

A Meta-analysis Study of Acute Undisplaced Scaphoid Fractures Management

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ABSTRACT

Managing scaphoid fractures varies among hospitals and depends upon local preferences and protocols. This study aimed to perform a meta-analysis to compare the results of conservative management of acute scaphoid fracture versus the surgical management. Patients and methods: This meta-analysis study restricted to RCT, and comparative studies, either prospective or retrospective, which studied the outcome of percutaneous fixation by cannulated screw versus conservative treatment with casting in patients with acute undisplaced scaphoid fractures. Results: We filtered 250 record; leaving 9 studies that met all inclusion criteria. The total number of patients in all the included studies was 589 patients; 308 of them had conservative cast management (conservative group), and 281 patients had percutaneous fixation by cannulated screw (surgical group). We found all 9 studies reported successful union rate, with total number of patients (N=589). Our meta-analysis study showed that; overall (successful union rate) in surgical group was 98.4%, while in conservative group was 92.8%. Meta-analysis of (non-union "failure"), fixed and random-effects models showed highly significant decrease in non-union "failure" rate in the experimental group compared to conservative group ($p=0.002$, $p=0.019$ respectively). Conclusion: Surgical management of non-displaced scaphoid fractures, was considered superior to conservative cast management, in union rate, early time of union, but the 2 approaches were comparable regarding the rate of complications.

Keywords: Undisplaced Scaphoid Fractures; Heterogeneity; Meta-analysis Study

INTRODUCTION

The scaphoid is the most commonly fractured carpal bone, accounting for over 60% of carpal fractures and 11% of all hand fractures in young and active individuals (1). Traditionally, nondisplaced or minimally displaced fractures involving the waist of the scaphoid have been treated by casting with thumb immobilization, but these methods require prolonged immobilization for at least 12 weeks, which may delay rehabilitation and lead to joint stiffness and poor clinical outcomes (2).

Conservative treatment carries risks of non-union of scaphoid fractures (3). Percutaneous screw fixation has increased in popularity with the use of new headless compression screws and better surgical techniques, for which the benefits outweigh the risks (4).

Managing scaphoid fractures varies among hospitals and depends upon local preferences and protocols. However, as a general principle, management involves balancing risk level based on available evidence (5).

How to best manage minimally displaced scaphoid waist fractures remains unclear. Displaced fractures have been described in the literature with fracture gap > 1 mm, but the exact description of minimally displaced fracture is not available in the literature. Therefore, we consider a minimally displaced fracture as one with ≤ 1 mm gap (6).

This study aimed to perform a meta-analysis to compare the results of conservative management of acute scaphoid fracture versus the surgical management.

PATIENTS AND METHODS

An initial search was carried out using the PubMed, Cochrane library and JBJS (Journal of Bone & Joint Surgery) & Google scholar using the following keywords: acute undisplaced scaphoid fractures, percutaneous fixation by cannulated screw, conservative treatment with casting. Review articles and bibliographies of each study identified were searched for additional references that may contain further related studies. When two or more papers were based on an identical study, the paper was used that principally investigated the outcome of percutaneous fixation by cannulated screw versus conservative treatment with casting in patients with acute undisplaced scaphoid fractures.

The study was restricted to RCTs and comparative studies, either prospective or retrospective, which studied the outcome of percutaneous fixation by cannulated screw versus conservative treatment with casting in patients with acute undisplaced scaphoid fractures.

Inclusion criteria:

Articles discussing scaphoid fractures which are: acute scaphoid fractures, non displaced or minimally displaced (<1 mm) and Scaphoid waist fractures. Articles discussing comparison both conservative management, operative management

Exclusion criteria:

Articles describing other types of management of acute scaphoid fractures. Articles in other languages than english. Articles discussing: irreducible fractures, displaced (>1mm) and oblique waist fractures even if undisplaced.

Method:

Locating and selecting studies: Abstracts of articles identified using the above search strategy was viewed, and articles that appear of fulfill the inclusion criteria was retrieved in full.

Data extraction: Using the following keywords: acute undisplaced scaphoid fractures, percutaneous fixation by cannulated screw, conservative treatment with casting, data will be independently extracted by two reviewers and cross-checked.

Evidence of publication bias: Using the funnel plot method. A funnel plot is a simple scatter plot of the intervention effect estimates from individual studies against some measure of each study's size or precision.

