Complications of Distal Radius Fractures in the Elderly: A systematic review and meta-analysis

Authors:

Paul Kooner[1], BSc

Rajeshwar S Sidhu[2], MS (Ortho)

Joy C. MacDermid[3], BScPT, PhD

Ruby Grewal[4], MD, MSc, FRCSC

1 Medical Student
Division of Orthopedic Surgery
University of Western Ontario,
Roth|McFarlane Hand and Upper Limb Center,
St Joseph's Health Care, London, Ontario, Canada
E-mail: kooner.paul@gmail.com

2 Senior Registrar
Department of Orthopedics
Sidhu Hospital, Ludhiana, Punjab, India
E-mail: rajeshwarsidhu@gmail.com

3 Professor
Roth|McFarlane Hand and Upper Limb Center Clinical Research Laboratories,
St Joseph's Health Centre,
Western University
London, Ontario, Canada
E-mail: jmacderm@uwo.ca

4 Associate Professor
Division of Orthopedic Surgery,
Western University
Roth|McFarlane Hand and Upper Limb Centre,
St Joseph's Health Centre, London, Ontario, Canada
E-mail: rgrewa@uwo.ca

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Abstract:

Purpose: Optimal treatment for elderly patients with distal radius fractures has remained controversial as the benefits and risks of surgical fixation are less clear than for a younger patient. Since complication rates can be unstable in small studies, synthesis may provide more accurate risk estimates. The purpose of this review was to assess the complications associated with the treatment of distal radius fractures in elderly patients through a systematic review and meta-analysis of the literature.

Methods: A PubMed, Medline, and Cochrane database search was conducted to identify articles for review. A broad search strategy using the keywords "complications" or "adverse events" and "distal/radius/wrist/colles/smith fractures" and "elderly" was used for data extraction. Only English language articles published between January 1996 and December 2016 (within the past 20 years) were considered for review.

Results: Based on our inclusion/exclusion criteria 20 studies were included for analysis. Sackett level of evidence (LOE) studies included were: 3 level one, 6 level two, 2 level three and 9 level four studies. There were 6 randomized control trials, 3 prospective cohorts, 2 case controls and 9 retrospective case series studies identified. The incidence of complications (i.e. requiring intervention) was significantly higher in the operative group (129/1095, 11.8%) versus the non-operative group (40/483, 8.3%) (p=0.008). External fixation (51/227, 22.5%) had significantly higher complication rates when compared to other fixation methods except dorsal plating (3/15, 20%). Percutaneous pinning (1/83, 1.2%) had significantly lower major complications compared to volar locked plating (VLP) (14/86, 16.3%). Furthermore, percutaneous pinning (0/83, 0%) had significantly less reoperation rates when compared to the VLP group (11/86, 12.8%) (p=0.006).

Conclusion: Given that complication rates are less with percutaneous pinning than plating, this minimally invasive fixation may have advantages for fixation of fractures in older adults.

1. Introduction

Distal radius fractures (DRFs) are one of the most common orthopedic injuries sustained by the elderly population.[1] These fractures are frequently the result of a low energy fall from standing height. In the United States, as many as 370 000 individuals 65 years of age and older sustain this type of fracture every year.[2,3] Despite the prevalence of DRFs amongst the elderly, the optimal management is not yet defined. While malunions are less likely to result in poor outcomes in this population[1], there is a subset of patients, typically active elderly patients, whose physical demands are such that malunions are not well tolerated. The method of fixation after a DRF is typically left to surgeon discretion as the literature has not shown one technique to be superior to another.[4-9] Volar locked plating is the most commonly used technique[10], although it has not been shown to yield superior results in this population.[7,8]

With similar outcomes reported for different management strategies, complication profiles may provide information that can be used to help guide treatment decisions. The purpose of this review was to assess the complications associated with the treatment of distal radius fractures in the elderly patients through a systematic review and meta-analysis of the literature.

2. Materials & Methods

Study selection was carried out by two authors who independently searched the PubMed, Medline, and Cochrane databases to identify articles for review. A broad search strategy using the keywords "complications" or "adverse events" and "distal/radius/wrist/colles/smith fractures" and "elderly" were used for data extraction. Due to the advancement of treatment options in DRFs, only English language articles published between January 1996 and December 2016 (within the past 20 years) were considered relevant for review.

