** Showing Initial data among this study.*

This means that the most common type of management complicated by malunion is closed reduction. The surgical approach was done by dorsal approach in 100 (38%) and volar approach in 82(31.2%) radio palmar approach in 69 (26.2%) and 12 pt. less invasive dorsal approach (Table 4-6).

	Approach	
	N	%
Dorsal	100	38%
Volar	82	31.2%
Radio palmar	69	26.2%
Less Invasive Dorsal	12	4.6%

Table 4: *Showing approach data among this study.*

Study	Pre-operative / Post-operative		Flexion	Extension	Pronation	Supination	Gripe Strength	VAS	Radial Dev.	Ulnar Dev.
			(Average)							
1	Pre-operative		48°	44°	73°	47°	39 kg	7	18°	22°
	Post-operative		51°	48°	79°	71°	53kg	3	25°	30°
2	Pre-operative	D	30°	40°	80°	90°	20 kg	7	20°	15°
		P	48°	40°	80°	50°	40 kg	7	15°	23°
	Post-operative	D	50°	50°	80°	90°	40 kg	2	25°	20°
		P	53°	50°	80°	75°	57 kg	3	28°	33°
3	Pre-operative	D	30°	55°	74°	59°				
		P	25°	32°	43°	21°				
	Post-operative	D	55°	77°	87°	80°				
		P	32°	72°	72°	67°				
4	Pre-operative		30°	44°	51°	65°	49 kg	8	28°	23°
	Post-operative		50°	59°	78°	79°	107 kg	1	23°	33°
5	Pre-operative	D	44°	63°	63°	32°	17 kg		13°	16°
		P	66°	44°	83°	35°	17 kg		13°	16°
	Post-operative	D	70°	76°	83°	72°	30 kg		15°	23°
		P	72°	72°	84°	67°	31 kg		16°	19°
6	Pre-operative		26°	77°	50°	23°	29 kg	4	33°	5°
	Post-operative		71°	76°	70°	57°	47 kg	.8	16°	22°
7	Pre-operative	D	54°	67°	79°	78°	.44	4.5	22°	32°
		P	55°	69°	64°	71°	.74	4.8	23°	29°
	Post-operative	D	43°	59°	70°	76°	.71	1.5	19°	34°
		P	71°	65°	75°	82°	.92	1.2	19°	36°
8	Pre-operative		40°	52°	62°	56°		7	5°	17°
	Post-operative		54°	58°	75°	77°		2	7.5°	22°
9	Pre-operative		22°	69°	64°	70°	14 Kg		18°	18°
	Post-operative		57°	65°	79°	79°			13°	30°
10	Pre-operative		44°	39°	75°	16°	10.9 Kg	1.1		
	Post-operative		60°	70°	84°	79°	26.7 Kg	.3		
11	Pre-operative	D	82°		128°		38 Kg			
		P	98°		136°		51 Kg			
	Post-operative	D	121°		158°		83 Kg			
		P	132°		162°		84 Kg			

Table 5: *Showing Clinical data among this study pre-operative and post-operative.*

P: Palmar Displacement; D: Dorsal Displacement,

Study	Pre-operative / Post-operative		Palmar Tilt (Average)	Dorsal Tilt (Average)	Radial Inclination (Average)	Ulnar Variance (Average)
1	Pre-operative		32^{o}			+8 mm
	Post-operative		11^{o}			+1 mm
2	Pre-Operative	D		22^0	14^0	4 mm
		P	32^0		18^0	8 mm
	Post-operative	D		0^0	24^0	0 mm
		P	13^0		30^0	0 mm
3	Pre-Operative	D		20^0	14.2^0	3.4 mm
		P	10.7^0		14.9^0	1.8 mm
	Post-operative	D		4^0	16.8^0	1.2 mm
		P	2.4^0		16.8^0	.1 mm
4	Pre-operative			19^0	19^0	7 mm
	Post-operative			0^0	20^0	3 mm
5	Pre-Operative	D		31^0	9^0	5 mm
		P	27^0		11^0	5 mm
	Post-operative	D		-10^0	21^0	0 mm
		P	10^0		21^0	0 mm
6	Pre-operative			37^0	10^0	4 mm
	Post-operative		4.3^0		18.9^0	0 mm
7	Pre-Operative	D		22^0	20^0	4 mm
		P	15^0		16^0	1.8 mm
	Post-operative	D		12^0	29^0	2.2 mm
		P	7^0		26^0	-.2 mm
8	Pre-operative			30^0	19^0	13 mm
	Post-operative			4^0	22^0	1 mm
9	Pre-operative			32^0	13^0	7 mm
	Post-operative		1^0		20^0	1 mm
10	Pre-operative			23^0	29^0	3.6 mm
	Post-operative		11^0		22^0	.9 mm
11	Pre-Operative	D		37^0		3.4 mm
		P	37^0			4.4 mm
	Post-operative	D		1.2^0		-.1 mm
		P	9.4^0			.4 mm