Statistical analysis:

Data entry, processing and statistical analysis was carried out using MedCalc ver. 18.2 (MedCalc, Ostend, Belgium). A meta-analysis was performed to calculate direct estimates of treatment effect for each technique. According to heterogeneity of treatment effect across trials using the I²-statistics; a fixed-effect model ($P \geq 0.1$) or random-effects model ($P < 0.1$) was used. Generally, P-values less than 0.05 (5%) was considered to be statistically significant. Chi-Square test was used to examine the relationship between two qualitative variables. Mann-Whitney's Test (U test) was used to assess the statistical significance of the difference of a non-parametric variable between two study groups.

RESULTS

The demographic characteristics and clinical data in all 9 studies showed the included studies published between 2001 and 2015. Regarding the type of surgical procedure; all studies used conservative treatment with casting versus percutaneous fixation by cannulated screw. The total number of patients in all the included studies was 589 patients; 308 of them had conservative cast management (conservative group), and 281 patients had percutaneous fixation by headless screw (experimental group). The average age of all patients was (29.8 ± 2.6 years); with youngest mean age of 24 years in Bond et al. 2001 study; and oldest mean age of 33 years in Saedén et al, 2001 study. Regarding gender, 482 patients were males representing (81.8%) of total patients, while (18.2%) 107 patients were females (**Table 1**). Comparing the 2 groups according to basic clinical, and post-operative outcome variables revealed non-

significant difference as regards number of patients, age and sex of patients ($p > 0.05$) (**Table 2**). We found all 9 studies reported successful union rate in experimental group in fixed and random-effects models were (98.4% and 98.3% respectively) (**Table 3**). Successful union rate in conservative group in fixed and random-effects models were (92.4% and 92.8% respectively). I^2 (inconsistency) was 59%; with significant Q test for heterogeneity ($p < 0.05$); so random-effects model was chosen to assess prevalence; with overall (successful union rate) in conservative group = 92.8% (**Table 4**). Fixed and random-effects models showed highly significant decrease in average time of union in experimental group compared to conservative group ($p < 0.001$ respectively) (**Figure 1**). Fixed-effects model was chosen to assess prevalence; with overall (non-union “failure” rate) in experimental group = 1.2% (**Figure 2**). While, fixed-effects model was chosen to assess prevalence; with overall (non-union “failure” rate) in conservative group = 7.4% (**Figure 3**).

Regarding meta-analysis of (non-union “failure”), fixed and random-effects models showed highly significant decrease in non-union “failure” rate in the experimental group compared to conservative group ($p=0.002$, $p= 0.019$ respectively). I^2 (inconsistency) was 0%; with non-significant Q test for heterogeneity ($p > 0.05$); so fixed-effects model was chosen to assess safety; with overall RR= 0.209, with highly significant increase in safety in the experimental group compared to conservative group ($p = 0.002$) (**Table 5**).

Table (1): Summary of patients and study characteristics:

N	Author	Number of patients	Mean age (years)	Sex	
				Male	Female
1	Bond et al, 2001	25	24	22	3
2	Adolfsson et al, 2001	53	31.5	39	14
3	Saedén et al, 2001	62	33	49	13
4	Papaloizos et al, 2004	94	29	77	17
5	Dias et al, 2005	88	29.3	79	9
6	McQueen et al, 2008	60	29.4	50	10
7	Vinnars et al, 2008	75	30.5	58	17
8	Schädel-Höpfner et al, 2010	94	32.25	77	17
9	Clementson et al, 2015	38	29.5	31	7

#Studies were arranged according to publication year.

Table (2): Comparison between the 2 groups of studies as regards age and sex using Mann-Whitney's U and Chi square tests:

Variable	Experimental group (9 studies)	Conservative group (9 studies)	Mann-Whitney's U test
	Median (IQR)	Median (IQR)	P value
Number of patients	32 (22 – 41)	30 (27 – 41)	= 0.8246
Mean age (years)	29 (28 – 30)	30 (29 – 33)	= 0.1819
Variable	Experimental group (9 studies) N=281	Conservative group (9 studies) N=308	P value Chi square
Sex	Female	50 (17.8%)	= 0.8228
	Male	231 (82.2%)	

IQR: inter-quartile range, N=number of patients underwent this procedure. % per column total.

