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Volar plate fixation *vs.* non-operative management for distal radius fractures in older adults: a meta-analysis

Y.-X. ZHANG[1], C. LI[1], S.-W. WANG[1], M.-L. ZHANG[2], H.-W. ZHANG[1]

[1]Department of Orthopedics, Zaozhuang Hospital of Traditional Chinese Medicine, Zaozhuang, Shandong Province, P.R. China
[2]Department of Acupuncture, Zaozhuang Hospital of Traditional Chinese Medicine, Zaozhuang, Shandong Province, P.R. China

Abstract. – OBJECTIVE: The aim of the study was to perform a systematic literature search and conduct a meta-analysis of studies comparing clinical and functional outcomes of open reduction with internal fixation (ORIF) using a volar plate and closed reduction with casting for distal radius fracture in older adults (≥60 years of age).

MATERIALS AND METHODS: A comprehensive electronic search was done for PubMed, Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Google scholar databases. Only randomized controlled trials (RCTs) comparing the two treatment modalities for functional and clinical outcomes were eligible to be included.

RESULTS: A total of 5 RCTs were included. The pooled estimates suggested reduced DASH scores (WMD 5.62; 95% CI, -8.55, -2.69) and improved grip strength [Grip strength compared to the contralateral side (%): WMD 13.07; 95% CI, 6.11, 20.02] in subjects receiving ORIF with volar plating. There were no significant differences in the range of motion of the wrist joint, pain scores, and rates of complications between the two treatment modalities. The overall quality of the included studies was moderate.

CONCLUSIONS: Our study indicates that older adults treated with volar plating for fracture of distal radius have better DASH scores and improved grip strengths. However, improved DASH scores may not be clinically relevant. Furthermore, there may be no difference in pain scores, ROM, and the rates of complications between the two treatment modalities. Further trials with large sample size are required to provide more robust evidence on this topic.

Key Words:
Volar plate fixation, Non-operative management, Distal radius fractures, Meta-analysis, Geriatric.

Introduction

Among the varied fractures encountered in orthopedic care, distal radius fracture are common in the elderly population[1,2]. Older adults have osteoporotic bones, making it difficult for surgeons to manage such injuries[2,3]. It is, however, imperative that these fractures are managed adequately as outcomes will immensely impact the overall functioning and quality of life. Among the available treatment options are closed reduction and casting, stabilization using K-wire (Kirschner wire), external fixation, and open reduction and internal fixation (ORIF) with volar locking plates[3-5]. Initial treatment with closed reduction and casting is simple and convenient and usually suffices for stable fractures. However, surgical intervention may be additionally needed in cases of unstable fractures[4-7]. In younger patients, healing with radiographic evidence of displacement usually leads to inferior clinical outcomes. However, the same correlation between radiographic and clinical parameters has not been established for older adults[8].

In recent years, ORIF with volar plating has emerged as a preferred treatment option because of lower risk of tendon irritation and rupture, as well as improved outcomes compared to the conventional non-operative method of immobilization using casting[6,7]. Many of the evidence, either in support of or against the use of ORIF with volar plating comes from individual studies that vary in terms of study design, characteristics of study subjects, geographical location, sample size, and measurement of outcomes. To ensure evidence-based practice, it is important to determine which treatment option offers major results in terms of clinical and functional outcomes, especially in older adults. In a recent meta-analysis, Ochen et al[4] have pooled evidence from 8 randomized controlled trials (RCTs) and 23 observational studies comparing outcomes of operative

Corresponding Author: Hongwei Zhang, MD, e-mail: yangsq_666@126.com

and non-operative treatment of distal radius fractures. However, in a sub-group analysis of older adults in their study, the authors could compare functional outcomes by pooling data only from two RCTs and two observational studies. With the publication of recent randomized controlled trials, there is a need for high-level updated evidence on this topic. Therefore, the purpose of this meta-analysis was to compare clinical and functional outcomes of ORIF using a volar plate and closed reduction with casting for distal radius fractures with a focus on older adults.

Materials and Methods

Search Strategy

A comprehensive electronic search was done for PubMed, Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Google scholar databases for English, as well as non-English language papers published up to 15th February 2020. For non-English language papers, google translator was used for translation to English and thereafter, extract relevant information. Free text words and medical subject heading (MeSH) terms were used. Details of the search strategy have been provided in the supplementary document (**Supplementary Table I**). The current meta-analysis was not registered in PROSPERO.

Two authors reviewed citations and selected studies. After removing the duplicates, the screening of titles and abstracts was performed as a first step. Thereafter, a review of the full text of potential studies was done. Any discrepancies related to the inclusion of studies were resolved through detailed discussion among the study authors. Only those studies that adequately suited the inclusion criteria were selected for the meta-analysis. The bibliographic list of the identified studies and relevant reviews on the subject were examined for additional possible studies.

Inclusion and Exclusion Criteria

Studies were eligible for inclusion if they compared ORIF using a volar plate against closed reduction with casting, in older patients (≥ 60 years) with distal radius fractures. The included studies should have compared the two management techniques with respect to either functional or clinical outcomes or both. Only RCTs were eligible to be included. We excluded non-randomized studies, retrospective studies, case series, case reports, and review articles. Studies involving a population of mixed age groups were also excluded unless data of older adults were reported separately.

Data Extraction and Quality Assessment

Two authors independently extracted data from the included studies using a pre-tested data extraction sheet. The data extracted was subsequently matched for consistency. Any discrepancies were resolved through discussion. The following data were sourced: the surname of the first author, the year in which the study was published, the geographical location where the study was done, the design of the study, characteristics of the study subjects, study groups, and study outcomes. Data that were reported at the last follow up period were considered for the meta-analysis. The primary outcome of interest was the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) scores. Secondary outcomes of interest were grip strength, pain scores, range of motion (ROM), and complication rates.

