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Functional Outcome and Range of Motion Between Internal Plate Fixation Versus Kirschner Wire for Management of Distal Radius Fracture: A Meta-Analysis

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ABSTRACT

Introduction: A significant percentage of fractures treated in clinical practice are distal radius fractures, which are among the most common orthopaedics injuries. Distal radius fractures are common and can affect wrist function and general quality of life, thus they need to be addressed carefully. This research aims to assess the evidence supporting VLP and K-wire fixation procedures in the treatment of distal radius fractures.

Methods: According to PRISMA guideline statement, the research was conducted. A systematic search was conducted in past 10 years. This research will include English-language, randomized, controlled studies that compare VLP with K-wire fixation for the management of distal radius fracture and have full-text. Data collection included functional outcome measures, specifically the Disabilities of the Arm, Shoulder, and Hand (DASH), wrist Range of Motion, and clinical complication, which have been recommended as the best available patient-reported outcome measurement instruments for distal radius fractures.

Result: The plate group had a higher DASH score with a difference of 1.46 but this result was not statistically significant (95% CI=3.09-(-0.16), p=0.08). Based on grip strength, it was found that the grip strength was greater in the wire group although there was no statistically significant difference (2.28; 95%CI=-0.13-4.70, p=0.06). There were fewer complications when using the plate with an Odd Ratio of 0.31 (95% CI=0.22-0.43, p<0.00001).

Discussion: Plate fixation is still valuable because of its stability, brief period of immobility, and rapid return to an active life. The usage of locking plate fixations in the treatment of distal radius fractures has increased recently. Anatomical repair of the articular surface and fragment alignment promotes functional rehabilitation and delays the onset of osteoarthritis. K-wires are commonly used because they are easy to implant, don't injure tissue much, have an atraumatic insertion, and result in less stiffness and edema. Two other advantages are reduced risk of infection and enhanced fracture healing. Their disadvantages include wire migration, peripheral neurovascular injury, and less firm fixation. There was no difference between the two groups DASH scores or grip strengths according to the forest plot results. After a year, the study of wrist range of motion revealed no appreciable variations in flexion, extension, or pronation. It was discovered that treating distal radius fractures with plates had fewer difficulties than treating them with wires, based on the patient's issues.

Keywords: Distal Radius Fracture, Fracture, Kirschner Wire, Plate Screw.

INTRODUCTION

Fractures of the distal radius are among the most prevalent orthopedic injuries, accounting for a substantial proportion of fractures treated in clinical practice. These fractures typically occur at the distal end of the radius bone and are frequently caused by impacts on an outstretched hand or other wrist region trauma. Due to their prevalence and potential impact on wrist function and overall quality of life, distal radius fractures must be effectively managed.[1]

Over the years, both surgical and non-surgical approaches have been utilized in the treatment of distal radius fractures. Internal plate fixation and Kirschner wire (K-wire) fixation are two commonly used surgical techniques. Closed reduction and fixation with percutaneous Kirschner wires (K-wire) has historically been the most common operative approach for distal radius fractures, providing a relatively rapid and cost-effective treatment. However, recent studies have demonstrated that open reduction and internal fixation with Kirschner wires (I-wire) may be superior. It was accepted that patients with unstable extraarticular or simple intraarticular distal radius fractures should contemplate percutaneous K-wire fixation. However, because percutaneous K-wires are not load-bearing devices, they cannot prevent radial shortening, particularly in osteoporotic bone, which has been linked to poor postoperative functional outcomes. Open reduction and internal fixation with a volar locking plate (VLP) is increasingly used as an alternative to K-wire fixation, as it provides stability and permits early hand and wrist mobilization. Both K-wire fixation and VLP fixation offer unique advantages and considerations in terms of stability, functional outcomes, and potential complications. [2]

A comprehensive review of the existing literature and clinical studies can provide valuable insights into the optimal treatment approach for various patient profiles and fracture patterns. The purpose of this paper is to conduct a comprehensive meta-analysis using RCTs to evaluate the evidence for VLP and K-wire fixation techniques in the treatment of distal radius fractures. This meta-analysis sought to determine whether patients treated with volar locking plates for distal radius fractures (1) had improved function, (2) had better wrist motion, and (3) had fewer complications than patients treated with K-wires.[3]

MATERIALS & METHODS

Search Methodology and Data Extraction

According to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guideline statement, the research was conducted. A systematic search was conducted between July 2013 and 2023 to identify prospective studies for inclusion in this investigation. PubMed, Embase, and Google Scholar are utilized as databases. Two evaluators evaluated the abstracts and reference lists independently. Disagreements among examiners regarding the inclusion or exclusion of a study will be resolved by consensus and, if necessary, consultation with a third reviewer. This research will include English-language, randomized, controlled studies that compare VLP with K-wire fixation for the management of distal radius fracture and have full-text. The following key terms and combinations were used to search databases: (distal radius [Title/Abstract] OR distal radial [Title/Abstract]) AND random*. The electronic search was supplemented by a manual examination of relevant articles' reference lists. We collected data regarding the publication year, study design, duration, location, number of centers, number of participants, mean age of participants, categories of fractures included and reported outcomes. Data collection included functional outcome measures, specifically the Disabilities of the Arm, Shoulder, and Hand (DASH), wrist Range of Motion, and clinical complication, which have been recommended as the best available patient-reported outcome measurement instruments for distal radius fractures.

