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ORIGINAL ARTICLE

Comparative Study of Different Fixation Techniques in Distal Radius Fractures: A Systematic Review and Meta-analysis

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ABSTRACT
Objective: This systematic review compared results of nonsurgical and surgical distal radius fracture therapy.
Methods: A thorough search of the literature was carried out utilizing a number of databases, such as Medline, Embase, and Cochrane. Using the following Boolean operators, all databases were searched from the records of 2012-2023: distal radius fracture, conservative therapy, nonoperative treatment, surgical treatment, and operative. In order to compare the functional results of the surgical and nonsurgical groups, we collected all prospective and retrospective controlled studies.
Results: From the available research, seven were prospective studies and seven were comparative retrospectives. We enrolled a total of 1310 patients; 655 were assigned to the nonsurgical group and 655 to the surgical group. In terms of DASH, grip strength, and the majority of other functional evaluations, the two therapy modalities had comparable outcomes. Rang of wrist flexion, ulnar variance, radial length, and radial inclination were all significantly different.
Conclusion: According to this meta-analysis, compared to nonsurgical treatment, surgical treatment for distal radius fractures reduced the DASH score and increased the range of wrist supination and pronation in certain patients. This meta-analysis lends credence to the idea that distal radius fracture surgery may be the best option for certain individuals.
Keywords: Distal radius fracture; Meta-analysis; Nonsurgical; Surgical

INTRODUCTION
Distal radius fractures (DRFs) are the most common orthopedic injuries and can cause wrist joint disability[1]. However, the current literature on the optimal management is more controversial. Over the past two decades, several surgical procedures have contributed to improved fracture stability, including external fixation, intramedullary fixation, open reduction internal fixation (ORIF) techniques, as well as arthroscopic assisted reduction and fixation[2–12]. Recent studies[13, 14] reported that there was insufficient evidence to determine when to perform surgery, what type of surgery is best, and what nonsurgical treatment is best for the treatment of DRFs.

One possible surgical treatment method is bridging external fixation. This technique relies on ligament taxis to obtain and maintain fracture alignment[6]. However, since the introduction of locking plates, open reduction and internal fixation (ORIF) has become increasingly popular in surgical reduction[7]. This technique provides immediate stable fixation that allows early mobilization[5, 8] and may result in a more rapid recovery and improved regain of function[9]. Conversely, bridging external fixation augmented (with or without additional Kirschner wires) is a less demanding, less invasive and faster procedure. Excellent results have been described for both techniques[10–15]. However, no conclusive evidence has been published favoring ORIF with a volar locking plate over bridging external fixation or vice versa[16].

A conducted a meta-analysis of studies published between 1980 and 2004[4] on external and internal fixation of distal radial fractures. They concluded there was not sufficient evidence to support the use of ORIF over external fixation. However, outcome data from a large variety of different techniques of internal fixation were pooled. Studies on both locking and no locking implants were included resulting in considerable heterogeneity across studies[11]. More recently, study performed a similar meta-analysis comparing functional outcome at 1 year in patients with unstable distal radius fractures. The authors pooled data from 12 randomized and nonrandomized trials on seven different techniques of internal fixation. A secondary subgroup analysis of four studies for volar locking plates revealed a significant difference on the disabilities of the arm shoulder and hand (DASH) score in favor of this technique. Unfortunately, exact DASH scores could not be reported, and therefore, clinical relevance of these differences is difficult to evaluate[18]. Moreover, this analysis included one retrospective study[19] and one trial that compared volar locking plates with closed reduction and percutaneous pinning[20]. The authors emphasized that their results were tempered by a substantial heterogeneity present across studies[17]. However, their significant findings justify further examination regarding the benefits of volar locking plates.

Recent studies on ORIF with volar locking plate have described most benefit in the early postoperative period[21,22].

Several randomized studies were designed to assess the outcome of VLP versus EF for distal radius fracture cases[10,11]. A meta-analysis[12] aimed to assess EF versus VLP in unstable fractures of distal radial concluded that cases treated with a VLP could obtain better functional outcomes. Another meta-analysis by Zhang et al.[13] reported a drastically opposing conclusion that the two methods had similar functional recovery. However, limited by the smaller sample sizes of the included studies, the two meta-analyses could not report more stratified analyses and could not conclude with more details. Very recently, several randomized controlled trials (RCTs)[14-17] addressing this topic provided new evidence, making it possible to update the results concerning this topic with powerful convincing.