Table 6: *Showing Radiological data among this study pre-operative and post-operative.*

P: Palmar Displacement; D: Dorsal Displacement.

Bone graft done in 177 [6-16] and not done in 86 [8,11,15] comparison between this two groups postoperative there is significant increase in flexion and extension of the wrist in patients who don't used bone graft but there is no significant difference in pronation and supination between this two groups. There is no significant in gripe strength with using bone graft (64.5 kg) compared to patients without bone graft (60.8 kg) (Table 7-10).

Number of patients	Bone Graft	Healing	Time of Union	Flexion (Average)		Extension (Average)	Pronation (Average)	Supination (Average)	Gripe Strength (Average)	VAS (Average)
177	Yes	175 H 2 Non	9.5 w	Pre	41.6°	51.9°	67.5°	60.2°	35.9 kg	6.7
				Post	56.6°	59.9°	78.3°	77.1°	64.5 kg	1.9
86	No	86 H	13 w	Pre	30.8°	53.1°	59.5°	26.3°	30.9 kg	2.5
				Post	61.5°	73.5°	77.8°	77.8°	60.8 kg	0.5

Table 7: *Showing comparison between using bone graft or not pre-operative and post-operative among this study.*

	Using Bone Graft (N = 177)	Without Bone Graft (N = 86)	Chi-Square	
	Mean ± S.D	Mean ± S.D	T	P Value
Flexion	56.6 ± 15.47	61.5 ± 13.57	18	0.002
Extension	59.9 ± 17.11	73.5 ± 16.64	25	0.000
Pronation	78.3 ± 21.37	77.8 ± 17.28	2.11	0.1295
Supination	77.1 ± 20.26	77.8 ± 17.28	1.01	0.8414

Table 8: *Comparison between using bone graft and without bone graft.*

P < 0.05: Significant. P > 0.05: Not Significant.

	Using Bone Graft (N = 177)	Without Bone Graft (N = 86)	Chi-Square	
	Mean ± S.D	Mean ± S.D	t	P Value
Gripe Strength (kg)	64.5 ± 18.14	60.8 ± 9.21	3	0.154

Table 9: *Comparison between using bone graft and without bone graft in Gripe strength.*

P < 0.05: Significant. P > 0.05: Not Significant.

	VAS	Chi-Square	
		T	P Value
Using Bone Graft (X10)	1.9	3.43	0.032
Without Bone Graft (X10)	0.5		

Table 10: *Comparison between using bone graft and without bone graft in VAS.*

P < 0.05: Significant. P > 0.05: Not Significant.

Analysis of VAS there was significant decrease in vas (.5) without using bone graft compared to patients with bone graft (1.9) 66 pt. has palmar displaced malunited distal radius and fixed by volar T plate, 119 pt. has dorsal displacement and fixed by dorsal T plate, volar fixed angle plate is used in palmar and dorsal displaced malunited distal radius in 72 pt (Table 11).