The quality assessment of the included studies was done independently by two authors using the Cochrane tool of risk of bias assessment[9]. Studies were evaluated for risk of bias in the following domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting.

Statistical Analysis

Statistical analysis was done using STATA version 13.0. Effect sizes were reported as weighted mean differences (WMD) for continuous outcomes. For categorical outcomes, pooled relative risks (RR) were calculated. All estimates were reported with 95% confidence intervals (CI). The heterogeneity of effects was assessed and quantified by the I^2 statistic. I^2 value ≥50% was considered to represent substantial heterogeneity[10]. In cases with substantial heterogeneity, a random-effects model was used for the meta-analysis while for I^2 values <50% a fixed-effects model was used[10]. A p-value of <0.05 was considered statistically significant. Publication bias was assessed using Egger's test.

Results

A total of 1371 unique citations were obtained upon executing the search strategy (Figure 1). Out of these, 1263 were excluded based on title

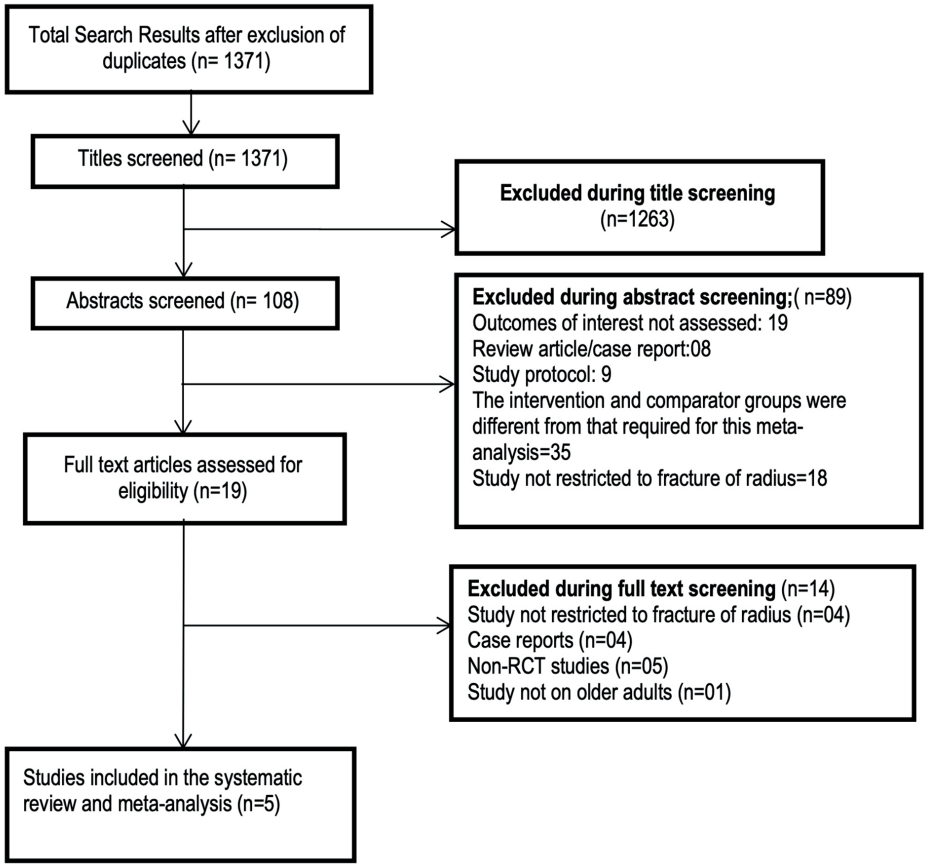

Figure 1. Study flowchart.

screening. Furthermore, 89 citations were excluded after reading the abstract. The full text of the remaining 19 articles was reviewed. Out of these, 14 articles were excluded upon full-text review as they did not fulfill the inclusion criteria. A total of 5 studies were included in the systematic review and meta-analysis[11-15]. Table I presents the study characteristics along with the key outcomes. Out of the five RCTs included in the meta-analysis, one each was conducted in Austria, Spain, Sweden, and Germany. The study by Chung et al[14] was a multicentric RCT conducted in the United States, Canada, and Singapore. **Supplementary Table II** presents the author's judgment of the risk of bias assessment of included studies. The overall quality of the studies was moderate. Blinding of participants and outcome assessment could not be carried out in any trial due to the nature of the intervention.

Effect on DASH Score

There were 4 studies with 444 subjects reporting this outcome of interest. The pooled analysis suggested a significantly reduced DASH score among subjects undergoing ORIF with volar plating compared to those that received non-operative management, i.e., closed reduction and casting (WMD -5.62; 95% CI, -8.55, -2.69; I^2=43.7%) (Figure 2). There was no evidence of publication bias (p=0.56). The funnel plot is presented as **Supplementary Figure 1**.

Effect on Grip Strength

Data from 2 studies with 216 subjects were pooled for this variable. Meta-analysis indicated improved grip strength in patients receiving ORIF with volar plating *vs.* those managed conservatively [*Grip strength compared to contralateral side* (%) (WMD 13.07; 95% CI, 6.11, 20.02; I^2= 0%)] (Figure 3). There was no evidence of publication bias (p=0.24). The funnel plot is presented as **Supplementary Figure 2**. The study by Arora et al[11] reported absolute grip strength as mean (standard deviation) in kilograms. They reported significantly improved grip strength in the intervention group [22.2 (6.3)] that received ORIF with volar plating as compared to the control group [18.8 (5.8)] (p<0.05).