For inclusion, studies had to meet the following criteria: must be original articles (i.e. no meta-analysis), reporting on any variants of distal radius fractures and were Sackett level of evidence 1 to 4. Results reported for patients must be aged 50 years or older, with a minimum follow-up of 6 months, and who had reported complications after treatment.

Specific exclusion criteria were as follows: articles with less than 20 subjects; did not report on outcomes or complications of treatment; included concurrent or associated injuries with distal radius fractures. Sackett level 5 evidence studies including: expert opinion, cadaveric, biomechanical, individual case studies, review, technical and epidemiological papers were excluded.

In total, 1,229 English articles were identified through the literature search. Two authors independently screened the titles and abstracts using the inclusion and exclusion criteria. These results omitted 1,196 articles leaving 33 for subsequent full text review. Of these remaining articles, additional 13 were excluded. Any controversy or disagreement was resolved by the senior author by discussion and consensus. This left 20 articles for evaluation and inclusion into our systematic review. A diagram outlining our search and filtered results are illustrated in figure 1.

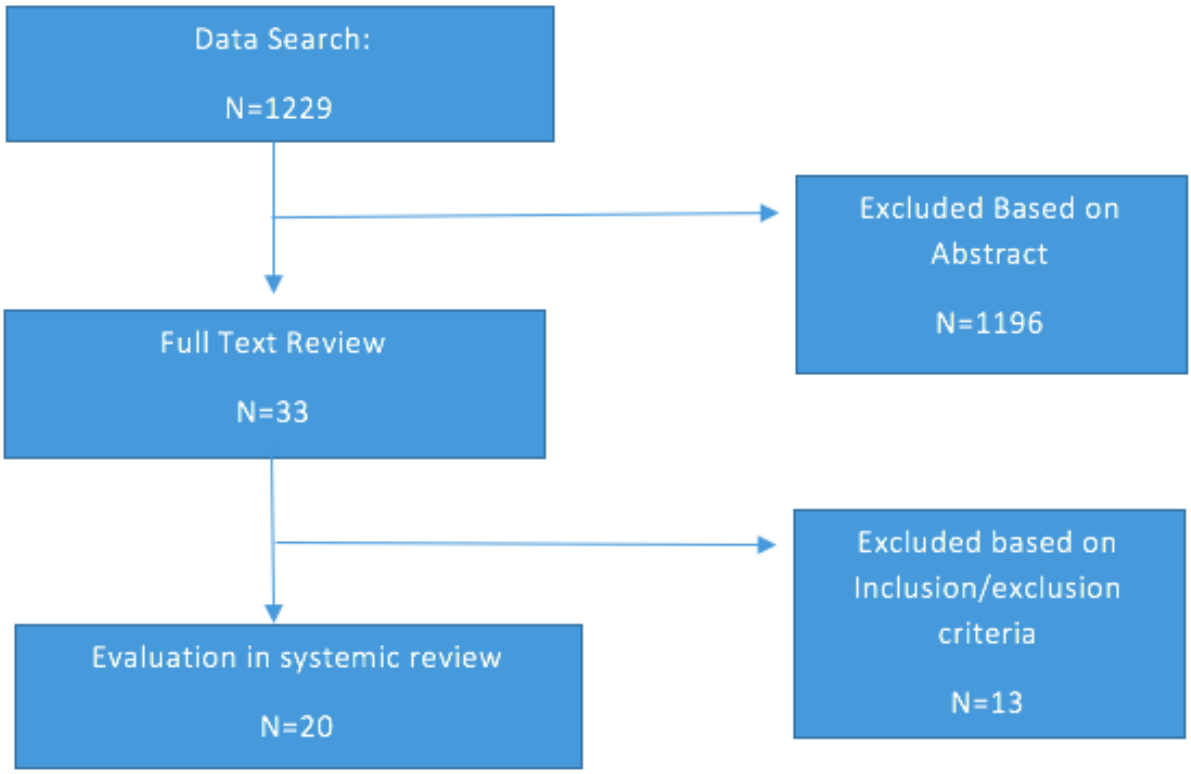

Figure 1. Flow Diagram of Search Results.

Two authors extracted and summarized data from the included studies as follows: sample size, type of intervention used, complications, clinical and radio-graphic outcomes. As complications were the primary outcome of this review, a validated complication checklist developed by McKay and colleagues[11] was used to standardize data extraction. The checklist classifies DRF complications and allows for the assessment of severity of each complication. A grade of mild (1), moderate (2), or severe (3) was assigned to each complication based on its characteristics as outlined in table 1. Grades 2 and 3 complications were considered serious, as they required further treatment or intervention. All serious complications for each treatment arm were compared between level of evidence 1 and 2 studies, randomized control trials, and all studies in this review.