Implant	No of patients	Palmar Tilt (Average)		Dorsal Tilt (Average)	Radial Inclination (Average)	Ulnar Variance (Average)
Conventional Volar T Plate	66	Pre	25.4°		14.6°	5.7 mm
		Post	7.1°		22.6°	.5 mm
Dorsal T Plate	107	Pre		27°	15.2°	5.4 mm
		Post		3.7°	22.5°	.7 mm
Volar Angle Fixed Plate	72	Pre	23.5°	30°	18.3°	3.4 mm
		Post	9.2°	-7.6°	23.7°	.5 mm
Fixed angle Dorsal Nail plate	12	Pre		32°	13°	7 mm
		Post	1°		20°	1 mm
K Wire	6	Pre		19°	19°	7 mm
		Post		0°	20°	3 mm

***Table 11:** Comparison between implants used among this study.*

Cases with palmary displaced deformity managed by volar approach and open wedge osteotomy and fixed by conventional volar T plate seen in 4 studies [6-8,10]. Radiological Finding post-operative improved, The mean palmar tilt is 7.1^{0}, radial inclination is 22.6°, ulnar variance .5 mm. Cases with dorsally displaced deformity managed through dorsal Approach and open wedge osteotomy and fixed with dorsal plate is seen in 7 studies [6-8,10,13,16]. Radiological Finding post-operative improved. The mean dorsal tilt is 1.3^{0}; radial inclination is 22.5^{0}, ulnar variance .7 mm. The recent studies (4 studies) [11,12,15,16] used Volar Angle Fixed Plate in dorsal or palmar displacement through volar approach and open wedge osteotomy and post-operative radiological parameters is excellent and more significant than conventional or dorsal plate (Table 12). The mean palmar tilt in volar group is 9.2^{0}, the mean Dorsal tilt in dorsal group is -7.6^{0}, radial inclination is 23.7^{0}, ulnar variance +. 5 mm (Table 12).

	Conventional Volar (N = 66)	Dorsal T plate (N = 119)	Volar angle fixed plate (N = 72)	Chi-Square	
	Mean ± S.D	Mean ± S.D	Mean ± S.D	T	P Value
Palmar Tilt	7.1 ± 2.46	1.3 ± 0.31	9.2 ± 2.42	15	0.041

***Table 12:** Comparison between conventional volar, dorsal and volar angle fixed plate in palmar tilt in postoperative.*

P < 0.05: Significant. P > 0.05: Not Significant.

This table shows that there is significant increase in palmar tilt in volar fixed angle plate compared to conventional volar and dorsal plate (Table 13).

	Dorsal T plate (N = 119)	Volar angle fixed plate (N = 72)	Chi-Square	
	Mean ± S.D	Mean ± S.D	T	P Value
Dorsal Tilt	1.3 ± 0.35	-7.6 ± 2.14	24	0.001

***Table 13:** Comparison between dorsal and volar angle fixed plate in dorsal tilt in postoperative in postoperative.*

P < 0.05: Significant. P > 0.05: Not Significant.

There is no significant in radial inclination in correction by conventional volar plate compared to dorsal and volar angle fixed plate, and no significant in ulnar variance in conventional volar compared to dorsal and volar angle fixed plate (Table 14 and 15).

	Conventional Volar (N = 66)	Dorsal T plate (N = 119)	Volar angle fixed plate (N=72)	Chi-Square	
	Mean ± S.D	Mean ± S.D	Mean ± S.D	T	P Value
Radial Inclination	22.6 ± 5.38	22.5 ± 5.37	23.7 ± 5.31	1	0.546

Table 14: *Comparison between conventional volar, dorsal and volar angle fixed plate in radial inclination in postoperative.*

P < 0.05: Significant. P > 0.05: Not Significant.

	Chi-Square	Volar angle fixed plate (N = 72)	Dorsal T plate (N = 119)	Conventional Volar (N = 66)	
	Mean ± S.D	Mean ± S.D	Mean ± S.D	T	P Value
Ulnar Variance (mm)	0.5 ± 0.15	.7 ± 0.48	0.5 ± 0.16	1	0.341

Table 15: *Comparison between conventional volar, dorsal and volar angle fixed plate in ulnar variance in postoperative.*

P < 0.05: Significant. P > 0.05: Not Significant.

Discussion

This review show that the majority of patients with malunited distal radius occur in females more than males (112 M 151 F) that may be due to menopause and osteoporosis [3].

The initial treatment of fracture distal radius is also play an important role in malunion such as closed reduction with casting which represent more than 81% of the total cases included in this study but open reduction and internal fixation of fracture distal radius is rarely lead to malunion [6,7]. Neglection to fracture distal radius without management is also lead to malunion [13], so closed reduction in fracture distal radius according to this review is often lead to malunion [1].