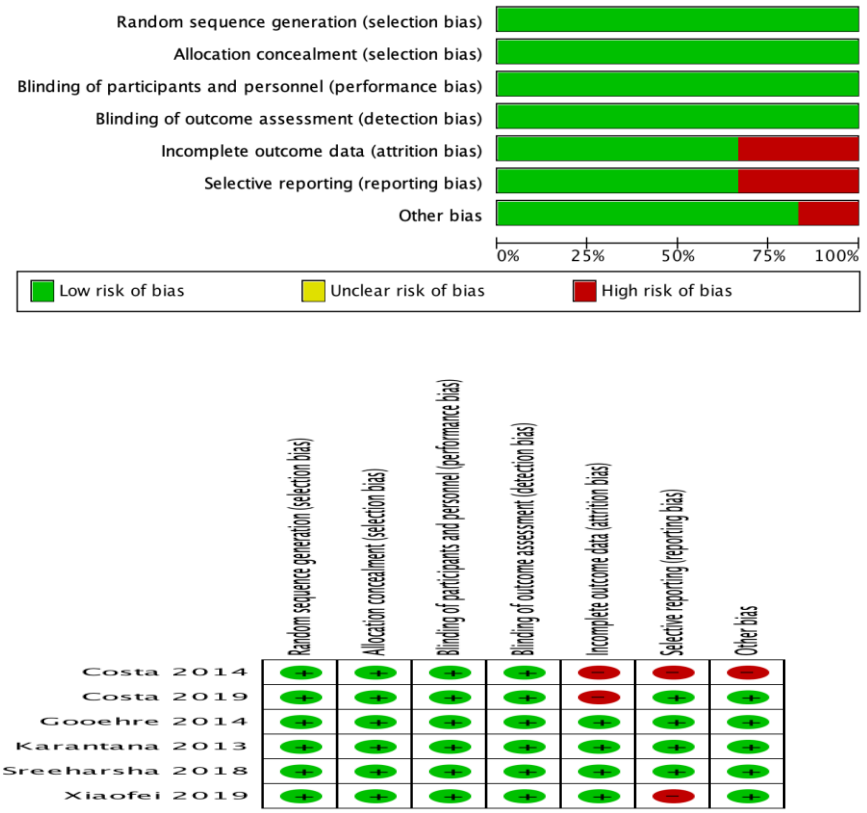

Figure 1. Risk of Bias Assessment

Inclusion Standards

Following were the inclusion criteria for studies: 1) prospective or retrospective RCT comparative English studies comparing K-wire fixation and VLP fixation in patients with distal radius fracture, and 2) reporting outcomes measurements including wrist range of motion (ROM), Disabilities of the Arm, Shoulder, and Hand (DASH) Score, and Complication score.

Table 1. PICO Criteria for Inclusion Study

	Inclusion	Exclusion
Population	Patient with distal radius fracture	Patient with associated carpal fracture, forearm fracture, casting
Intervention	Patients treated with K-wire fixation	Patients treated with conservative measures and surgery of other technique other than all-arthroscopic or mini-open rotator cuff repair
Control	Patients treated with VLP fixation	Patients treated with conservative measures and surgery of other technique other than all-arthroscopic or mini-open rotator cuff repair
Outcome	DASH score, Wrist ROM, and Complications	Outcomes not clearly mentioned Outcome with other parameter than our inclusion criteria.
Design	Randomized controlled trials (RCT)	Case report, case series, cross-sectional study, cohort study, systematic review or meta-analyses

Quality Evaluation

Each article was independently reviewed by two reviewers. Any observed discrepancies are resolved through consensus and thorough discussion. The quality of included RCTs will be evaluated by the same two independent reviewers using Cochrane's 7-item criteria for judging risk of bias in the 'Risk of bias' assessment tool, which includes selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias.

Data Synthesis

All identified and included studies had their fundamental characteristics and outcomes extracted using designated tables in Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Review Manager (RevMan, computer program version 5.3, the Cochrane Collaboration, 2014; The Nordic Cochrane Center, Denmark) was used to perform quantitative analysis when the data were available. The outcomes were represented as forest tracts. In each study,

the mean difference for continuous outcomes and the odds ratio for dichotomous outcomes were calculated along with a 95% confidence interval (CI). When the heterogeneity (I2) was 50%, a fixed-effects model was used, whereas a random-effects model was used when the heterogeneity was >50%.