Table 1. Distal Radius Fracture Complication Checklist and Score Sheet.[11]

Scoring: Mild 1, Moderate 2, Severe 3

Nerve complications:

- Median nerve compression/carpal tunnel syndrome

Mild—symptoms only, no specific treatment (1)
Moderate—diagnostic procedure (EMG) and/or treatment (physiotherapy, splint) (2)
Severe—surgery required (3)

- Radial nerve compression/neuropathy

Mild—symptoms only, no specific treatment (1)
Moderate—diagnostic procedure (EMG) and/or treatment (physiotherapy, splint) (2)
Severe—surgery required (3)

- Reflex sympathetic dystrophy (including abnormal pain, stiffness, and vasomotor symptoms)

Mild—symptoms only, no specific treatment (1)
Moderate—symptoms and treatment (physiotherapy, 1–2 stellate ganglion blocks) (2)
Severe—more than 2 stellate ganglion blocks (3)

- Ulnar nerve compression/neuropathy

Mild—symptoms only, no specific treatment (1)
Moderate—diagnostic procedure (EMG) and/or treatment (physiotherapy, splint) (2)
Severe—surgery required (3)

Bone/joint complications:

- Arthritis

Mild—slight joint changes (minute osteophytes) (1)
Moderate—sclerosis, osteophytic changes, narrowed joint space (2)
Severe—large cysts, almost obliterated joint space (3)

- Carpal instability/subluxation

Mild—symptoms only, no specific treatment (1)
Moderate—treatment (physiotherapy, splint) (2)
Severe—surgery required (3)

- Delayed union

Moderate—resolved within 6 months (2)
Severe—nonunion of fracture (3)

- Distal radioulnar joint problems

Mild—pain on axial loading, instability with activity, resolved without specific treatment (1)
Moderate—pain with axial loading/activity, specific diagnosis, resolved with treatment (2)
Severe—persistent arthritis/instability limiting activity with specific diagnosis (3)

Tendon complications:

- Dupuytren's contracture

Mild—nodules present, no contracture (1)
Moderate—nodules and contracture present, no surgery required (2)
Severe—contracture surgery required (3)

- Tendon adhesions/scarring

Mild—symptoms only, no specific treatment (1)
Moderate—treatment (physiotherapy, injected steroids) (2)
Severe—surgery required (3)

- Tendon rupture—extensor pollicis longus

Severe—surgery required (3)

- Tendon rupture tear—other

Mild—symptoms only, no specific treatment (1)
Moderate—treatment (physiotherapy, splint) (2)
Severe—surgery required (3)

- Tendonitis/tenosynovitis

Mild—symptoms only, no specific treatment (1)
Moderate—treatment (physiotherapy, injected steroids) (2)
Severe—surgery required (3)

- Trigger finger

Mild—symptoms only, no specific treatment (1)
Moderate—treatment (physiotherapy, injected steroids, surgery) (2)

Other complications:

- Compartment syndrome

Severe—surgical fasciotomy required (3)

- Miscellaneous

Mild—symptoms only, resolved without specific treatment (1)
Moderate—diagnostic procedure and/or resolved with treatment (2)
Severe—persistent despite treatment or surgery required (3)

- Pin site/incision infection

Mild—resolved without specific treatment (1)
Moderate—resolved with treatment (2)

Total number of complications
Total score (sum of all complication scores)

Secondary outcomes of this review assessed clinical outcomes after the treated fracture. Clinical outcomes were measured as Disabilities of the Arm, Shoulder, and Hand (DASH) score, and reoperation rates of each intervention. These variables were chosen because they were the most consistently reported variables in majority of the articles included for review.

