

Management of Acute Undisplaced Scaphoid Fractures : A Meta-analysis Study

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ABSTRACT

Scaphoid fractures are common but present unique challenges because of the particular geometry of the fractures and the tenuous vascular pattern of the scaphoid. Delays in diagnosis and inadequate treatment for acute scaphoid fractures can lead to nonunions and subsequent degenerative wrist arthritis. The current study aimed to discuss comparison between non-operative and minimally invasive treatment (percutaneous screw fixation) for acute minimally or undisplaced scaphoid fractures.

Patients and methods: This meta-analysis depend on studies used conservative treatment with casting versus percutaneous fixation by cannulated screw for treatment patients with acute undisplaced scaphoid fractures. **Results:** meta-analysis was done on 9 studies which described and compared the 2 different techniques for management of acute undisplaced scaphoid fractures; with overall number of patients (N=589). We found all 9 studies reported successful union rate, with total number of patients (N=589). We also found 7 studies reported average time of union, with total number of patients (N=420). We also found 8 studies reported non-union or failure rate, with total number of patients (N=551). We also found 6 studies reported AVN “avascular necrosis” rate, with total number of patients (N=388). We calculated efficacy for each technique through (successful union rate) and (average time of union). We calculated safety for each technique through (non-union or failure rate) and (AVN rate). **Conclusion:** Surgical fixation of non-displaced scaphoid fractures is a reliable technique provides satisfactory results with high union and minimal complication rates compared to conservative cast management.

Keywords: Scaphoid Fractures; percutaneous fixation by cannulated screw, conservative treatment with casting

INTRODUCTION

Scaphoid fractures that are believed to be non-displaced first require radiographic follow-up to confirm that the fracture truly is non-displaced. If the fracture displaces, surgery is indicated to reduce the fracture and provide internal stabilization. If it remains non-displaced, cast immobilization is an accepted method of treatment, but it is falling out of favor due to the frequent need for prolonged casting. Treatment recommendations for cast treatment of a nondisplaced scaphoid waist fracture consists of 4 weeks in a long arm thumb spica cast, followed by 6–8 weeks in a short arm thumb spica cast ⁽¹⁾.

Conservative treatment by cast immobilization below the elbow with thumb metacarpophalangeal joint inclusion remains a widely accepted method in the

management of stable scaphoid fractures (A1 and A2) because the rate of healing is considered to be satisfactory. Conservative treatment appears to have an advantage over surgical treatment due to the possibility of numerous surgical complications, but conservative treatment with long immobilization periods results in nonunion from 1.5 to 37 % of the time. Although cast immobilization is associated with low rates of morbidity and long-term disability, the time until patients can resume work and daily activities may also be prolonged compared to surgery ⁽²⁾.

Complications after non-operative treatment include symptomatic pseudoarthrosis, malunion, and osteonecrosis, whereas surgical complications also include symptomatic hardware, neurovascular injury, and persistent pain ⁽³⁾. To avoid such complications, some surgeons recommend early internal fixation even for non-displaced fractures. The technique of percutaneous cannulated screw fixation of non-displaced or minimally displaced scaphoid fractures has been described in both anatomic and clinical studies and has demonstrated promising results. However, the role, benefits, and risks associated with internal fixation of non-displaced or minimally displaced scaphoid fractures remain controversial and have not been established ⁽⁴⁾.

There is no evidence to suggest that surgical treatment of all scaphoid fractures leads to a lower rate of nonunion or early osteoarthritis (OA), and discussion about the treatment of undisplaced stable fractures at the waist of the scaphoid remains controversial ⁽⁵⁾. Unstable fractures require rigid fixation; however, nondisplaced scaphoid waist fractures can be successfully managed with or without surgery. Earlier return to work and shorter immobilization periods with operative treatment have consistently been reported ⁽⁶⁾.

In non-displaced acute scaphoid fractures treated by limited access and screw fixation, the union rate has been reported to be as high as 100%. However, non-displaced stable fractures can be treated by conservative means, since they are likely to heal under sufficiently long immobilization. For active people who are ambitious in making a prompt return to their profession and sports, long wrist immobilization means a relevant reduction of major activities. Thus, they may demand operative treatment even in the presence of uncomplicated scaphoid fractures, which can be treated by plaster cast with good outcomes ⁽⁷⁾.