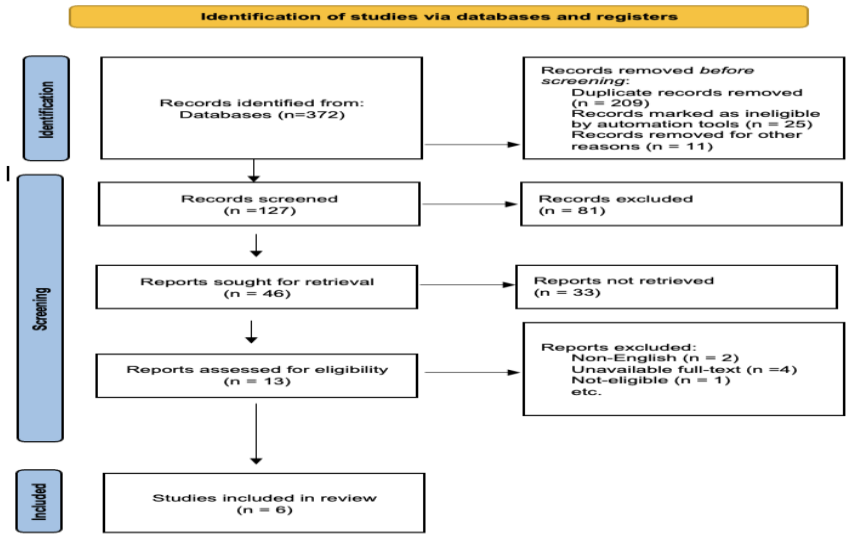

Figure 2. PRISMA flowchart for the included study.

RESULT

Table 2. Characteristic of the studies

No.	Studies	Journal	Study Design	Level of Evidence
1	Xiaofei[3] (2019)	Journal of Orthopedic Surgery and Research	Retrospective Comparative Study	II
2	Gooehre[4] (2014)	The Journal of Hand Surgery	Randomized Controlled Trial	I
3	Costa[5] (2014)	British Medical Journal	Randomized Controlled Trial	I
4	Karantana[6] (2013)	The Journal Of Bone And Joint Surgery	Randomized Controlled Trial	I
5	Costa[7] (2019)	The Bone and Joint Journal	Randomized Controlled Trial	I
6	Sreeharsha[8] (2018)	The Journal of Bone And Joint Surgery	Randomized Controlled Trial	I

Table 3. Characteristic of the study populations

No.	Studies	Subject	Age (year)	Male	Female	Follow Up
1	Xiaofei[3] (2019)	P: 39 W: 23	P: 52.0±14.6 W: 50.5±15.2	P: 23 W: 13	P: 16 W: 10	P: 16m W: 19m
2	Gooehre[4] (2014)	P: 21 W: 19	P: 71.3±5.7 W: 73.8±8.9	P: 3 W: 0	P: 18 W: 19	P: 12m W: 12m
3	Costa [5] (2014)	P: 231 W: 230	P: 58.3 ± 14.9 W: 59.7 ± 16.4	NA	NA	P: 12m W:12m
4	Karantana[6] (2013)	P: 66 W: 64	P: 18 to 73 W: 18 to 73	NA	NA	P: 12m W:12m
5	Costa[7] (2019)	P: 204 W: 198	P: 58.3 ± 14.3 W: 59.1 ± 16.5	NA	NA	P: 60m W: 60m
6	Sreeharsha[8] (2018)	P: 23 W: 17	P: 50.7 ± 20.5 W: 59.1 ± 16.5	P: 5 W: 3	P: 18 W: 14	P: 12m W: 12m

Table 4. Characteristic of Outcome of studies

No	Reference	Outcome Measure		
		DASH Score	Grip Strength	Complication score
1	Xiaofei[3] (2019)	P: 12±15 W: 16±12	P: 26.2±7.4 W: 25.7±6.2	P: 4 W: 3
2	Gooehre[4] (2014)	NA	P: 32.7±4.4 W: 30.6±7.6	P: 4 W: 3
3	Costa [5] (2014)	P: 13±15.6 W: 16.2±17.9	NA	P: 54 W: 144
4	Karantana[6] (2013)	P: 9±12 W: 12±15	P: 95±22 W: 84±19	P: 13 W: 9
5	Costa[7] (2019)	P: 4.9±11.3 W: 4.9±11.9	NA	P: 2 W: 1
6	Sreeharsha[8] (2018)	P: 8±19 W: 7±12	P: 85±22 W: 95±64	NA