Dorsal deformity of malunited fracture distal radius is the majority of cases in this study which represent more than 62% but palmar displacement represent 37%. Many studies have demonstrated that corrective osteotomy which restores anatomical configuration can effect an improvement in wrist function, forearm rotation, grip strength and pain [17].

Corrective osteotomy using dorsal plates and dorsal approach had been performed for malunited distal radius with dorsal displacement. However, a high incidence of plate removal has been reported because of painful hardware, tendon rupture [18].

According to this review volar approach is more easier and popular due it's minor complication than dorsal approach and can be used in volar or dorsal displacement of malunited fracture distal radius by volar angle fixed plate. Moreover, a volar approach is easier than a dorsal approach and the reduction of the volar cortex is simple because of less comminution and the advantage of direct vision [16].

Several surgical techniques have been described for the correction of the distal radial deformity, including closed or open wedge osteotomy. A closing wedge osteotomy allows direct bone-to-bone contact and offers more stability, preventing the need for bone grafting as well as the potential for nonunion. However, this technique can cause the distal radius to become shortened relative to the ulna and often paired with shortening the ulna to maintain the distal radio ulnar joint. Opening wedge osteotomies are more popular because they restore the radial length preventing the need for a distal ulna procedure. This technique can also correct angular deformities in both the frontal and sagittal planes. The disadvantage of opening wedge osteotomies is the risk of increased instability of the construct before it has healed completely [4].

In this review, open wedge osteotomy and plate fixation with bone grafting is considered the majority (177 pt.) [6,7], because the distal radius is usually shortened and/or angulated. Open wedge osteotomy effectively restores the length of the radius. Bone grafts or bone graft substitutes are used to fill this void, based on the concept that they create better structural stability and optimal substance for bone formation. Autogenous bone grafts from the iliac crest are used in most cases. However, the use of bone grafts can lead to donor site morbidity, delayed union at bone-graft interfaces, and additional operation time. The main advantages of bone graft substitutes are shortening the surgical time and decreased iliac crest morbidity [19].

Corrective osteotomy and plate fixation of the malunited distal radius fracture with the use of bone grafts has been extensively described in the review (8 studies) [6-9,12-14,16]. A 3 studies [8,11,15] have evaluated bone healing after corrective osteotomy and plate fixation without bone grafting. None of these studies reported healing problems. However, healing occur within 9.5 w with bone graft and 13 w without bone graft. Healing not occurred in 2 cases with bone graft but all cases without bone graft was healed. Clinical outcomes postoperative of the wrist improved in cases without bone graft significant than with bone graft. Pronation and supination has no significant difference. Grip strength has no significant difference, Visual Analogue scale for pain (VAS) decreased without bone graft to reached 0.5, while with bone graft VAS reached 1.9.

Conventional volar plate which used in many studies in this review used only with palmar displacement through volar approach and the postoperative radiological parameters is significant but this plate can't be used with dorsal displacement [7]. Dorsal plate through dorsal approach in cases with dorsal displacement and the postoperative radiological parameters is significant but extensor tendon irritation and painful hardware is common [7].

Studies which used Volar Angle Fixed Plate is better as it used in cases of volar or dorsal displacement through volar approach and had postoperative radiological parameters is significant more than conventional volar and dorsal plate [11].

This corrective osteotomy using a volar locking plate through volar approach without the use of bone grafting could effectively produce a significant improvement in wrist function, gripe strength, VAS. This review obtained an excellent correction of deformity based on radiographic parameters, with low morbidity and no nonunion, hardware failure or need for hardware removal [15].

The use of fixed-angle locking plates reduces the risk of postoperative bone displacement, and requires a shorter immobilization time, Moreover, the mechanical strength provided by this construct does not necessarily require the use of bone grafting.

Conclusion

The volar approach and locking plate, without necessarily the use of bone grafting, is an effective technique for addressing symptomatic and even severe deformities of the distal radius, and should be preferred especially in elderly patients with poor bone quality and with increased medical co-morbidities that may contraindicate the harvesting procedure, due to the longer operative time and the higher risks of bleeding and infection.

Disclosure

None of the authors or my institution at any time received payment or services (from governmental, commercial, private foundations, etc.) for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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