The purpose of this study was to perform a systematic review and meta-analysis comparing the outcomes of surgical and nonsurgical management of DRFs.

MATERIALS AND METHODS
Using well-known electronic databases such as Medline, Embase, and Cochrane, we searched for relevant publications from 2012 to 2023. We followed the guidelines laid out by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[18] and searched prospective papers using the following keywords: "distal radius fracture, conservative therapy, nonoperative treatment, surgical treatment, and operative" all together and separately. Finding reviews and research that addressed the same or similar issues was the purpose of looking

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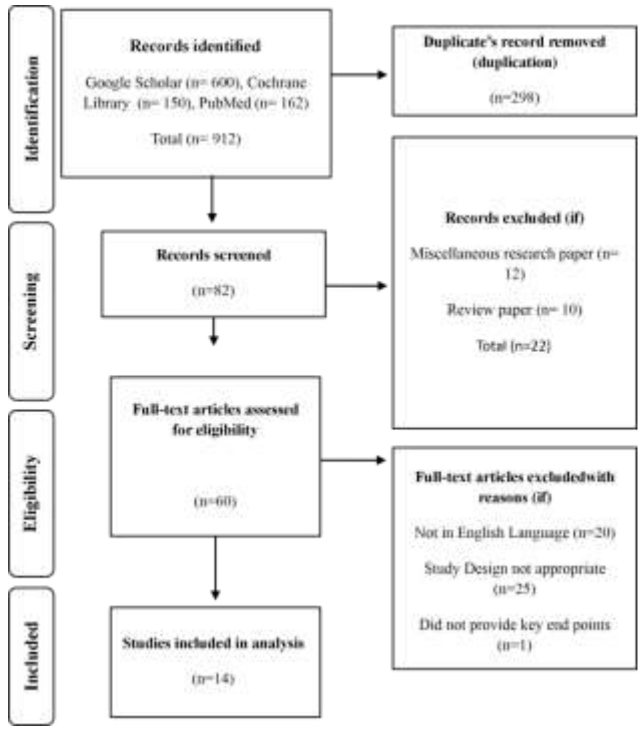
for additional relevant publications. Google Scholar was also used to look for possible studies. Articles that met these criteria were considered for inclusion: (1) RCTs that sought to compare VLP and EF outcomes in unstable distal radius fractures; (2) studies included cases with a confirmed diagnosis of the fracture; (3) studies reported functional outcomes; (4) studies allowed for data extraction on participant characteristics; (5) studies were published in English; and (6) when overlapping samples included multiple populations, the articles with the most results were selected. We excluded case reports, letters, brief reports, communications, reviews, studies without a random assignment, studies involving non-human participants, and publications in languages other than English.

Furthermore, the following criteria were used to classify distal radius fractures as unstable: [12] repositioning of fracture pieces following closed reduction and cast immobilization; or additional subluxation, presence of an intra-articular fracture, accompanying ulnar styloid fracture, age greater than 60 years, or presence of dorsal comminution. Problems were categorized as minor if they were transient or did not impair the ultimate degree of function, and as serious if they required surgery, caused persistent nerve damage, or regularly reduced function.
All of the papers that were originally pulled from the databases were examined separately by two scholars. Separately, the same two researchers used a consistent methodology to collect all pertinent data and information. It was brought up with a second reviewer to be resolved when a consensus failed to address a data discrepancy. Article facts (including first author, publication year, and study design), participant details (including age, sex, and sample size), therapy specifics (including VLP and EF), and outcome details were gathered for every research that was examined. To determine the possibility of bias, the Cochrane Collaboration utilized its Risk of Bias tool [19] for each study. We followed the guidelines and ranked the potential for bias in each study from lowest to greatest. The whole evaluation included the following seven points: First, creating the sequence; second, concealing the allocation; third, blinding participants; fourth, blinding outcomes; fifth, insufficient evaluation of findings; sixth, incomplete data; and seventh, additional biases. Because not enough data was available, we cannot say with certainty whether the relevant items were biased or not.