Table I. Key details of the studies included in the meta-analysis.

Author, year of publication	Country	Study design	Subjects	Intervention and control groups	Key outcomes	Follow-up
Arora et al (2011)[11]	Austria	Prospective randomized study	Patients ≥65 years with unstable distal radius fracture	Intervention: ORIF using volar fixed angle implants (N=36) Control: Closed reduction and casting (N=37)	**DASH score; Mean (SD)** Intervention=5.7 (11.1); Control=8.0 (9.3) **Pain score; Mean (SD)** Intervention=0.1 (0.3); Control=0.1 (0.5) **Mean (SD) range of motion (°)** Extension: Intervention=59 (10); Control=61 (7.0) Flexion: Intervention=55 (11); Control=57 (10) Pronation: Intervention = 84 (7.0); Control = 85 (8.0) Supination: Intervention = 85 (8.0); Control=85 (8.0) Radial deviation: Intervention = 24 (16.0); Control = 25 (7.0) Ulnar deviation: Intervention = 35 (8.0); Control = 35 (8.0) Grip strength in Kg; Mean (SD) Intervention = 22.2 (6.3); Control= 18.8 (5.8) **Complications** Overall, there were significantly more complications in the intervention group than in the control group (thirteen compared with five) ($p < 0.05$). Intervention group: In 13 subjects (36%) Extensor tenosynovitis (N = 5) Flexor tenosynovitis (N = 4) Extensor pollicis longus tendon rupture (N= 1) Carpal tunnel syndrome (N = 1) Complex regional pain syndrome type 1 (N = 2) Control group: In 5 subjects (13.5%) Complex regional pain syndrome type 1 (N= 5)	12 months

Continued

Effect on Visual Analog Scale (VAS) Pain Score

A total of 3 studies with 325 patients reported VAS scores. Meta-analysis suggested no significant differences in the pain score between the two treatment modalities (WMD -0.30; 95% CI, -1.28, 0.69; I^2= 72.5%) (Figure 4). There was no evidence of publication bias (p=0.49). The funnel plot is presented as **Supplementary Figure 3**.

Effect on ROM

The pooled estimates suggested similar degree of attained ROM at the wrist in terms of extension (WMD -0.22; 95% CI, -2.23, 1.78; I^2= 0%) and flexion (WMD 0.21; 95% CI, -7.47, 7.89; I^2=90.3%) (Figure 5) as well as for pronation (WMD 2.79; 95% CI, -1.41, 6.99; I^2=82.2%) and supination (WMD 3.47; 95% CI, -1.60, 8.53; I^2= 83.5%) (Figure 6). Meta-analysis for radial deviation (WMD -1.00; 95% CI, -2.90, 0.90; I^2= 0%) and ulnar deviation (WMD 2.04; 95% CI, -1.88, 5.96; I^2=58.2%) also indicated no statistically significant difference between the two groups (Figure 7). There was no evidence of publication bias for any of the ROM outcomes.

Table I *(Continued)*. Key details of the studies included in the meta-analysis.

Author, year of publication	Country	Study design	Subjects	Intervention and control groups	Key outcomes	Follow-up
Mendez et al (2017)[12]	Spain	RCT	Patients ≥60 years with intra-articular distal radius fracture	Intervention: ORIF using volar locking plates (N=50) Control: Closed reduction and casting (N=47)	**DASH score; Mean (SD)** Intervention = 16 (14); Control = 2 8 (21) **Pain score; Mean (SD)** Intervention = 2 (2); Control = 3 (2) **Mean (SD) range of motion (°)** Extension: Intervention=57 (11); Control = 54 (13) Flexion: Intervention=54 (13); Control = 60 (16) Pronation: Intervention=84 (10); Control = 71 (19) Supination: Intervention=85 (8); Control=72 (20) **Grip strength compared to the contralateral side (%); Mean (SD)** Intervention: 73 (27); Control: 64 (33) **Complications** Intervention group: In 2 subjects (4%) Extensor pollicis longus tendon rupture (N = 1) Carpal tunnel syndrome (N=1) Control group: In 1 subject (2.1%) Complex regional pain syndrome type 1 (N = 1)	24 months
Saving et al (2019)[13]	Sweden	RCT	Patients ≥75 years with dorsally displaced distal radius fracture	Intervention: ORIF using volar locking plates (N=56) Control: Closed reduction and casting (N=63)	**DASH score; Mean (SD)** Intervention= 15.6 (17); Control = 23.1 (19.8) **Mean (SD) range of motion (°)** Extension: Intervention = 55 (11); Control= 56 (12) Flexion: Intervention = 63 (13); Control = 51 (14) Pronation: Intervention = 85 (9); Control = 83 (10) Supination: Intervention = 9 6 (16); Control = 92 (17) Radial deviation: Intervention = 22 (4); Control = 23 (7) Ulnar deviation: Intervention = 30 (11); Control=26 (8) **Grip strength compared to the contralateral side (%); Mean (SD)** Intervention: 96 (23.7); Control: 80.9 (23.6) Complications Intervention group: In 19 subjects (34%) Carpal tunnel syndrome (N = 4) Flexor tendon rupture (N = 1) Atrial fibrillation and myocardial infarction (N = 1) Flexor tenosynovitis (N = 2) Nerve numbness (N = 7) Wound infection (N = 2) Scar adherence/keloid (N = 2) Control group: In 15 subjects (23.8%) Complex regional pain syndrome type 1 (N = 2) Carpal tunnel syndrome (N=5) Nerve numbness (N=5) Malunion requiring corrective osteotomy (N = 3)	12 months

Continued

Table I *(Continued)*. Key details of the studies included in the meta-analysis.