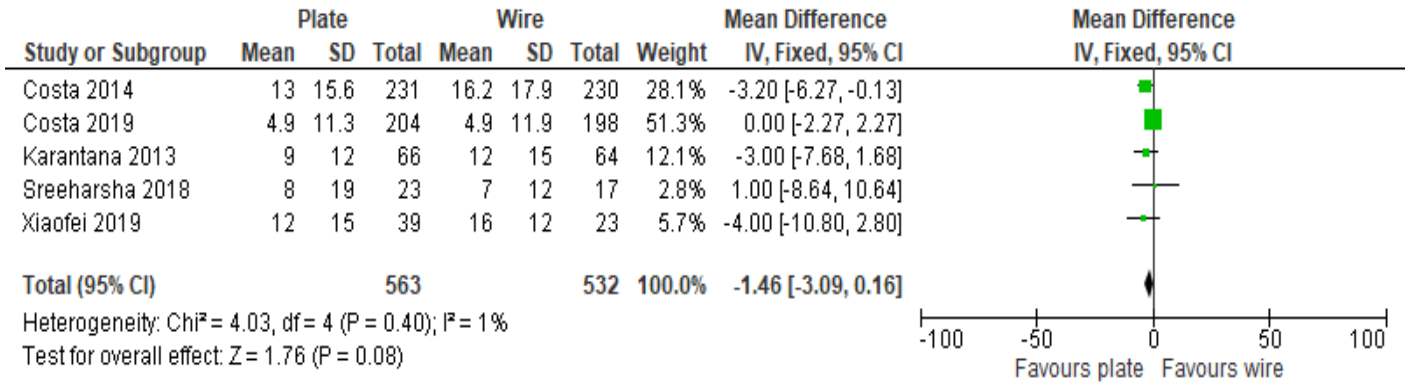

Figure 3. Forest Plot of The Comparison of The DASH score Between The Use of Wire and Plate in Distal Radius Fractures

Based on the DASH score, there are 5 studies that discuss the comparison of the DASH score between the use of wire and plate in distal radius fractures, namely Costa (2014), Costa (2019), Karantana (2013), Sheeharsha (2018), and Xiaofei (2019). Based on the forest plot results, the plate group had a higher DASH score with a difference of 1.46 but this result was not statistically significant (95% CI=3.09-(-0.16), p=0.08).

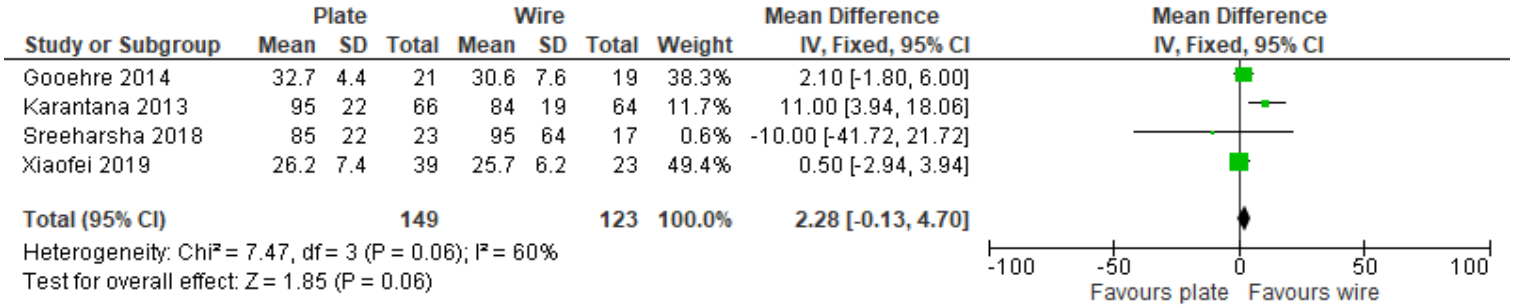

Figure 4. Forest Plot of The Comparison of The Grip Strength Between The Use of Wire and Plate in Distal Radius Fractures

Based on grip strength, there were 4 studies that mentioned comparisons in the two groups, namely Gooehre (2014), Karantana (2013), Sreeharsha (2018), and Xiaofei (2019). Based on the results of the forest plot, it was found that the grip strength was greater in the wire group although there was no statistically significant difference (2.28; 95%CI=-0.13-4.70, p=0.06).

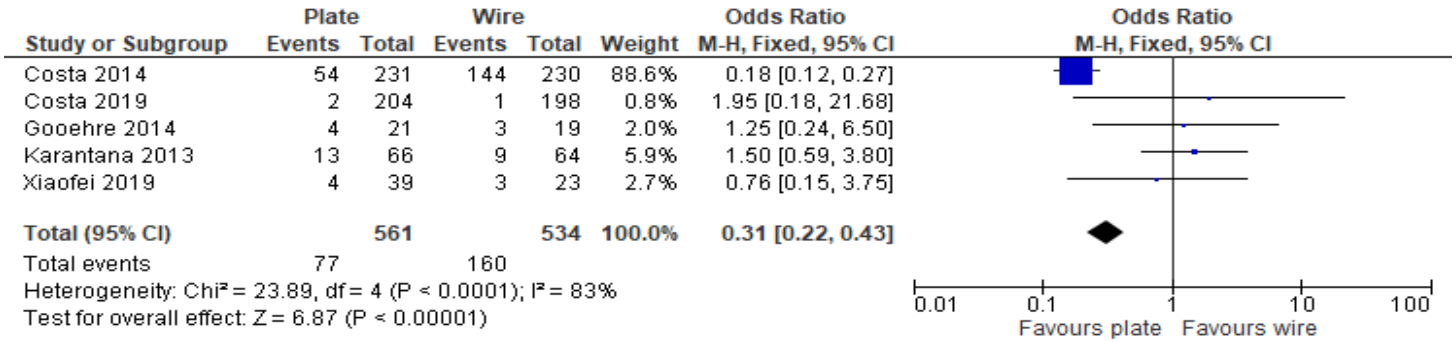

Figure 5. Forest Plot of The Comparison of Complication Events Between The Use of Wire and Plate in Distal Radius Fractures