Each of the two reviewers—whose names are up there—ran their own evaluation of the evidence using the Jadad scale [20]. Study quality in terms of random participant selection, group blinding, and individual participant accountability are the three dimensions upon which the Jadad scale is based. A study can get a score between zero and five on each of these criteria. A "yes" response for the "accountability" item would get one star, while a "yes" for the "randomization" and "blinding" items would earn two stars. In order to choose which papers to include in our meta-analysis, we looked for quality ratings of one or two stars [21]. When combining discrete variables like the number of complications in each group, the relevant 95% confidence interval (CI) and the risk ratio (RR) were utilized. Utilizing mean difference (MD) and 95% CI, we were able to integrate continuous variables such as wrist range of motion (WRM), etc. We used a random model to apply an inverse variance approach to all of the pooled variables. The heterogeneity of each analysis was assessed with the use of the I2 statistic. For every analytical technique, there were three levels of heterogeneity: low (I2 < 25%), moderate (I2 25-50%), and high (I2 > 50%) [22]. When the value of I2 was 50% or below, the studies were removed from the analysis in a consecutive fashion. Researchers employed Egger's weighted regression method [24] and Begg's rank correlation [23] to evaluate possible publishing biases. Results and participant characteristics from each group were used to guide the subsequent stratified analyses. Cochrane Collaboration software (version 5.2) from Oxford, UK was used to finish pooling processes and forest plots. A publishing bias assessment was conducted using Stata 15.1 (Stata Corporation, College Station, TX, USA). For every analysis, a p-value below 0.05 was deemed statistically significant.

RESULTS

Ultimately, 912 articles were included after the initial search in the electronic datasets, among which 298 were removed due to duplication. Most of the remaining articles were removed by reading the titles or abstracts. Finally, 14 [1-14] studies were included in the current study by browsing 82 full-text manuscripts. The flow chart for the literature selection process can be found in (Fig.1). 14



The study comprised fourteen trials that provided DASH scores. When all thirteen studies' data were combined, a significant amount of heterogeneity was found (I2 = 69%). The results demonstrated that surgical therapy significantly reduced DASH score compared to the nonsurgical group. (WMD 3.98, 95% CI 2.00 to 5.95,P<0.001 Table 2).

There were fourteen studies that looked at grip strength. While seven of the papers utilized kilograms as their research indicator unit, the other seven utilized percentages. Due to the high degree of heterogeneity among the studies (I2=60.83%), a random-effects model was employed in papers where the grip strength was reported in kilograms. The surgical and nonsurgical groups were very similar. WMD → 1.83 (95% CI -3.77 to 0.10), P = 0.06, Table 2. Studies that represented grip strength as a percentage used a random-effects model, and the test for heterogeneity found significant findings (Λ2 = 88.35%). After the procedure, the two groups were significantly different from one another. In Table 2, with a 95% confidence interval of -11.61 to -1.60 and a p-value of less than 0.01. Nine studies were subjected to radial deviation analysis. A random-effects model was used to combine the results of nine trials, and a considerable amount of heterogeneity was discovered (Λ2 = 96.66%). No significant difference was seen between the nonsurgical and surgical groups (WMD − 2.85, 95% CI -7.69 to 2.00, P = 0.25, Table 2). The radial inclination study took into account eleven studies. When a random-effects model was applied to the pooled data from 10 trials, a significant amount of variance was seen (Λ2 = 86.12%). There was a significant difference in radial inclination between the surgical and nonsurgical groups across all ten trials. In Table 2, (WMD −…3.31, 95% CI -4.47 to -2.15, P < 0.001). A total of three studies made up the radial length analysis. Significant heterogeneity (Λ2 = 65.51%) was found when data from the three studies were pooled and analyzed using a random-effects model.

Table 1: displays the demographic information of the patients included in all 13 trials.