Table (3): Meta-analysis of successful union rate in experimental group - Proportion:

N	Study	Sample size	Proportion (%)	95% CI	Weight (%)	
					Fixed	Random
1	Bond et al. 2001	11	100	71.509 to 100	4.14	4.65
2	Adolfsson et al, 2001	25	88	68.781 to 97.453	8.97	9.41
3	Saedén et al, 2001	32	100	89.112 to 100	11.38	11.57
4	Papaloizos et al, 2004	32	96.87	83.783 to 99.92	11.38	11.57
5	Dias et al, 2005	44	100	91.958 to 100	15.52	14.96
6	McQueen et al, 2008	30	100	88.430 to 100	10.69	10.97
7	Vinnars et al, 2008	40	100	91.190 to 100	14.14	13.87
8	Schädel-Höpfner et al, 2010	53	100	93.277 to 100	18.62	17.28
9	Clementson et al, 2015	14	100	76.836 to 100	5.17	5.73
	Total (fixed effects)	281	98.432	96.240 to 99.524	100	100
	Total (random effects)	281	98.372	96.400 to 99.578	100	100

Q test for heterogeneity = 9.35, $p = 0.3136$, I^2 (inconsistency) = 14.4%.

Table (4): Meta-analysis of successful union rate in conservative group - Proportion:

N	Study	Sample size	Proportion (%)	95% CI	Weight (%)	
					Fixed	Random
1	Bond et al. 2001	14	100	76.836 to 100	4.73	7.44
2	Adolfsson et al, 2001	28	89.286	71.774 to 97.733	9.15	10.56
3	Saedén et al, 2001	30	93.333	77.926 to 99.182	9.78	10.88
4	Papaloizos et al, 2004	62	95.161	86.504 to 98.991	19.87	13.95
5	Dias et al, 2005	44	75	59.662 to 86.807	14.20	12.58
6	McQueen et al, 2008	30	90	73.471 to 97.888	9.78	10.88
7	Vinnars et al, 2008	35	97.143	85.083 to 99.928	11.36	11.58
8	Schädel-Höpfner et al, 2010	41	97.561	87.145 to 99.938	13.25	12.27
9	Clementson et al, 2015	24	100	85.753 to 100	7.89	9.85
	Total (fixed effects)	308	92.458	88.978 to 95.112	100	100
	Total (random effects)	308	92.800	87.604 to 96.670	100	100

Q test for heterogeneity = 19.664, degree of freedom (DF) = 8, $p = 0.0117^*$, I^2 (inconsistency) = 59.32%.

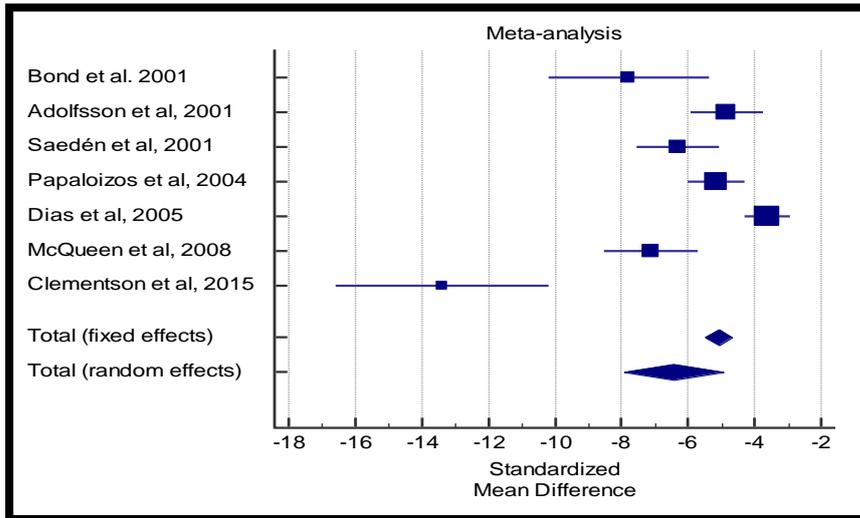


Figure (1): Forest plot of (average time of union) on experimental vs conservative technique usage - Mean difference.