Author, year of publication	Country	Study design	Subjects	Intervention and control groups	Key outcomes	Follow-up
Chung et al (2019)[14]	USA, Canada and Singapore	RCT	Patients ≥ 60 years with distal radius fracture	Intervention: ORIF using volar locking plates (N=65) Control: Closed reduction and casting (N = 104)	**Complications** In the intervention group, a total of 31 adverse events (47.7%) occurred; In the control group, atotal of 76 (73.1%) adverse events occurred. Carpal tunnel syndrome Intervention=12/65 (18.5%); Control = 25/104 (24.0%) Malunion Intervention = 1/65 (1.5%); Control = 35/104 (33.7%) Tendinitis/tenosynovitis Intervention = 3/65 (4.6%); Control = 3/104 (2.9%) Delayed union Intervention = 1/65 (1.5%); Control = 3/104 (2.9%) Regional pain syndrome Intervention = 10/65 (15.4%); Control = 14/104 (13.5%)	12 months
Bartl et al (2014)[15]	Germany	RCT	Patients ≥ 65 years with distal radius fracture	Intervention: ORIF using volar locking plates (N = 73) Control: Closed reduction and casting (N = 82)	**DASH score; Mean (SD)** Intervention = 14 (16.1); Control = 19 (21.3) **Pain score; Mean (SD)** Intervention = 76.9 (13.9); Control = 73.9 (16.8) Mean (SD) range of motion (°) Extension: Intervention = 77.5 (11.7); Control = 77.5 (10.0) Flexion: Intervention = 83.2 (11.9); Control = 86.5 (12.8) Pronation: Intervention = 77.8 (5.6); Control = 77.6 (9.4) Supination: Intervention = 87.5 (5.9); Control = 88.2 (8.3) Complications Intervention group: A total of 19 adverse events (26%) Carpal tunnel syndrome (N = 1) Wound healing disorder (N = 1) Rupture of extensor tendon (N = 1) Malposition of implant needing revision (N = 4) Death (N = 4) Further fractures (N = 1) Others (N = 7) Control group: A total of 53 advers events (64.6%) Carpal tunnel syndrome (N = 2) Malposition of implant needing revision (N = 2) Complex regional pain syndrome (N = 1) Rupture of extensor tendon (N = 1) Rupture of flexor tendon (N=1) Reduction loss necessitating revision (N =3 7) Nerve lesion (N = 3) Skin pressure mark (N = 1) Death (N = 1) Further fracture (N =2) Others (N= 2)	12 months

ORIF, Open reduction and internal fixation; SD, Standard Deviation; RCT, Randomized controlled trial; DASH, Disabilities of the Arm, Shoulder and Hand questionnaire.

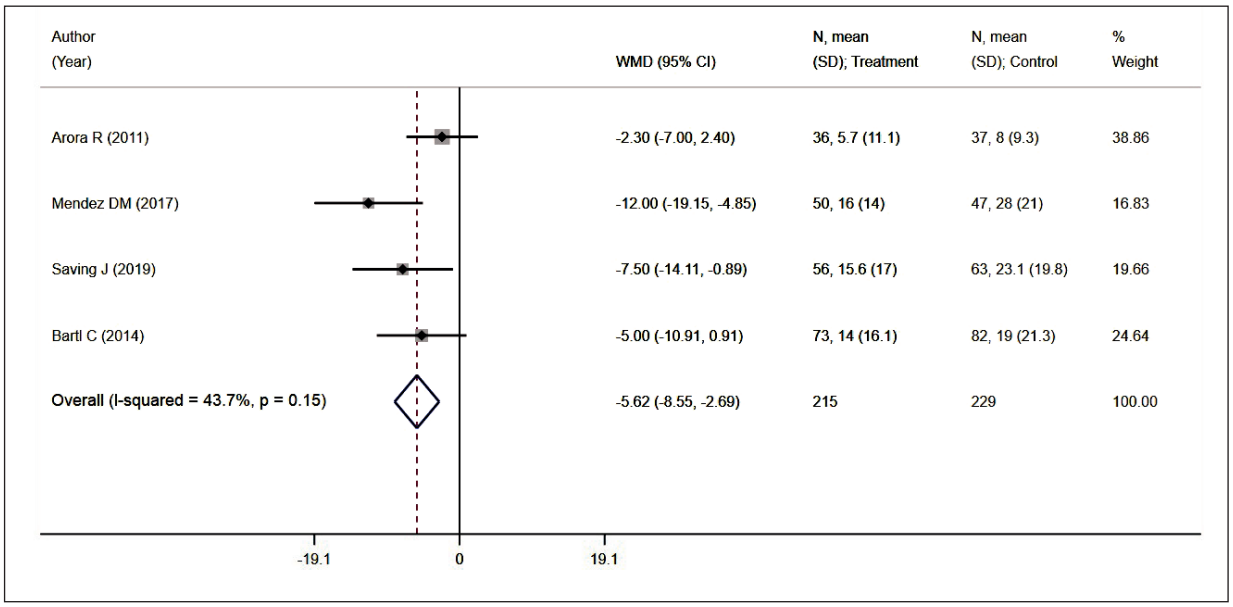

Figure 2. Comparison of pooled DASH scores between ORIF with volar plating and closed reduction with casting.