No.	Author and publication date	Study design	Sample size	Treatment		Mean age(years)		follow-up(m)	No.	Author and publication date	Study design	Sample size	Treatment		Mean age(years)		follow-up(m)
1	Martinez-Mendez. 2018	RCT	97	47	50	70 ± 7	67 ± 8	29	2	Martinez-Mendez. 2019	RCT	17.6667	-5.8333	-29.333	70 ± 8	67 ± 9	29
2	Mulders. 2019	RCT	95	44	48	60	59	12	3	Mulders. 2020	RCT	18.2	8.4	-1.4	-11.2	-21	-30.8
3	Simiö.2019	RCT	80	42	38	64	62	24	4	Simiö.2020	RCT	32.2667	26.7238	21.181	15.6381	10.0952	4.55238
4	Wong.2010	RCT	60	30	30	71	70	N-S19; S20	6	Wong.2011	RCT	70.5	76.6	82.7	88.8	94.9	N-S19; S21
5	Sharma. 2014	RCT	66	32	32	48.10 ± 10.30	52.39 ± 9.05	24	7	Sharma. 2015	RCT	10.6667	-5.3333	-21.333	48.10 ± 10.31	52.39 ± 9.06	25
6	Bartl.2014	RCT	149	81	68	74.4 ± 7.1	75.3 ± 6.7	-	8	Bartl.2015	RCT	18.3333	-22.167	-62.667	74.4 ± 7.2	75.3 ± 6.8	-
7	Rikke Thorninger.2022	RCT	85	42	43	74	75	12	9	Rikke Thorninger.2023	RCT	31.6667	24.9524	18.2381	11.5238	4.80952	-1.9048
8	Hanna Südow.2022	RCT	66	33	33	76 ± 4.75	78 ± 5	36	10	Hanna Südow.2023	RCT	11	-5.5	-22	76 ± 4.76	78 ± 6	36
9	Jenny Saving.2019	RCT	119	63	56	78 ± 7	80 ± 5	12	12	Jenny Saving.2020	RCT	16.3333	-15.167	-46.667	78 ± 8	80 ± 6	12
10	C.A. Selles.2021	RCT	90	46	44	59 ± 10.37	62 ± 12.59	12	13	C.A. Selles.2022	RCT	14	-9	-32	59 ± 10.38	62 ± 12.60	12
11	S. S. Hasselland.2021	RCT	100	50	50	73.9 ± 5.75	73.4 ± 6.5	12	14	S. S. Hasselland.2022	RCT	16.6667	-8.3333	-33.333	73.9 ± 5.76	73.4 ± 6.6	12
12	Mohammad Dehghani.2022	RCT	50	25	25	33.72 ± 6.74	37.68 ± 9.18	24	15	Mohammad Dehghani.2023	RCT	8.33333	-4.1667	-16.667	33.72 ± 6.75	37.68 ± 9.19	24
13	Muhammad Tahir.2021	RCT	159	72	87	81 ± 2	81 ± 3	12	16	Muhammad Tahir.2022	RCT	34	-2	-38	81 ± 4	81 ± 5	12
14	Kevin C. Chung.2021	RCT	94	44	50	74.3 ± 10.6	67.1 ± 6.3	24	17	Kevin C. Chung.2021	RCT	18.6667	-3.3333	-25.333	74.3 ± 10.6	67.1 ± 6.4	24

A significantly lower radial length was seen in the nonsurgical group compared to the surgical group (WMD − 2.67, 95% CI -3.58 to -1.77, P < 0.001, Table 2). Analyses of ulnar deviations included nine studies. There was a notable amount of heterogeneity (Λ2 = 94.01%) found when the data from the nine trials were combined using a random-effects model. Significant differences were not seen between the nonsurgical and surgical groups in Table 2 (WMD − 2.31, 95% CI -5.72 to 1.11, P = 0.19). Seven studies made up the ulnar variance analysis. A random-effects model was employed due to the data indicating substantial heterogeneity (Λ2 = 96.12%). The results from the groups that had surgery and those that did not demonstrate no statistically significant difference (WMD0.35, 95% CI -1.08 to 1.79, P = 0.63), as shown in Table 2. Two studies are part of the analysis of volar titles. When the data from both studies were combined, no significant heterogeneity was found (Λ2 = 0%). The nonsurgical group had much less vertex tilt than the surgery group. Here is the data from Table 2: (WMD −–3.21, 95% CI -3.61 to -2.82, P < 0.001). The investigation of the wrist supination range included twelve trials. A random-effects model was used since the findings demonstrated a high level of heterogeneity (Λ2 = 86.62%). The range of wrist supination was significantly different between the individuals that underwent surgery and those that did not. (Appearance in Table 2: Weighted mean difference -3.10, 95% confidence range -5.27 to -0.92, p = 0.01). The range of wrist pronation was determined in twelve trials for the research. A random-effects model was employed because of the considerable heterogeneity (˙Υ2 = 70.74%). The surgical group had a substantially wider range of wrist pronation than the non-surgical group. Here is the data from Table 2: with a 95% confidence interval of -3.01 to -0.22 and a p-value of less than 0.02. Nine studies examined the extent to which the wrist could be extended. There was no noticeable variance (Λ2 = 23.76%) when the outcomes of all nine trials were pooled. The surgical and nonsurgical groups were very similar. (95% CI -1.37 to1.45, P = 0.96, Table 2), with a means of WMD0.04. We considered eleven papers for the range of wrist flexion analysis. Because of the notable heterogeneity (Λ2 = 83.33%), a random-effects model was employed. The surgical and nonsurgical groups were very similar. (Table 2) has the results (Ward-Mean-Depth (WMD) → 2.88, 95% CI -6.26 to 0.49, P = 0.09).