This study aimed to discuss comparison between non-operative and minimally invasive treatment (percutaneous screw fixation) for acute minimally or undisplaced scaphoid fractures. Also, evaluate the radiological and functional outcome and complications.

PATIENTS AND METHODS

This meta-analysis 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. An initial search was carried out using the PubMed and Google scholar using the following keywords: acute undisplaced scaphoid

fractures, percutaneous fixation by cannulated screw, conservative treatment with casting 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.

Inclusion and exclusion 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. While, 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.

Methodology:

Abstracts of articles identified using the above search strategy was viewed, and articles that appear of fulfill the inclusion criteria were retrieved in full. Data extracted by use 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. 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.

The demographic and clinical data in all 9 studies showed the included studies published between 2001 and 2015. 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

Statistical analysis:

Data was carried out using MedCalc ver. 18.2 (MedCalc, Ostend, Belgium) and meta-analysis was done 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 current meta-analysis showed that; fixed and random-effects models showed highly significant increase in successful union rate in the experimental group compared to conservative group ($p = 0.001$, $p = 0.045$ respectively) (**Table 1**).

We found 7 studies reported average time of union, with total number of patients (N=420). 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) (**Table 2**). 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) (**Figure 1&2**).

We found 6 studies reported AVN “avascular necrosis” rate, with total number of patients (N=388). Fixed and random-effects models showed non-significant difference in AVN rate, between the 2 groups ($p > 0.05$ respectively). I^2 (inconsistency) was 46%; with non-significant Q test for heterogeneity ($p > 0.05$); so fixed-effects model was chosen to assess safety; with overall RR= 0.878, with non-significant difference in safety in the experimental group compared to conservative group ($p > 0.05$) (**Figure 3&4**).

Table (1): Meta-analysis of (successful union) achievement on experimental vs conservative technique usage - Risk Ratio:

N	Study	Experimental	Conservative	RR	95% CI	Z	P value	Weight (%)	
								Fixed	Random
1	Bond et al. 2001	11/11	14/14	-					
2	Adolfsson et al, 2001	22/25	25/28	0.986	0.812 to 1.196			3.53	6.67
3	Saeden et al, 2001	32/32	28/30	1.071	0.957 to 1.199			10.44	13.86
4	Papaloizos et al, 2004	31/32	59/62	1.018	0.936 to 1.107			18.82	18.37
5	Dias et al, 2005	44/44	33/44	1.328	1.116 to 1.581			4.37	7.85
6	McQueen et al, 2008	30/30	27/30	1.109	0.971 to 1.267			7.42	11.33
7	Vinnars et al, 2008	40/40	34/35	1.031	0.955 to 1.112			22.80	19.76
8	Schädel-Höpfner et al, 2010	53/53	40/41	1.027	0.964 to 1.095			32.62	22.16
9	Clementson et al, 2015	14/14	24/24	-					
	Total (fixed effects)	277/281	284/308	1.080	1.033 to 1.129	3.366	0.001**	100	100
	Total (random effects)	277/281	284/308	1.060	1.001 to 1.121	2.009	0.045*	100	100

Q test for heterogeneity = 12.143, degree of freedom (DF) = 6, $p = 0.0588$, I^2 (inconsistency) = 50.6% and risk ratio (RR) = 1.08.

Table (2): Meta-analysis of (average time of union) on experimental vs conservative technique usage – Mean difference:

N	Study	Experimental	Conservative	Total	SMD	SE	95% CI	t	P value	Weight (%)	
										Fixed	Random
1	Bond et al. 2001	11	14	25	-7.78	1.168	-10.202 to -5.36			3.20	12.05
2	Adolfsson et al, 2001	25	28	53	-4.85	0.544	-5.945 to -3.761			14.75	15.61
3	Saeden et al, 2001	32	30	62	-6.30	0.620	-7.548 to -5.069			11.36	15.24
4	Papaloizos et al, 2004	32	62	94	-5.16	0.434	-6.022 to -4.299			23.17	16.09
5	Dias et al, 2005	44	44	88	-3.60	0.344	-4.291 to -2.922			36.79	16.42
6	McQueen et al, 2008	30	30	60	-7.11	0.698	-8.513 to -5.719			8.96	14.83
7	Clementson et al, 2015	14	24	38	-13.3	1.572	-16.58 to -10.21			1.77	9.75
	Total (fixed effects)	188	232	420	-5.07	0.209	-5.489 to -4.668	-24.3	<0.001**	100	100
	Total (random effects)	188	232	420	-6.44	0.751	-7.918 to -4.965	-8.57	<0.001**	100	100

SMD: standard mean difference, SE: standard error, CI: confidence interval.
Q test for heterogeneity = 64.34, degree of freedom (DF) = 6, $p < 0.0001^{**}$,
 I^2 (inconsistency) = 90.7% and SMD = -6.44.

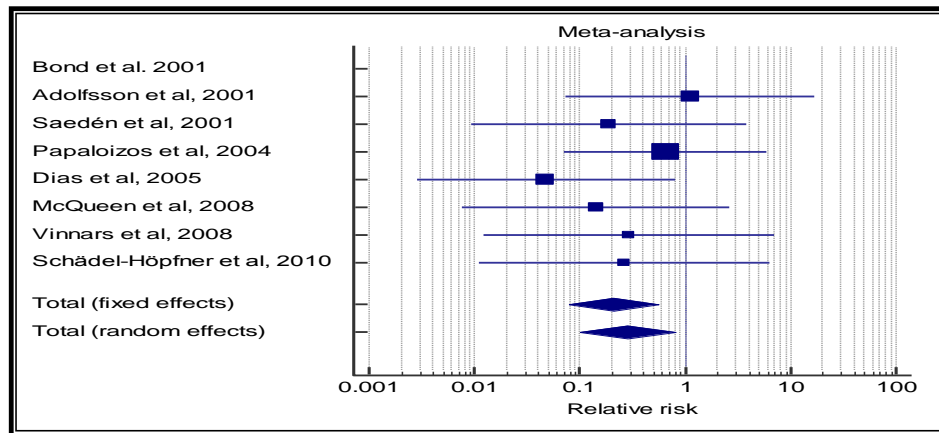


Figure (1): Forest plot of (non-union “failure”) on experimental vs conservative technique - Risk Ratio.

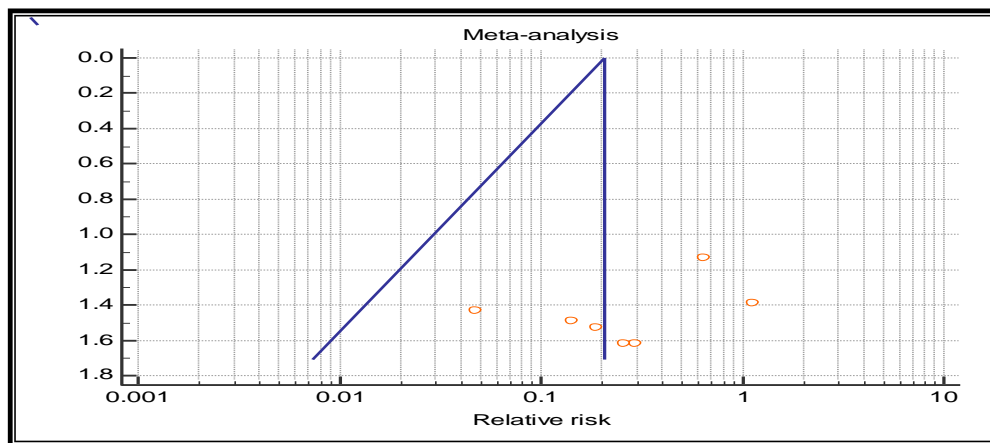


Figure (2): Funnel plot of (non-union “failure”) on experimental vs conservative technique - Risk Ratio (publication bias was non-significant).