Effect on Rates of Complications

The incidence of complications was reported by all 5 included studies. On pooled analysis, there were no statistically significant differences in the complication rates among the two treatment modalities (RR 0.94; 95% CI, 0.51, 1.74; I^2=81.6%) (Figure 8). There was no evidence of publication bias (p=0.33). The funnel plot is presented as **Supplementary Figure 4**.

Discussion

The present meta-analysis compared outcomes between ORIF using volar locking plates and closed reduction with casting for management of distal radius fracture in older adults. Data from a limited number of studies suggest that the use of ORIF with volar locking plates led to reduced DASH scores and improved grip strength.

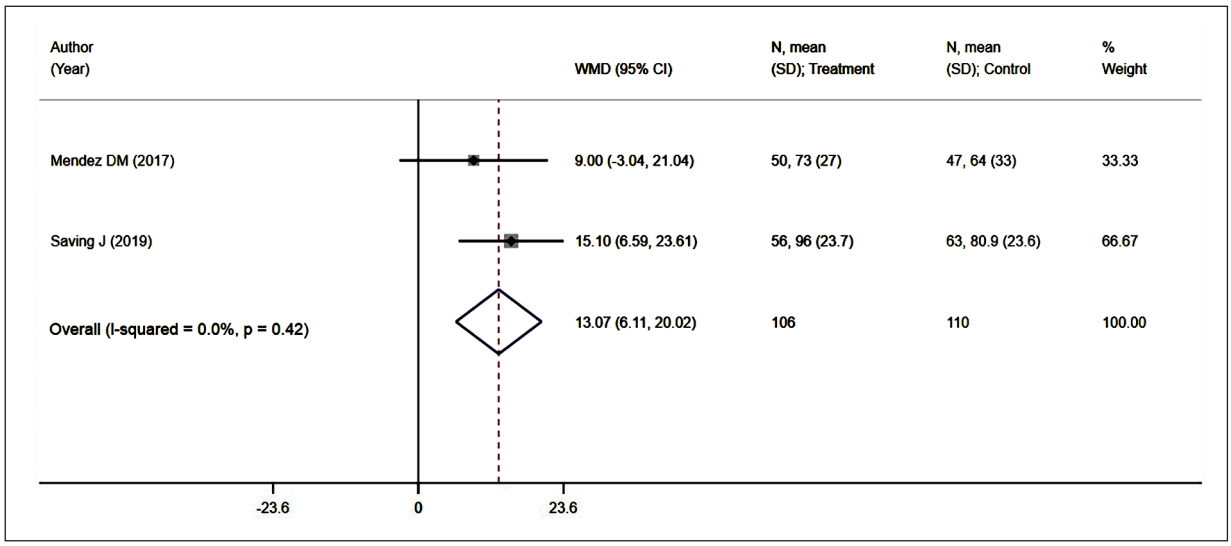

Figure 3. Comparison of grip strength between ORIF with volar plating and closed reduction with casting.

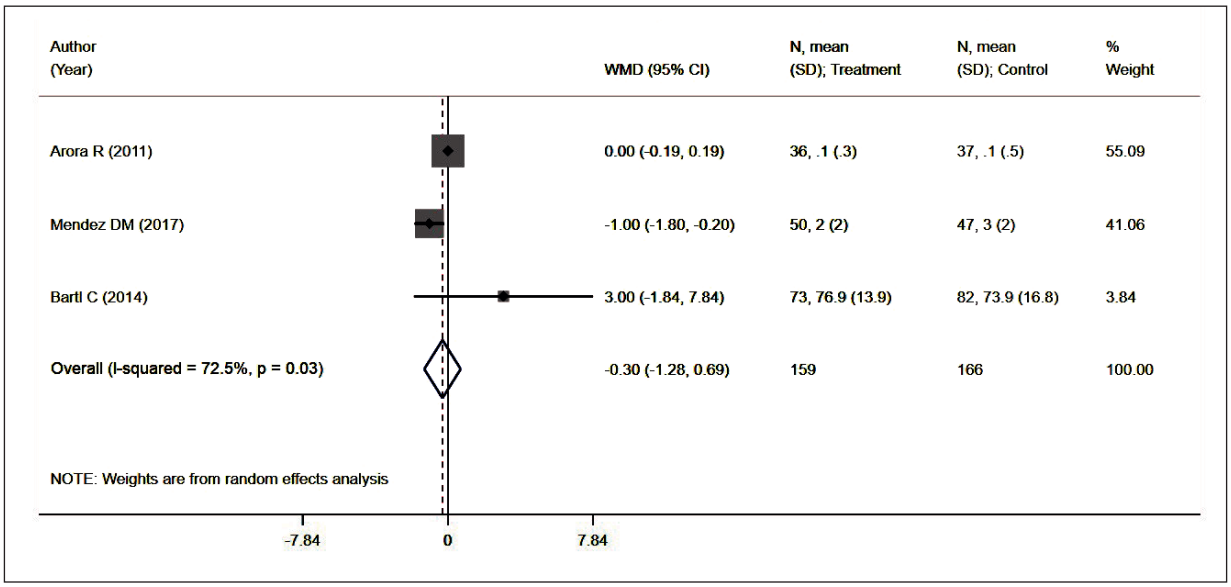

Figure 4. Comparison of pain scores between ORIF with volar plating and closed reduction with casting.

This operative modality was not associated with a higher rate of complications as compared to closed reduction with immobilization cast. The pain scores and ROM at the wrist joint were also not significantly different between the two groups.