In a funnel plot, the combined effect size (OR) is shown by the vertical line. In a perfect world, the studies would be inverted funnel-shaped, with the 95% confidence interval line on each diagonal and studies uniformly dispersed along the vertical axis. We performed the egger test (Table 3) to account for the subjective nature of funnel plot results; all studies, with the exception of the DASH score and the supination study, did not exhibit publication bias. We performed sensitivity analysis of all trials using the leave-one-out approach to confirm that the DASH score and the supination outcome were stable. The results showed no change, indicating that our study was solid.

Table-2: The outcome of a comprehensive review

Group	N	WMD (95%CI)	WMB	P Value
DASH(points)		13	3.98(2.00,5.95)	< 0.001
	≥ 65	8	3.79(0.91,6.68)	
	< 65	5	4.45(2.24,6.84)	
Grip strength (%)		7	-6.60(-11.61,-1.60)	0.01
	≥ 65	6	-4.39(-8.65,-0.14)	
	< 65	1	-16.88(-19.04,-14.72)	
Grip strength (kg)		7	-1.83(-3.77,0.10)	0.06
	≥ 65	3	-0.84(-3.73,2.04)	
	< 65	4	-2.55(-5.21,0.11)	
Radial deviation(°)		9	-2.85(-7.69,2.00)	0.25
	≥ 65	4	1.31(0.01,2.61)	
	< 65	5	-6.33(-13.96,1.30)	
Radial inclination(°)		10	-3.31(-4.47,-2.15)	< 0.001
	≥ 65	7	-3.95(-5.44,-2.46)	
	< 65	3	-2.12(-3.39,-0.84)	
Radial length(mm)		3	-2.67(-3.58,-1.77)	< 0.001
Ulnar deviation(°)		9	-2.31(-5.72,1.11)	0.19
	≥ 65	4	-1.58(-3.89,0.74)	
	< 65	5	-2.87(-8.91,3.17)	
Ulnar variance(mm)		7	0.35(-1.08,1.79)	0.63
	≥ 65	6	0.63(-0.94,2.20)	
	< 65	1	-1.30(-2.13,-0.47)	
Volar title(°)		2	-3.21(-3.61,-2.82)	< 0.001
Range of wrist supination(°)		12	-3.10(-5.27,-0.92)	0.01
	≥ 65	7	-2.64(-5.97,0.70)	
	< 65	5	-3.86(-6.68,-1.03)	
Range of wrist pronation(°)		11	-1.62(-3.01,-0.22)	0.02
	≥ 65	7	-1.94(-4.52,0.64)	
	< 65	4	-1.80(-3.49,-0.11)	
Range of wrist extension(°)		9	0.04(-1.37,1.45)	0.96
	≥ 65	7	0.82(-0.53,2.17)	
	< 65	2	-2.55(-6.37,1.27)	
Range of wrist flexion(°)		11	-2.88(-6.26,0.49)	0.09

Table-3: A systematic review and meta-analysis comparing non-surgical and surgical approaches to treating distal radius fractures (Egger's test)

Variables	t	P
DASH score	4.43	0.001
Radial inclination	-1.12	0.296
Range of wrist pronation	-2.1	0.065
Range of wrist supination	-3.68	0.004
Range of wrist flexion	-0.77	0.461