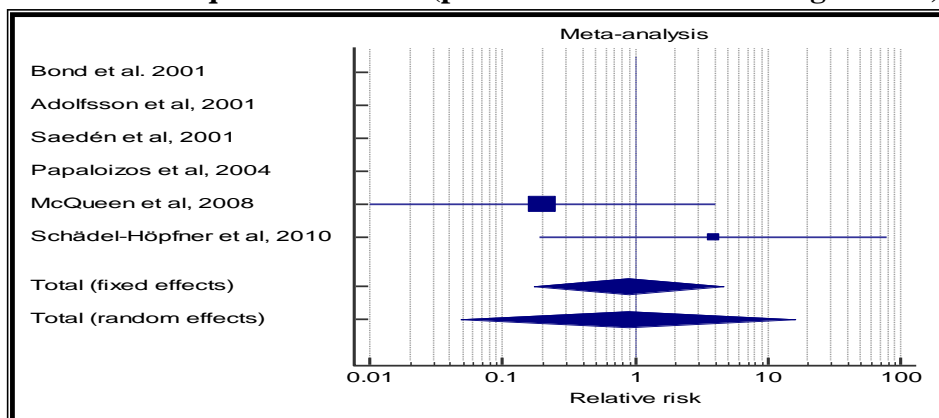


Figure (3): Forest plot of (AVN) on experimental vs conservative technique - Risk Ratio.

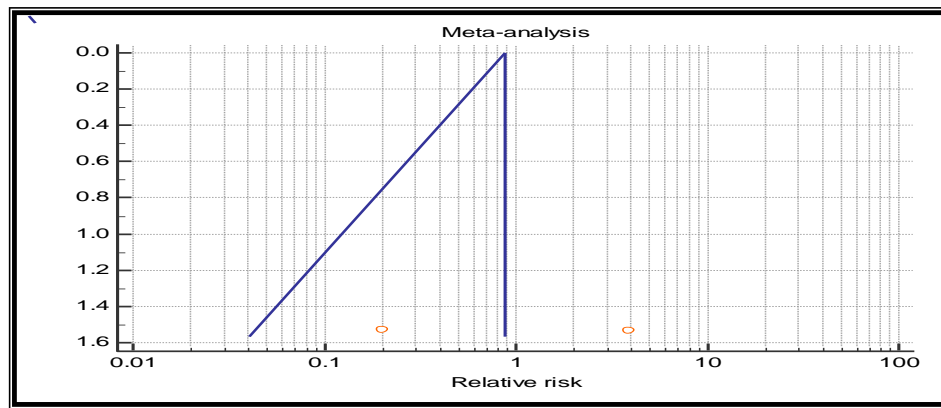


Figure (4): Funnel plot of (AVN) on experimental vs conservative technique - Risk Ratio (publication bias was non-significant).

DISCUSSION

Conservative treatment of minimally displaced scaphoid waist fractures carries risks of non-union of scaphoid fractures. 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 ⁽⁸⁾.

The present meta-analysis aimed to evaluate comparison between non-operative and minimally invasive treatment (percutaneous screw fixation) for acute minimally or undisplaced scaphoid 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). At least one of these outcome measures considered; union rate, average time of union, union failure rate and AVN (complications) rate.

Regarding descriptive analysis of all studies included, we found that; 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 Herbert screw.

Patients who achieved favorable post-operative outcomes were pooled to evaluate efficacy by: Proportions and Risk Ratio (RR), for achievement of successful union rate, and Standard Mean Difference (SMD), for achievement of early time of union.

Yassin et al. ⁽⁹⁾ 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.

Our results came in agreement with **Rambau et al.** ⁽¹⁰⁾ studied evaluation and management of nondisplaced scaphoid waist fractures in the athlete, and reported that, the union rate for non-operative treatment ranges between 88 and 95%, with operative union rates approaching 100%.

In agreement with our study, **Goffin et al.** ⁽¹²⁾ in a large meta-analysis of 11 studies, reported that, six studies recorded fracture union data: union rate 97%. On

meta-analysis, union rates (RR = 1.14; 95%CI: 1.01-1.28; $P < 0.03$) and mean times to union (MD 4.2 wk; 95%CI: 3.94-4.36; $P < 0.001$) were all significantly better for the surgical cohort compared to the conservative cohort.