Critical appraisal of the included studies was conducted by two authors using the previously described Structured Effectiveness Quality Evaluation Scale[12] (SEQES), as seen in table 2. The SEQES score rates the quality of the article through a checklist of seven categories: study question, study design, subjects, intervention, outcomes, analysis, and recommendations. Each category has several criteria each of which received a score of 0, 1, or 2 indicating if the criterion was not met at all, partially met or fully met respectively. The final SEQES score was then used to designate a high-, moderate-, or low-quality assessment of each study. High quality studies had SEQES scores between 33 to 48, moderate quality studies had scores between 17 to 32, and low quality studies had scores <16. The level of evidence of each study was also graded 1 to 4 based on the Sackett level of evidence scale.[13]

Table 2. Structured Evaluation Quality Effectiveness Scale.[12]

Study question:

1. Was relevant background work cited to establish a foundation for the research questions?

Study design:

2. Was a comparison group used?

3. Was patient status at more than one time point considered?

4. Was data collection performed prospectively?

5. Were patients randomized to groups?

6. Were patients blinded to the extent possible?

7. Were treatment providers randomized to the extent possible?

8. Was an independent evaluator used to administer the outcome measures?

Subjects:

9. Did sampling procedures minimize sample/selection biases?

10. Were inclusion/exclusion criteria defined?

11. Was an appropriate enrollment obtained?

12. Was appropriate retention/follow-up obtained?

Intervention:

13. Was the intervention applied according to established principles?

14. Were biases due to the treatment provider minimized?

15. Was the intervention compared to the appropriate comparator?

Outcomes:

16. Was an appropriate primary outcome defined?

17. Was an appropriate secondary outcomes considered?

18. Was an appropriate follow-up period incorporated?

Analysis:

19. Was an appropriate statistical test(s) performed to indicate differences related to the intervention?

20. Was it established that the study had significant power to identify treatment effects?

21. Were the size and significance of the effects reported?

22. Were missing data accounted for and considered in interpreting results?

23. Were clinical and practical significance considered in interpreting results?

Recommendations:

24. Were the conclusions/clinical recommendations supported by the study objectives, analysis, and results?

Scoring methodology:

0—criterion was not met

1—criterion was partially met

2—criterion was fully met

Total quality score:

Low (0 to 16)

Moderate (17 to 32)

High (33 to 48 points)

3. Statistical Analysis

All major complications (grade 2 and 3) were synthesized into a categorical variable (major complication yes/no). A chi square test and post hoc testing was used to determine significant differences between groups. Level of significance was set as $p<0.05$, with a correction used in instances where multiple comparisons were made.

4. Results

We identified 1,229 articles in the primary search, and 33 studies for full text evaluation. Based on our exclusion criteria, 13 were eliminated leaving 20 for analysis (figure 1). Sackett level of evidence (LOE) studies included were: 3 level one, 6 level two, 2 level three and 9 level four studies. There were 6 randomized control trials, 3 prospective cohorts, 2 case controls and 9 retrospective case series studies identified. These results along with SEQES scores are summarized in table 3.

Table 3. Search Results and SEQES Scores.

Year	Title	Authors	Journal	Study Design	Sackett LOE	SEQES
2016	External fixation is more suitable for intra-articular fractures of the distal radius in elderly patients.	Ma C, Deng Q, Pu H, Cheng X, Kan Y, Yang J, Yusufu A, Cao L	Bone Res.	Prospective	2	44
2016	Volar locking plate vs epibloc system for distal radius fractures in the elderly.	Solarino G, Vicenti G, Abate A, Carrozzo M, Picca G, Colella A, Moretti B	Injury.	Retrospective	4	32
2015	Is locking plate fixation a better option than casting for distal radius fracture in elderly people?	Hung LP, Leung YF, Ip WY, Lee YL.	Hong Kong Med J	Retrospective	4	30
2014	Complications associated with operative versus nonsurgical treatment of distal radius fractures in patients aged 65 years and older.	Lutz K, Yeoh KM, MacDermid JC, Symonette C, Grewal R.	J Hand Surg Am	Case control	3	36
2014	Comparison of palmar fixed-angle plate fixation with K-wire fixation of distal radius fractures (AO A2, A3, C1) in elderly patients.	Goehre F, Otto W, Schwan S, Mendel T, Vergroesen PP, Lindemann-Sperfeld L.	J Hand Surg Eur	RCT	2	44
2014	The treatment of displaced intra-articular distal radius fractures in elderly patients.	Bartl C, Stengel D, Bruckner T, Gebhard F	Dtsch Arztebl Int	RCT	2	39
2014	Comparison between cast immobilization versus volar locking plate fixation of distal radius fractures in active elderly patients	Chan YH, Foo TL, Yeo CJ, Chew WY.	Hand Surg	Retrospective	4	29
2012	Distraction plating for the treatment of highly comminuted distal radius fractures in elderly patients.	Richard MJ, Katolik LI, Hanel DP, Wartinbee DA, Ruch DS	J Hand Surg Am	Retrospective	4	25
2011	A prospective randomized trial comparing nono perative treatment with volar locking plate fixati on for displaced and unstable distal radial fractu res in patients sixty-five years of age and older.	Arora R, Lutz M, Deml C, Krappinger D, Haug L, Gabl M.	J Bone Joint Surg Am	RCT	1	47
2010	Distal radial fractures in the elderly: operative compared with non-operative treatment.	Egol KA, Walsh M,	J Bone Joint Surg Am	Case control	3	32
2010	Unstable distal radius fractures in the elderly patient--volar fixed-angle plate osteosynthesis prevents secondary loss of reduction.	Figl M, Weninger P, Jurkowitsch J, Hofbauer M, Schauer J,	J Trauma	Retrospective	4	22