Based on the complications experienced by the patient, it was found that the treatment of distal radius fractures with plates had fewer complications than those with wires. Treatment using a plate has an Odd Ratio of 0.31 (95% CI=0.22-0.43, p<0.00001) which means using a plate has a 0.31 times lower risk than using a plate in the management of distal radius fractures.

Table 5. 12 months Follow up Wrist Range of Motion

No	Reference	Wrist ROM											
		Flexion			Extension			Supination			Pronation		
		6 weeks	12 weeks	1 year	6 weeks	12 weeks	1 year	6 weeks	12 weeks	1 year	6 weeks	12 weeks	1 year
1	Xiaofei (2019)	NA	NA	P: 69.7±9.6 W: 62.3±7.7	NA	NA	P: 61.1±10.9 W: 60.2±11.8	NA	NA	P: 70.6±10.8 W: 63.6±8.9	NA	NA	P: 66.8±9.6 W: 73.1±8.7
2	Gooehre (2014)	P: 73.2±17.0 W: 70.3±20.5	P: 81.4±14.2 W: 77.4±18.8	P: 86.7±14.7 W: 80.5±18.4	P: 79.8±18.7 W: 72.7±17.2	P: 85.8±16.3 W: 80.4±17.2	P: 91.2±14.0 W: 85.4±16.5	P: 90.7±12.1 W: 79.9±17.7	P: 94.0±6.7 W: 86.8±12.2	P: 95.6±7.8 W: 93.8±5.7	P: 87.5±14.9 W: 84.4±18.7	P: 93.0±9.3 W: 91.3±11.0	P: 96.1±5.9 W: 95.9±6.5
3	Karantana (2013)	P: 59 ± 18 W: 47 ± 22	NA	P: 88±19 W: 87±16	P: 57 ± 22 W: 17 ± 30	NA	P: 93±17 W: 93±18	P: 73 ± 23 W: 37 ± 26	NA	P: 95±10 W: 96±7	P: 80 ± 17 W: 65 ± 28	NA	P: 95±8 W: 98±6
4	Sreeharsha (2018)	P: 51±12 W: 23±14	P: 59±13 W: 55±18	P: 66±14 W: 75±12	P: 48±18 W: 16±13	P: 59±15 W: 47±18	P: 62±17 W: 67±19	P: 73±19 W: 38±28	P: 84±12 W: 75±22	P: 89±2 W: 89±2	NA	NA	NA

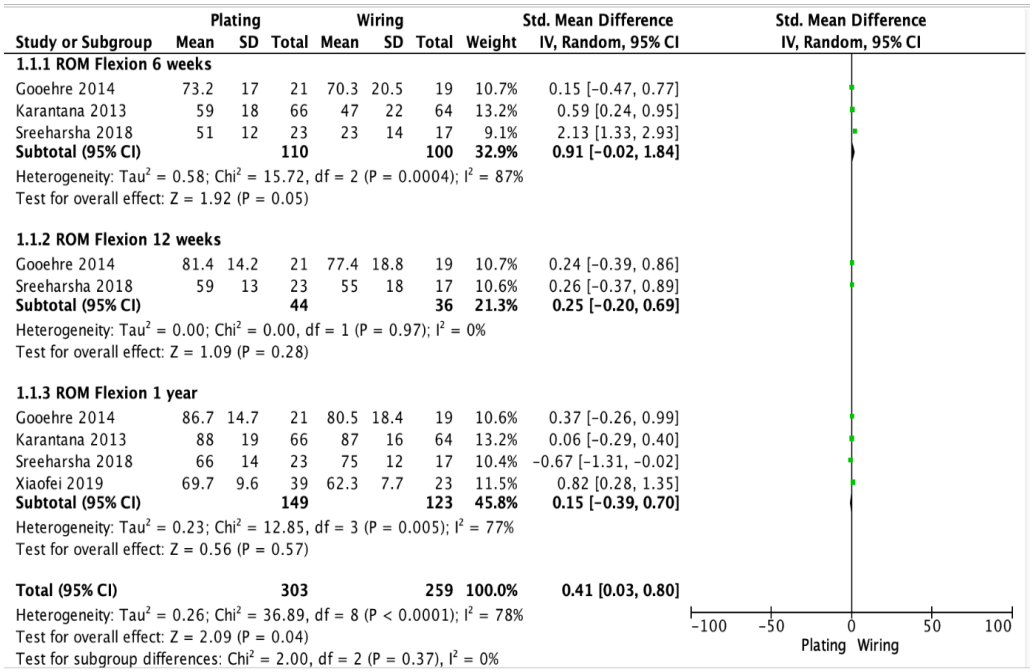

Figure 6. Forest Plot of The Comparison of The Wrist Flexion ROM Between The Use of Wire and Plate in Distal Radius Fractures