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.**⁽⁹⁾ who 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).

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), $P > 0.001$]⁽⁶¹⁾

Also, **Alnaeem et al.**⁽¹²⁾ in his systematic review and meta-analysis examining the differences between nonsurgical management and percutaneous fixation of minimally and non-displaced scaphoid fractures, reported that, average time to union was 11.4 weeks (80 days) for conservative cast group versus 7.1 weeks (50 days) for surgical group ($P < .05$).

Our meta-analysis results came in agreement with **Li et al.**⁽¹³⁾ who conducted a meta-analysis of surgical versus nonsurgical treatment for scaphoid waist fracture with slight or no displacement, and reported that, surgical approach can reduce the incidence of non-union (RR=0.20, 95%CI: 0.06–0.69, $P < 0.01$). Also, **de Boer et al.**⁽¹⁴⁾ in his large updated meta-analysis study of 10 studies with 452 patients, also reported that, there was no significant difference between surgical and conservative treatment on the rate of non-union ($p=0.61$). The risk ratio was 0.70 (range, 0.18–2.75).

We found 6 studies reported AVN “avascular necrosis” rate, with total number of patients (N=388). Our meta-analysis study showed that; overall (AVN rate) in surgical group was 1.6%, and in conservative group was 1.2%. Our results came in agreement with the updated meta-analysis of **de Boer et al.**⁽¹⁴⁾.

In disagreement with our study, **Goffin et al.**⁽¹¹⁾ in a large meta-analysis of 11 studies, reported that, AVN rate of conservative cohort was 7%, while in surgical cohort, there was no reported cases suffered AVN.

Our meta-analysis study also showed that; fixed and random-effects models showed non-significant difference in AVN rate, between the 2 groups ($p > 0.05$ respectively). I^2 (inconsistency) was 46%; with non-significant Q test for heterogeneity ($p > 0.05$); so fixed-effects model was chosen to assess safety; with overall RR= 0.878, with non-significant difference in safety in the surgical group compared to conservative group ($p > 0.05$). Our results came in agreement with **de Boer et al.**⁽¹⁴⁾ in his large updated meta-analysis study of 10 studies with 452

patients, also reported that, avascular necrosis was assessed in three studies, and there was no significant difference ($p=0.21$). The risk ratio was 0.32 (range, 0.05–1.91) ⁽⁶²⁾.

Regarding rate of all complications, **Alnaeem et al.** ⁽¹²⁾ reported that, there was a higher complication rate in surgical group (14% vs 7%), but this was not statistically significant ($P = 0.2$). However, it is possible that this analysis is underpowered to detect statistical significance. A total of 15 complications were reported in conservative group (9 delayed union, 3 nonunion, 1 dysesthesia, 1 persistent wrist pain, 1 persistent swelling) compared with 24 complications in surgical group (6 delayed union, 4 screw-related, 4 nonunion, 3 complex reflex sympathetic dystrophy, 2 persistent pain, 2 bone necrosis, 2 infections, 1 swelling). A mere comparison of the rate of complications between both groups should be approached cautiously because surgical complications tend to be more severe. Screw malposition is a disastrous complication with significant consequences and represented 16% of the reported complications in surgical group.

Generally, **Arsalan-Werner et al.** ⁽²⁾ reported that, under most circumstances, minimally invasive surgery with cannulated screws is the treatment of choice. A longer cast immobilization after minimal-invasive surgery is not necessary. But conservative treatment still has a place if the fracture is not dislocated nor unstable, but operative treatment can be offered to reduce the period of cast immobilization ⁽³³⁾.

Also, **Yassin et al.** ⁽⁹⁾ in his study proved that fixation of acute scaphoid fractures results in predictable satisfactory union rate and functional outcome ⁽⁵⁸⁾.

CONCLUSION

Surgical fixation of non-displaced scaphoid fractures is a reliable technique provides satisfactory results with high union and minimal complication rates compared to conservative cast management.

No Conflict of interest.

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