		Leixnering M Romo-Cardoso S, Dorsky S, Paksima N.				
2010	Extension fractures of the distal radius in patients older than 50: a prospective randomized study comparing fixation using mixed pins or a palmar fixed-angle plate.	Marcheix PS, Dotzis A, Benkö PE , Siegler J, Arnaud JP, Charissoux JL	J Hand Surg Eur	RCT	1	40
2010	Comparison between external fixation and cast treatment in the management of distal radius fractures in patients aged 65 years and older.	Aktekin CN, Altay M, Gursoy Z, Aktekin LA, Ozturk AM, Tabak AY.	J Hand Surg Am	Retrospective	4	30
2010	Casting versus percutaneous pinning for extra-articular fractures of the distal radius in an elderly Chinese population	Wong TC, Chiu Y, Tsang WL, Leung WY, Yam SK, Yeung SH.	J Hand Surg Eur	RCT	1	43
2009	A comparative study of clinical and radiologic locking plating. outcomes of unstable colles type distal radius fractures in patients older than 70 years: non-operative treatment versus vlp	Arora R, Gabl M, Gschwentner M, Deml C, Krappinger D, Lutz M.	J Orthop Trauma	Retrospective	4	29
2008	Comparative Outcomes Study Using VLP for Distal Radius Fractures in Both Young Adults and Adults Older Than 60 Years	Chung KC, Squitieri L, Kim HM.	J Hand Surg Am	Prospective	2	28
2008	A randomised clinical study comparing palmar and dorsal fixed-angle plates for the internal fixation of AO C-type fractures of the distal radius in the elderly.	Jakubietz RG, Gruenert JG, Kloss DF, Schindele S, Jakubietz MG.	J Hand Surg Eur	RCT	2	34
2007	A comparative study of clinical and radiological outcomes of dorsally angulated, unstable distal radius fractures in elderly patients: intrafocal pinning versus volar locking plating.	Oshige T, Sakai A, Zenke Y, Moritani S, Nakamura T.	J Hand Surg Am	Prospective	2	34
2007	Arthroscopically assisted reduction with volar plating or external fixation for displaced intra-articular fractures of the distal radius in the elderly patients.	Hattori Y, Doi K, Estrella EP, Chen G.	Hand Surg	Retrospective	4	30
2004	Volar fixed-angle plate fixation for unstable distal radius fractures in the elderly patient.	Orbay JL, Fernandez DL.	J Hand Surg Am	Retrospective	4	33

The incidence of complications requiring intervention (grades 2 and/or 3), either surgical or non-surgical, was significantly higher in the operative group (129/1095, 11.8%) versus the non-operative group (40/483, 8.3%) (p=0.008). When comparing all studies, external fixation (51/227, 13.1%) had significantly higher major complication rates than all other fixation methods except dorsal plating (3/15, 20%); VLP (64/674 9.5%), cast immobilization (40/483 8.3%), percutaneous pinning (9/146, 6.2%), and distraction plating (2/33, 6.1%) ($p<0.00008$) (Table 4).

Table 4. The Incidence of Complications Requiring Intervention in All Studies.

Treatment Method	Complications	Total Sample Size	Percentage	p value
Dorsal plate	3	15	20%	0.24
Ex fix	51	227	**13.1%**	**0.00001**
VLP	64	674	9.5%	0.18
Cast	40	483	8.3%	0.04
Perc pinning	9	146	6.2%	0.06
Distraction plating	2	33	6.1%	0.38

When comparing data from LOE 1 papers only, percutaneous pinning (1/83, 1.2%) had significantly lower major complications compared to volar locked plating (14/86, 16.3%) (p=0.002) (Table 5).