Differences in wrist ROM are assessed in several movements. In total ROM flexion follow up, it was found that no significant difference between plating group and the wiring group with a difference of 0.41 (95% CI=0.03-0.80;p=0.04) and was considered statistically significant

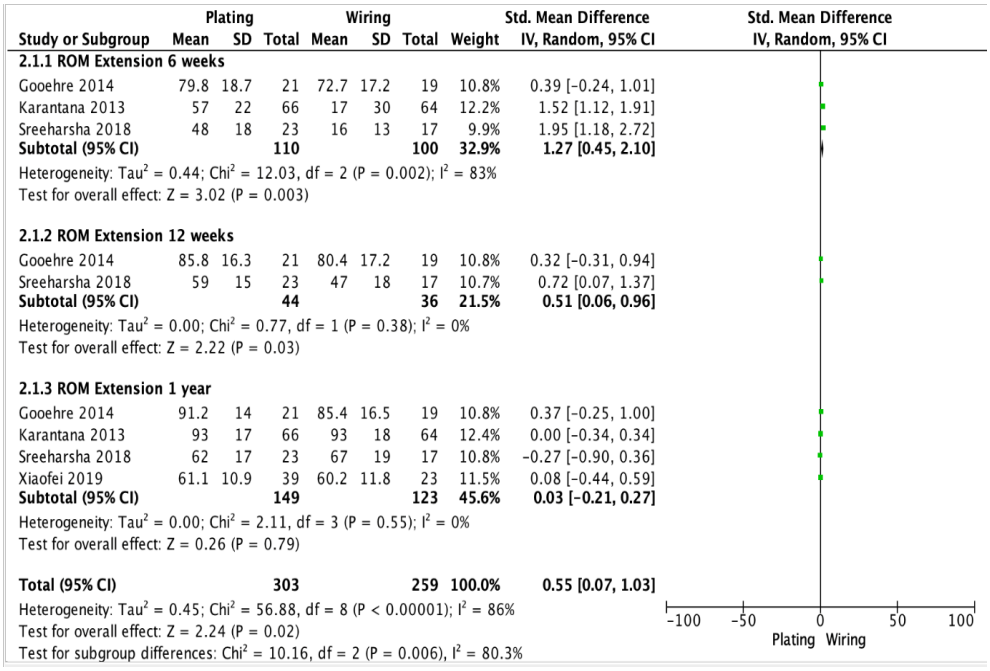

Figure 7. Forest Plot of The Comparison of The Wrist Extension ROM Between the Use of Wire and Plate in Distal Radius Fractures

In extension ROM, there was no significant difference between wire and plate. In the forest plot, the average difference in the wire is 0.55 (95% C1=0.07-1.03, p=0.02), which is statistically significant.

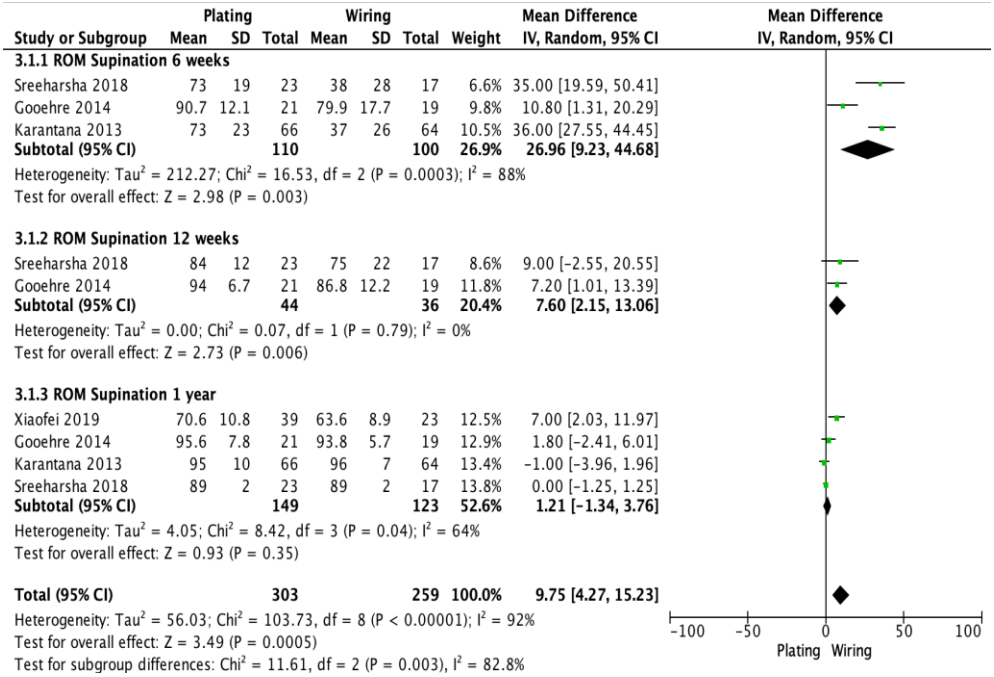

Figure 8. Forest Plot of The Comparison of The Wrist Supination ROM Between the Use of Wire and Plate in Distal Radius Fractures