The primary outcome of our study was to evaluate differences in patient-reported function-

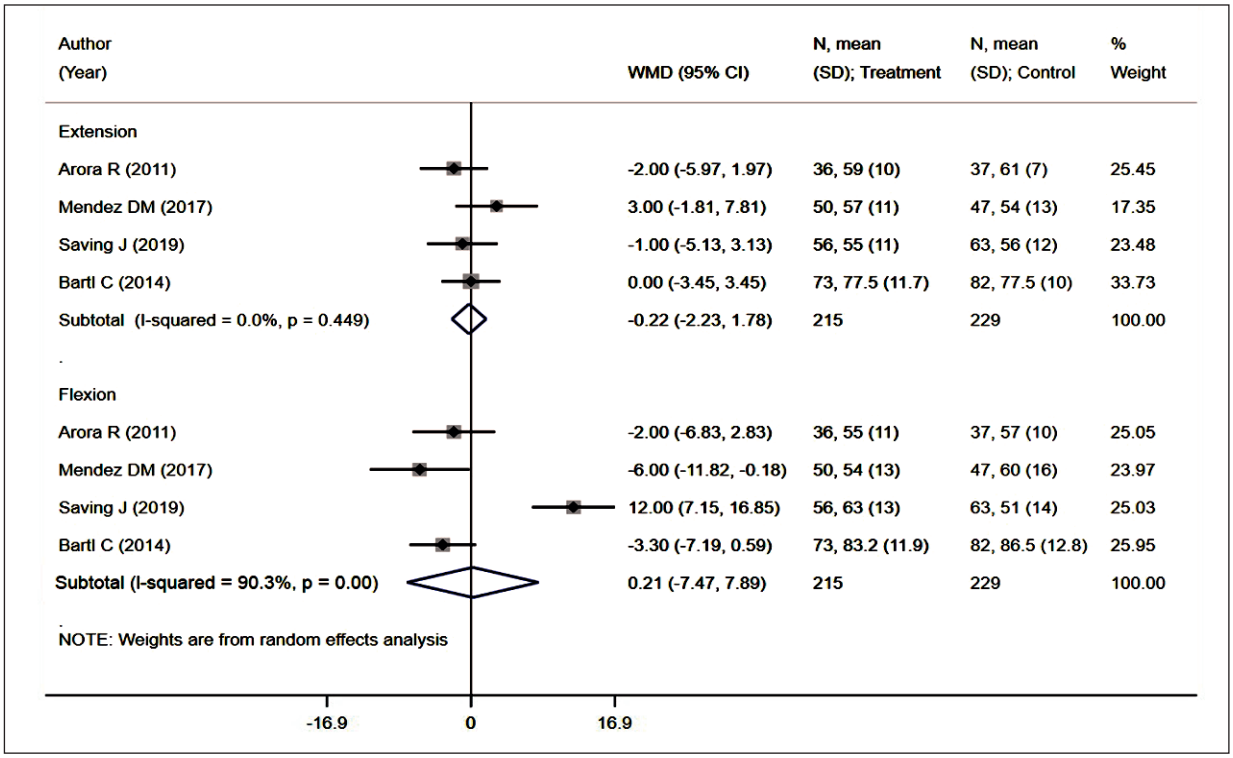

Figure 5. Comparison of range of extension and flexion at the wrist joint between ORIF with volar plating and closed reduction with casting.