Table 5. The Incidence of Complications Requiring Intervention in LOE 1 Studies.

Treatment Method	Complications	Total Sample Size	Percentages	p value
VLP	14	86	**16.3%**	**0.003**
Cast	6	67	8.9%	0.98
Perc pinning	1	83	**1.2%**	**0.002**

Looking at all the randomized controlled trials (LOE 1 and 2), percutaneous pinning (4/102, 3.9%) showed the lowest complication rates when compared to other fixation methods; VLP (27/206, 13.1%), dorsal plating (3/15, 20%), cast immobilization (6/67, 9.0%). However, this did not reach significance.

The most severe complications required reoperation and these rates were compared amongst each group. In all studies, plate fixation (volar (35/674, 5.2%) and dorsal (3/15, 20%)) had significantly higher rates of reoperation when compared to all other fixation methods (p=0.0003) (Table 6).

Table 6. Reoperation Rates in All Studies.

Treatment Method	Reoperation	Total Sample Size	Percentages	p value
Dorsal plate	3	15	**20%**	**0.0003**
VLP	35	674	**5.2%**	**0.0003**
Distraction plating	1	33	3.0%	0.93
Perc pinning	3	146	2.1%	0.38
Cast	8	483	1.7%	0.02
Ex fix	2	227	0.8%	0.03

Furthermore, volar locked plating showed significantly less reoperation rates when compared to dorsal locked plating (p=0.0003). In LOE 1 studies, percutaneous pinning (0/83, 0%) had significantly less reoperation rates when compared to the VLP group (11/86, 12.8%) (p=0.006). In all of the randomized controlled trials, plate fixation (volar (16/206, 7.8%), dorsal (3/15, 20%)) had significantly higher reoperation rates when compared to percutaneous pinning (0/102, 0%) and cast immobilization (0/157, 0%) (p=0.0002). Secondary clinical outcomes such as DASH and other functional assessment scores are shown in table 7.

Table 7. Clinical Outcomes.

	Authors	Study Design	Intervention	Outcomes	Pain
1	Ma C et al.	Prospective	a: Ex fix b: Plate	a: DASH: 18.8 b: DASH: 16.8	a: VAS 1.73 b: VAS: 1.65
2	Solarino et al.	Retrospective	a: Epibloc b: Plate (VLP)	a: DASH: 25.8, Demerit: 10.0 b: DASH: 11.0, Demerit: 6.2	a: VAS: 1.43 b: VAS: 1.0
3	Hung LP et al.	Retrospective	a: Plate b: Cast	a: DASH: 4.5 b: DASH: 13.6	
4	Lutz K et al.	Prospective/ Retrospective	a: Operative (Exfix, Plate, Pinning) b: Cast	a: PRWE: 17 b:PRWE: 16	
5	Goehre et al.	Prospective RCT	a: Plate (VLP) b: Pinning	a: DASH: 2, PRWE: 2 b: DASH: 2, PRWE: 2	
6	Bartl et al.	RCT	a: Plate (VLP) b: Cast	a: DASH: 14, EQ-5D VAS:76.9 b: DASH 19, EQ-5D VAS: 73.9	
7	Chan et al.	Retrospective	a: Plate (VLP) b: Cast	a: DASH: 6.7 b: DASH: 6.2	
8	Richard et al.	Retrospective	Plate (Distraction)	DASH: 32	
9	Arora et al. 2011	Prospective RCT	a: Plate (VLP) b: Cast	a: DASH: 5.7, PRWE: 12.8 b: DASH: 8.0, PRWE: 14.6	a: rest: 0.1, stress: 0.7 a: at rest: 0.1, stress: 0.6
10	Egol et al.	Case control	a: Operative (Ex fix + Plate) b: Cast	a: DASH: 10 b: DASH: 12.1	a: VAS: 1.2 b: VAS: 1.5