In wrist ROM supination, there is significant difference between the treatment of distal radius fractures with plates or wires. In the forest plot, there were discussed differences in supination with a final difference of 9.75 (95% CI=4.75-15.23, p<0.05) higher supination ROM in wiring group compared to plating group which was statistically significant.

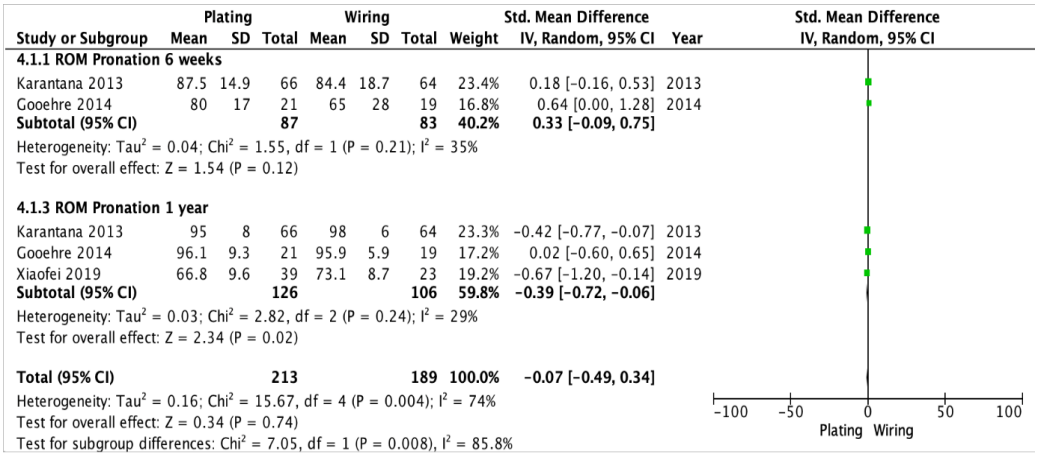

Figure 9. Forest Plot of The Comparison of The Wrist Pronation ROM Between the Use of Wire and Plate in Distal Radius Fractures

Based on wrist ROM pronation, after 12 months of follow-up, pronation ROM was found no significant difference on plate treatment and on wiring. In the forest plot, the average difference in the plate is 0.07 (95% C1=-0.49-0.34, p=0.74), which is not statistically significant.

DISCUSSION

Most cases in the accident and emergency department include distal radius fracture. Road traffic accidents, falls from great heights, work-related trauma, and sports trauma are the most frequent causes of injuries. Radial shortening, angulation, and articular incongruity are caused by the collapse of the fracture pieces, which may

cause persistent deformity. This relative ulnar lengthening and loss of reduction result in an unacceptably deformed wrist and discomfort on the medial side of the wrist [1]

The orthopedic surgeon must be knowledgeable about both the most recent treatment modalities and the potential problems that may arise when administering care for typical upper extremity injuries. Surgery is not always necessary to treat distal radius fractures. Numerous problems, including tendon irritation or rupture, malunion, non-union, and deformity, can occur even when patients are being watched in a non-operative environment. When treating distal radius fractures with conservative treatments, careful observation, regular follow-up, and conversion to surgical intervention are crucial. For displaced and unstable fractures of the distal radius, surgical intervention is a suitable alternative. Even though most patients respond favorably to current fixation procedures, several problems might occur.[2]

Due to its stability, short duration of immobilization, and quick return to prior active life, plate fixation retains its value. In recent years, the care of distal radius fractures has seen a rise in the use of locking plate fixations. Functional recovery is encouraged by anatomical restoration of the articular surface and fragment alignment, which also prevents early osteoarthritic alterations. Open reduction has disadvantages such as skin scarring, the potential for tendon damage, the necessity for a second treatment to remove the plate, a greater cost, and a higher technical skill need than using K-wires for percutaneous fixation. Volar plates are utilized to buttress volar fragments in several circumstances, and even dorsal pieces are supported using this method.[1]

K-wires are frequently preferred because they are simple to implant, cause little tissue damage, have atraumatic insertion, and cause reduced edema and stiffness. Less likelihood of infection and improved fracture healing are two other benefits. Lesser rigid fixation, peripheral neurovascular damage, and wire migration are their downsides. [1]