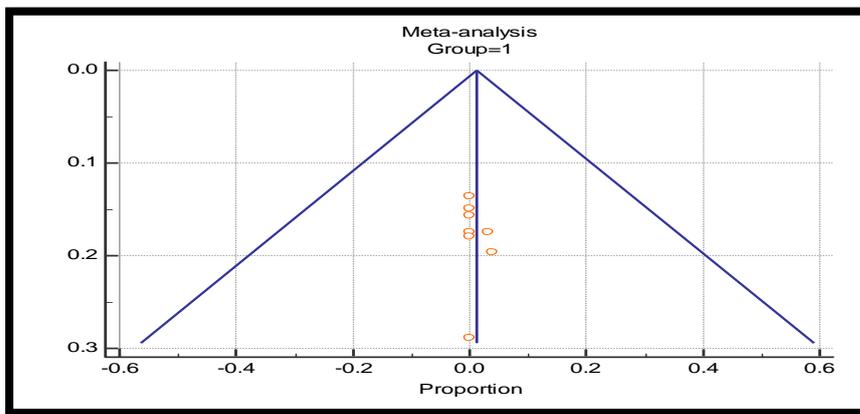


Figure (2): Funnel plot of (non-union “failure” rate) in experimental group – Proportion (publication bias was non-significant).

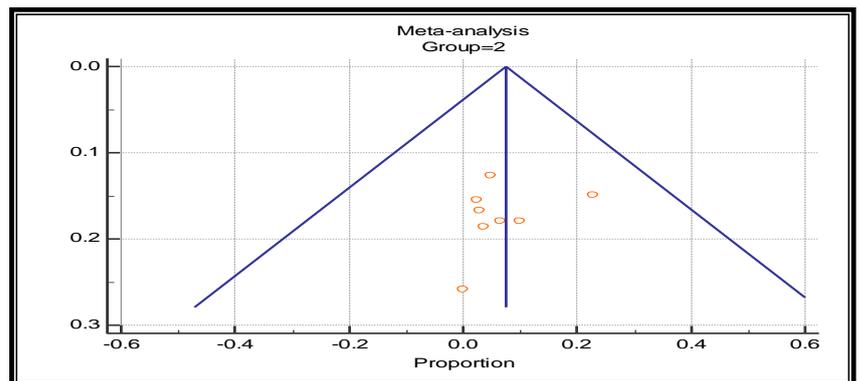


Figure (3): Funnel plot of (non-union “failure” rate) in conservative group – Proportion (publication bias was non-significant).

Table (5): Meta-analysis of (non-union “failure”) on experimental vs conservative technique usage - Risk Ratio:

N	Study	Experim ental	Conserv ative	RR	95% CI	Z	P value	Weight (%)	
								Fix ed	Rand om
1	Bond et al. 2001	0/11	0/14	-					
2	Adolfsson et al, 2001	1/25	1/28	1.12 0	0.0739 to 16.983			15. 17	15.17
3	Saedén et al, 2001	0/32	2/30	0.18 8	0.00939 to 3.761			12. 49	12.49
4	Papaloizos et al, 2004	1/32	3/62	0.64 6	0.0700 to 5.962			22. 69	22.69
5	Dias et al, 2005	0/44	10/44	0.04 76	0.00288 to 0.788			14. 23	14.23
6	McQueen et al, 2008	0/30	3/30	0.14 3	0.00770 to 2.652			13. 14	13.14
7	Vinnars et al, 2008	0/40	1/35	0.29 3	0.0123 to 6.963			11. 16	11.16
8	Schädel-Höpfner et al, 2010	0/53	1/41	0.25 9	0.0108 to 6.204			11. 12	11.12
	Total (fixed effects)	2/267	21/284	0.20 9	0.0788 to 0.552	- 3.1 57	0.002 **	100	100
	Total (random effects)	2/267	21/284	0.28 2	0.0977 to 0.812	- 2.3 45	0.019 **	100	100

Q test for heterogeneity = 3.656, $p = 0.723$, I^2 (inconsistency) = 0% and risk ratio (RR) = 0.209.

DISCUSSION:

This meta-analysis study restricted to RCTs, clinical trials, and comparative studies, either prospective or retrospective, which studied the outcome of percutaneous fixation by cannulated screw versus conservative treatment with casting in patients with acute undisplaced scaphoid fractures. The aim of this systematic review & meta-analysis was to provide cumulative data about the efficacy and safety of percutaneous fixation by cannulated screw versus conservative treatment with casting in patients with acute undisplaced scaphoid waist fractures.

The total number of patients in all the included studies was 589 patients; 308 of them had conservative cast management (conservative group), and 281 patients had percutaneous fixation by cannulated screw (surgical group). The average age of all patients was (29.8 ± 2.6 years); with youngest mean age of 24 years; and oldest mean age of 33 years in **Saedén et al. (7)** study.

Regarding gender, 482 patients were males representing (81.8%) of total patients, while (18.2%) 107 patients were females.