11	Figl et al.	Retrospective	Plate (VLP)	DASH: 28	VAS rest: 3.1, stress: 3.4
12	Marcheix et al.	Prospective RCT	a: Pinning b: Plate (VLP)	a: DASH: 22 b: DASH: 10	
13	Aktekin et al.	Retrospective	a: Ex fix b: Cast	a: DASH 21.9 b: DASH 20.3	
14	Wong et al.	RCT	a: Pinning b: Cast	a: mayo wrist score- 82 b: mayo wrist score- 80	
15	Arora et al. 2009	Retrospective	a: Plate (VLP) b: Cast	a: DASH 11.1 (0–17.4) b: DASH 11.6 (0–18.1)	
16	Chung et al.	Prospective	Plate (VLP)	MHQ score-85	
17	Jakubietz et al.	RCT	a: Plate (Dorsal) b: Plate (Volar)		a: VAS 3.1 b: VAS 1.2
18	Oshige et al.	Prospective	a: Pinning b: Plate (VLP)		
19	Hattori et al.	Retrospective	a: Ex fix b: Plate (VLP)	DASH (all) 13.8	
20	Orbay et al.	Retrospective	Plate (VLP)	DASH- 8.28	

5. Discussion

Currently, there remains no consensus regarding the most appropriate treatment for distal radius fractures in elderly patients.[4-9] If there is no significant difference between treatment method and clinical outcomes, potential complications become more critical in deciding the treatment strategy to recommend. In this review, 1,578 patients of the elderly population were evaluated for complications after treatment of distal radius fractures.

Our meta-analysis shows that operative treatment is associated with higher rates of complications when compared to non-operative management and these results are consistent with previously reported literature.[7,11,14,15] With each complication, there is an associated loss in quality of life, as there is an increased number of follow-up appointments, treatment costs and patient morbidity.[16]

There is an increasing popularity in the use of open reduction and internal fixation with plates and screws. Chan et al.[17] suggests that elderly patients who undergo ORIF regain functional outcomes faster, thus expediting recovery and return to independent living sooner. However, long-term results after operation are not statistically significant. Our results show that ORIF is associated with the highest rates of reoperation due to major complications when compared to other fixation methods. Of the most common complications that may arise; tendon rupture, tendonitis, and carpal tunnel syndrome were the most associated with a secondary surgery. Within the ORIF group, volar locked plating was shown to be a superior fixation method to dorsal locked plating as there were significantly less complications leading to reoperation. With no literature suggesting ORIF to be an optimal treatment modality, the higher risk of reoperation due to major complications should be considered when making treatment decisions in this population.

When compared to internal fixation, percutaneous pinning was shown to have significantly lower major complications and reoperation rates. Furthermore, percutaneous pinning is associated with substantially lower costs, as it is found to be 3 times cheaper when compared to internal fixation.[18] With no long term differences between these two treatments, percutaneous pinning offers a cheaper, less invasive treatment option with a lower complication profile. Of the major complications seen, pin tract infections were most common, all of

which were treated with a course of oral antibiotics. The most severe complications noted were tendon ruptures of the extensor pollicus longus; however, literature shows that internal fixation has a 6-fold higher risk of tendon rupture when compared to other fixation methods.[19]

Traditional treatment of DRFs in the elderly consists of closed reduction and cast immobilization. Bartl et al.[7] reported that mobility, functionality and quality of life provide marginal and inconsistent evidence for choosing operation over cast immobilization. Furthermore, literature suggests patients 65 years and older can tolerate higher degrees of malalignment while maintaining a good functional outcome.[20,21] Our results show that cast immobilization is associated with significantly less major complications when compared to the operative group. This highlights the preference of conservative management when considering DRFs in this population. In the casting group, the most common complications necessitating further intervention were carpal tunnel and complex regional pain syndromes.

External fixation was associated with significantly higher complication rates when compared to other fixation methods. Major complications included: pin tract infection, tendon rupture and complex regional pain syndrome. With equivocal treatment outcomes, a higher complication profile may limit the use of external fixation as a primary treatment option of DRFs.

Percutaneous pinning may offer an ideal solution for this population. Being a minimally invasive intervention, with only a small number of associated major complications, it offers the ability to somewhat restore alignment without the reoperation risks associated with either volar or dorsal plating.

This meta-analysis has several limitations. Complication profiles alone may not warrant the use of one treatment arm over the other. Clinical and radiographic outcomes need to be considered when making such decisions. The risk of bias and heterogeneity is a concern in any review of this type, as underlying differences in study design, fracture severity, variations in surgical technique, outcome measurement methods and length of follow up periods may be reported inconsistently throughout all studies. Complications were reported in highly variable ways across studies and we could only extract what was published. By using the previously validated complication checklist, SEQES score, Sackett level of evidence scale and the most consistently reported outcomes, we aim to minimize potential sources of heterogeneity.

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