Different surgical approaches have been suggested for treating distal radius unstable intra-articular fractures, however none stood up as significantly better than the others. The best therapy approach to use is still up for debate. In this meta-analysis, we compared the therapy of distal radius fractures using internal plate fixation and Kirschner wire. According to research by Yu et al., due to its benefits, the use of plates has become increasingly common in the management of unstable distal radius fractures. On the one hand, the open technique using a volar approach made fracture fragments well exposed for simple manipulation, which was more beneficial in minimizing compressed or impacted pieces. The fixed-angle and locking screw/hole offered for stronger support and enabled for the fastening of the little pieces.[3]

In the early postoperative period, volar locking-plate fixation reduces function loss and improves range of motion, according to research by Karantana et al.[6] At twelve weeks or one year, they found no functional advantage to the volar locking-plate treatment. The plate group consistently had greater grip strength, a secondary objective, although functional scores did not reflect this. Although open reduction and internal fixation in the wrist have gained popularity due to the enthusiasm for anatomical reduction, there is no concrete proof that these procedures are necessary for successful outcomes. It is unlikely that the debate over the long-term significance of different levels of extra-articular malunion will be settled anytime soon.[4]

Improved DASH scores, range of motion, and strength were also seen in the early postoperative period in the plate group, according to Nandyala et al.[8] The authors concluded that ORIF with a volar plate should be taken into consideration for patients who need a quicker return to function following surgical intervention,

even though this difference was not maintained at 1 year. The recommendation's financial effects, however, were not investigated.[5]

Study by Goehre et al[4] have demonstrated that patients treated with either of these techniques had a comparable functional outcome after a year in this comparison of palmar fixed-angle plate fixation and K-wire fixation for fractures of the distal radius in patients older than 65 years. During the first several months after plate fixation, there was a functional advantage: patients were able to resume daily activities 4 weeks earlier than those who underwent K-wire fixation. Osteosynthesis's primary stability is the root reason of this. The cast, which had been taken off for occupational therapy by the therapists, was given to the K-wire fixation group. We regarded the workout stability of the K-wire fixation. Both techniques allow for the anatomical reconstruction of the wrist, with the K-wire fixation method resulting in a slight reduction in reduction.[6]

The therapy of elderly individuals with unstable distal radius fractures of types A2, A3, and C1 can be accomplished using either technique. Due to the earlier return to everyday activities that is seen with this technique, palmar fixed-angle plate fixation is the optimum treatment if early functional postoperative care is needed. K-wire fixation, on the other hand, is a good minimally invasive substitute with equivalent clinical outcomes.[6]

Franceschi et al.[9] found that each treatment had advantages and disadvantages. Additional benefits of fixed-angle plates include the maintenance of the periosteal blood supply, support for subchondral bone and articular fragments, application in the presence of osteoporosis and metaphyseal comminution, and use of bone grafts to fill the space left by metaphyseal impaction. Additionally, comminuted distal radius fractures may be stabilized with satisfactory clinical and radiological outcomes with volar locking plates. Finally, VLP may enable early patient mobilization, preventing muscle weakening and joint stiffness. At the last follow-up, Kirschner wire fixing also offers outstanding outcomes that are comparable to plating.[7]

Based on comparing counts in groups, a study by Costa et al. (2014)[5] demonstrated that there was no evidence to imply that rates for any of the reported problems (such as wound infections) changed between treatment groups. Fortunately, there weren't many issues, and it's crucial to remember that the trial wasn't designed to look for differences in complications per se. There may still be differences in the specific complications, even though it is doubtful that the total rate of complications between K-wire fixation and locking-plate fixation would differ significantly. This makes sense naturally. Given that wires are frequently placed directly through the skin, which is a bacterially contaminated surface, one may anticipate that the rate of superficial infection will be higher in the wire group compared to the locking-plate group. Volar plates are utilized in a few circumstances to buttress volar fragments, and even dorsal pieces are supported using this method. K-wires are frequently used because they are simple to use, cause less tissue damage, are inserted without stress, cause less edema, and are less rigid. Other benefits include a decreased risk of infection and improved fracture healing. Their disadvantages include less severe rigid fixation, peripheral neurovascular injury, and wire migration.[8,9]

CONCLUSION

In this meta-analysis, 6 studies were used ranging from 2013 to 2019 which discussed the comparison of the treatment of distal radius fractures with plates and with wire. Based on the results of the forest plot, there was no difference in the DASH score (-1.46; 95% CI=3.09-(-0.16), p=0.08) and grip strength (2.28; 95% CI=-0.13-4.70, p=0.06) in the two groups. There were fewer complications when using the plate with an Odd Ratio of 0.31 (95% CI=0.22-0.43, p<0.00001). Based on the evaluation of

wrist ROM after one year, it was found that there were no significant differences in ROM flexion, extension and pronation. There was a difference in ROM in supination with a greater difference in the wiring group with a difference of 9.75 (95% CI=4.75-15.23, p<0.05).

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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