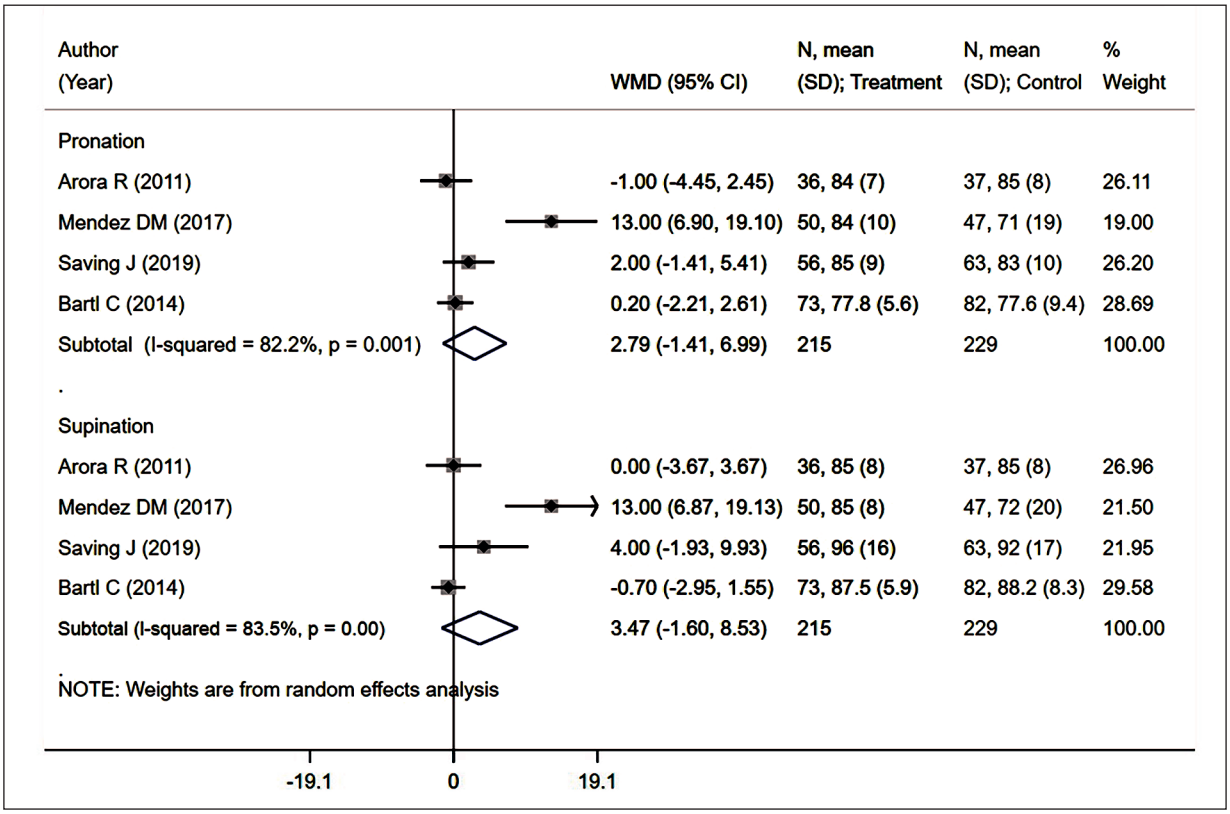

Figure 6. Comparison of range of pronation and supination at the wrist joint between ORIF with volar plating and closed reduction with casting.

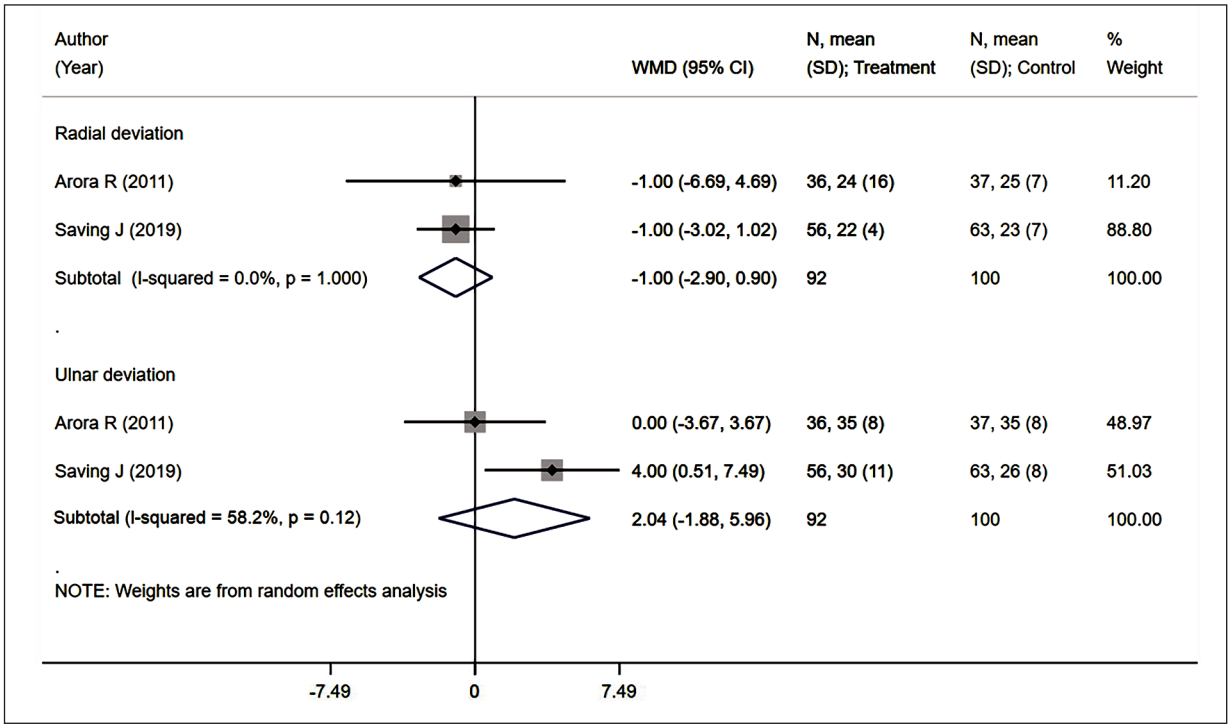

Figure 7. Comparison of radial and ulnar deviation between ORIF with volar plating and closed reduction with casting.