Our meta-analysis results came in agreement with **Alnaeem et al. (8)** studied a systematic review and meta-analysis examining the differences between nonsurgical management and percutaneous fixation of minimally and nondisplaced scaphoid fractures, and reported that, the average ages of different studies ranged between 24 to 34 years with sex-matched participants in different studies.

Regarding comparative analysis of studies included, data were divided into two groups: Surgical group (percutaneous fixation by herbert screw), Conservative group (cast treatment). Then, we started to compare the 2 groups according to basic clinical, and post-operative outcome variables.

Comparative study between the 2 groups revealed non-significant difference as regards number of patients, age and sex of patients ($p > 0.05$). Our results came in agreement with **Clementson et al. (9)** studied conservative treatment versus arthroscopic-assisted screw fixation of scaphoid waist fractures, and reported that, the 2 patient groups were comparable with regard to age, sex, and fracture classification⁽⁵⁵⁾.

We found all 9 studies reported successful union rate, with total number of patients (N=589). Our meta-analysis study showed that; overall (successful union rate) in surgical group was 98.4%, while in conservative group was 92.8%. Our results came in agreement with **Marzouki et al. (10)** studied surgical treatment by percutaneous anterior screw fixation of scaphoid fractures, and reported that, the union rate in surgical group was 95% (20 out of 21 patients).

In agreement with our study, **Shaterian et al. (11)** reported that, scaphoid fractures obtained excellent rates of union at 96.2% across all fractures types and treatment modalities. Patients treated with cast immobilization vs surgery showed no difference in rates of union (96.0% union in cast immobilization group vs 98.1% in surgery group).

Yassin et al. (12) presented a retrospective study of percutaneous fixation of acute scaphoid fractures, came worse than our results, and reported that, fracture union was achieved in only 11 (91.6%) cases.

We found 7 studies reported average time of union, with total number of patients (N=420). Our meta-analysis study showed that; fixed and random-effects models showed highly significant decrease in average time of union in surgical group compared to conservative group ($p < 0.001$ respectively). I^2 (inconsistency) was 90% with highly significant Q test for heterogeneity ($p < 0.01$), so random-effects model was chosen to assess efficacy; with overall SMD= -6.44, with highly significant increase in efficacy in the surgical group compared to conservative group ($p < 0.001$).

Our meta-analysis results came in agreement with **Yassin et al. (12)** conducted a retrospective study of percutaneous fixation of acute scaphoid fractures, and reported that, fracture union in surgical group was achieved at a mean of 8.29 weeks (6–12 weeks).

Our meta-analysis results came in disagreement with **Gurger et al. (13)** studied volar percutaneous screw fixation for scaphoid nonunion, and reported that, the mean time to union was 15.5 weeks (range = 8–30).

Also, our meta-analysis results came lower than that of **Marzouki et al. (10)** who studied surgical treatment by percutaneous anterior screw fixation of scaphoid fractures, and reported that, the mean time to union in surgical group was approximately 13 weeks (12–14).

Li et al. (14) reported 10 RCTs and 4 cohort studies with 765 patients, also reported that, surgical treatment shortened the time to union (SMD= -5.01, 95% CI: -7.47 to -2.58, $P < 0.001$), compared with nonsurgical treatment. Also, subgroup analyses showed that, the percutaneous fixation treatment can shorten the time to union [SMD= -1.82 ,95%CI (-2.22 to -1.42), $P > 0.001$].

de Boer et al. (15) revealed 10 studies with 452 patients, also reported that, time to union was significantly in favor of surgical treatment ($p < 0.001$). The SMD was -4.80 (weeks) (range, -5.15 to -4.44).

We found 8 studies reported non-union or failure rate, with total number of patients (N=551). Our meta-analysis study showed that; overall (non-union “failure” rate) in surgical group was 1.2%, while in conservative group was 7.4%. Our results came in agreement with **Goffin et al. (16)** conducted a large meta-analysis of 11 studies, reported that, non-union rates of conservative cohort ranged from 8% up to 21%, while in surgical cohort ranged from 2% to 4% only.

In disagreement with our results, **Marzouki et al. (10)** reported that, non-union rate in surgical group was 5%, but complications are generally rare and should not be a contraindication to the procedure.

CONCLUSION

Surgical management of non-displaced scaphoid fractures, was considered superior to conservative cast management, in union rate, early time of union, but the 2 approaches were comparable regarding the rate of complications.

No Conflict of interest.

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