DISCUSSION

This meta-analysis aimed to compare the functional and radiological outcomes of surgical and non-surgical treatments for distal radius fractures. Significant variations in DASH score, radial inclination, radial length, volar title, range of wrist pronation, range of wrist supination, and range of wrist flexion were seen in the surgical therapy group, indicating better wrist function. The current literature is more divided on how to treat distal radial fractures. Over the last 20 years, open reduction and volar plate fixing have grown in popularity[22]. Because of the maintenance of the reducing impact and improved DASH scores, Beharrie et al. proposed ORIF for elderly patients with distal radial fractures[23]. In their study, Kamano et al.[24] examined the use of lateral plating on 33 patients who had distal radius fractures that had displaced. On the 12-point scale developed by Gartland and Werley, the results varied from excellent to outstanding (nighty-7). According to the Physical Activity Scale and the PRWE score, 90% of the twenty patients who underwent ORIF and palmar locking plate treatment for distal radius fractures had excellent to good results[25]. Young et al.[26] evaluated the function and radiological results of twenty-five patients who had non-surgical treatment for displaced distal radius fractures. Based on the functional evaluation, it is evident that non-surgical therapy yields satisfactory outcomes; 22 patients (88%) had excellent or good results, whereas 3 (12%) had fair or poor results. There has been mixed evidence from studies that compared the efficacy of surgical and non-surgical methods for treating distal radial fractures. Martinez-Mendez et al.[27] compared the efficacy of conservative and surgical approaches to treating intra-articular distal radius fractures in elderly individuals. After 2 years of follow-up, there was a noticeable improvement in functional performance and quality of life when comparing volar plating fixation to conservative treatment. Surgical plating is more effective than conservative treatment for individuals with distal radius fractures, according to their findings. According to Bartl et al.[28], functional outcomes at 12 months were similar for 149 patients who had ORIF compared to plaster immobilization. It was also determined that primary nonsurgical treatment might be effective in certain instances. Arora et al.[29] could not find a difference in range of motion, pain level, PRWE, or DASH ratings between the surgical and non-surgical therapy groups at the twelve-month follow-up evaluation. There have been several meta-analyses published that compare surgical and non-surgical therapies. For unstable DRFs, Cui et al. discovered that open internal fixation was superior to external fixation in terms of surgical complications, clinical results, and radiological outcomes[30]. According to previous studies that compared ORIF with internal fixation for DRFs, the latter yielded better measures for follow-up outcomes[30]. Based on the data, surgical treatment for DRFs could not lead to better clinical outcomes. Between 22 and 25, Ju et al. examined 8 studies with 449 control subjects and 440 surgery patients. They determined that surgical and nonsurgical methods of treating DRFS provide similar results. Twelve hundred and seventy-eight participants from thirteen RCTs made up this meta-analysis, which compared the DASH scores. A statistically significant reduction in DASH score was seen in the surgical treatment groups. Along with it, there was no noticeable improvement in grip strength after surgical treatment. Comparing the surgical group to the non-surgical group, radiographic data showed significantly increased levels of radial inclination, radial length, and volar tilt. However, there was no change in radial deviation, ulnar deviation, or ulnar variance. Consistent with what Chen et al.[8] found, when comparing the groups who received surgery vs those that did not, there was no noticeable difference in the wrist range of motion. Nevertheless, there was a little difference in the amount of twisting ability between the two treatments. According to the age stratification component of this research, the surgical procedure improved radial inclination and lowered DASH and radial deviation for patients 65 and up compared to the non-surgical way. For patients younger than 65 years old, the surgical approach had several advantages over the non-surgical one. For example, it increased the range of motion for the wrist in supination, pronation, and flexion, decreased the DASH score, and improved radial inclination and ulnar variation. Therefore, we strongly believe that patients with distal radius fractures should seek surgical intervention as soon as possible. An important advantage of this meta-analysis is that all of the included publications were prospective RCTs. However, the following study limitations should be considered: Research on surgical treatments for distal radius fractures is limited, and it is possible that some of the included studies omitted information on surgical or non-operative management-related problems. Extensor and flexor tendon injuries, attritional tendon injuries, non-union, malunion, peri-implant fracture, symptomatic hardware, infection, and other problems are possible. There was a lack of consistency in the length of follow-up and a small number of research that fulfilled the inclusion criteria. (4) It is not possible to include some unpublished data and studies in this study. In order to overcome these limitations, future research should be structured differently. Surgical surgery improved grip strength and DASH scores compared to nonsurgical therapies for distal radius fractures, according to this meta-analysis. Based on the results of this meta-analysis, distal radius fracture surgery might be the way to go for certain people. More meta-analyses of individual patient data and randomized controlled trials are required to acquire more precise results.

CONCLUSION

According to this meta-analysis, compared to nonsurgical treatment, surgical treatment for distal radius fractures reduced the DASH score and increased the range of wrist supination and pronation in certain patients. This meta-analysis lends credence to the idea that distal radius fracture surgery may be the best option for certain individuals.

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