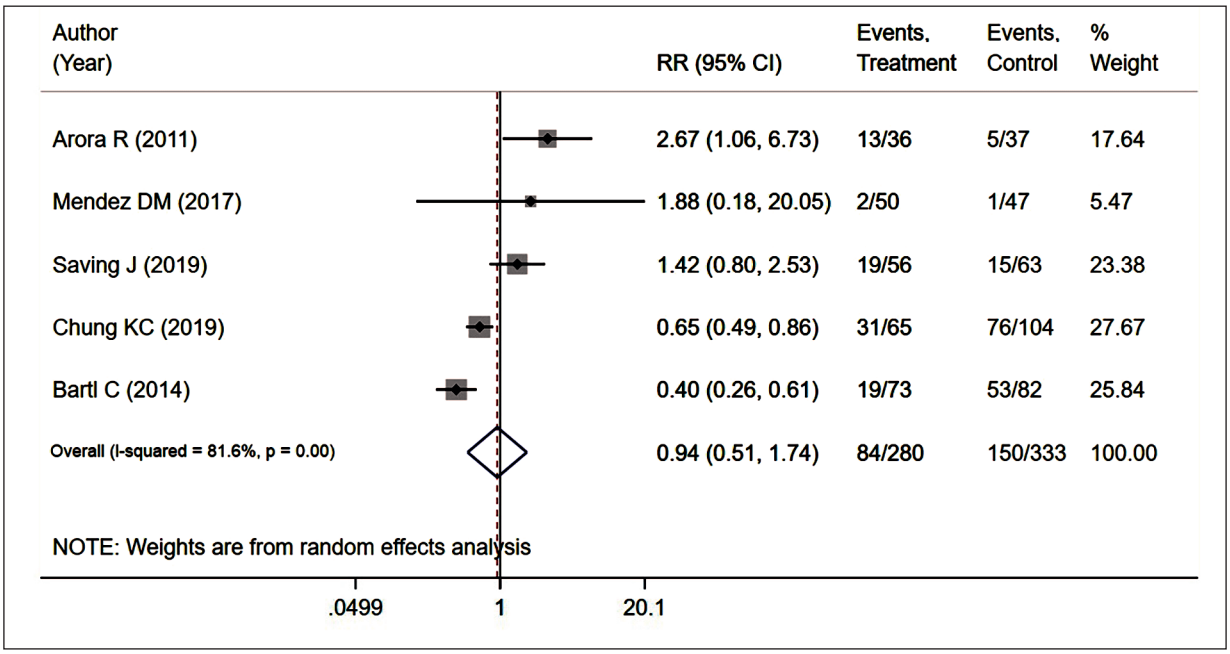

Figure 8. Comparison of complication rates between ORIF with volar plating and closed reduction with casting.

al scores between the two treatment modalities. The DASH questionnaire has been widely used to analyze problems related to the arm, shoulder, and hand from the patient's perspective. The questionnaire evaluates the degree of difficulty in performing physical activities, the severity of symptoms along with the impact of the health problem on the patient's daily functioning[16]. Our pooled outcomes of DASH scores from 4 trials suggest that patients treated with volar plating may have better functional outcomes as compared to those treated by closed reduction and casting. In comparison, the meta-analysis of Ochen et al[4], analyzing data from all age-groups, has also reported significantly better DASH scores in patients undergoing operative management of distal radius fractures as compared to those undergoing non-operative treatment (Mean difference -5.22; 95% CI -8.87, -1.57). However, in a sub-group analysis of older adults, the authors reported no difference in DASH scores between the two groups (Mean difference: -0.98; 95% CI -3.52, 1.57). This may be because only 4 studies (2 RCTs and 2 retrospective studies) were included in their sub-group analysis. Ju et al[17] and Chen et al[18] in their meta-analysis studies published in 2015 and 2016 respectively have also compared data for operative *vs.* non-operative treatment of distal radius fractures in the elderly. These reviews included a mix of RCTs and retrospective studies and were not focused solely on volar plating for the operative group. Both these studies also did not report significant differences in DASH scores between operative *vs.* non-operative management of distal radius fractures in the elderly.

In contrast, in our review only RCTs comparing volar plating with cast immobilization were included, thereby providing high-quality focused evidence. The WMD for DASH scores between the two groups was -5.62 with 95% CI of -8.55 and -2.69. Despite being statistically significant, it is important to note that the effect size of the analysis in favor of volar plating was not large. Scholars[19] have reported that the minimal clinically important difference (MCID) to be 10.83 points for DASH scores. MCID represents the smallest improvement of score considered worthwhile by a patient. Thus, regardless of the better DASH scores with volar plating, it may not have been clinically relevant.

We also noted improved grip strengths in the volar plating group of our review. A strong conclusion cannot be drawn from our analysis since data were pooled only from 2 RCTs. Better grip strengths following operative treatment, irrespective of the patient's age has also been reported by the review of Ochen et al[4]. Furthermore, evidence from retrospective studies also suggests that grip strengths may be improved with volar plate fixation as compared to cast immobilization in older

adults[20,21]. Chan et al[20], however, reported that despite improved grip strength with volar plating at an early follow-up period, long term benefits with operative management are not statistically significant. Our analysis did not demonstrate any significant differences between the two treatment modalities for pain and ROM. Similar results have been reported by the previous reviews[4,18].

Analysis of the effectiveness of any surgical procedure is incomplete without a discussion of its complications. Our pooled analysis did not demonstrate any significant difference in the risk of complications with volar plating and closed reduction with casting. Similar to our results, Ochen et al[4] reported no significant difference in complications between operative and non-operative treatment of distal radius fractures on a pooled analysis of both, RCTs and non-RCTs. However, for older adults, their study reported reduced complication rates with non-operative management. On the other hand, Chen et al[18] in their review focusing on older adults have also reported no difference in minor complications with operative and non-operative treatment; but they reported higher odds of major complications (those requiring surgical intervention) with operative management of distal radius fractures. The difference in the results of our study and previous reviews may be partly explained by the varied inclusion/exclusion criteria of the reviews. The varying nature of the complications and the non-specificity of the operative and non-operative treatment protocols assessed in the reviews further make comparisons difficult.

Limitations

Some limitations of our study need to be mentioned. Firstly, only 5 trials were eligible to be included in our review. Also, since data for all outcome variables were not reported by every trial, the number of studies in the pooled analysis were further limited. Secondly, high heterogeneity was observed in our meta-analysis which may be attributed to the methodological differences in the included studies. The results of any surgical procedure may vary with the exact nature of the injury, the surgical technique, skill and experience of the operator, etc. This may limit the generalization of the findings of a trial and this review to the entire population. Thirdly, due to the nature of the intervention, blinding was not possible. Therefore, patient-reported functional scores may be prone to bias and this may have skewed the results of our analysis.

Conclusions

To conclude our study indicates that older adults treated with volar plating for fracture of distal radius have better DASH scores and improved grip strengths. However, improved DASH scores may not be clinically relevant. Furthermore, there may be no difference in pain scores, ROM, and the rates of complications between the two treatment modalities. Current evidence, however, is from a limited number of studies. Further trials with large sample size are required to provide more robust evidence on this topic.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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