The Missed Scaphoid Fracture—Outcomes of Delayed Cast Treatment

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Abstract

Keywords

- scaphoid fracture
- union
- subacute scaphoid fracture
- missed scaphoid fracture
- computerized tomography
- treatment delay

Background The purpose of this study is to evaluate outcomes (report union rates and times based on CT) for subacute scaphoid fractures, defined as those presenting between 6 weeks and 6 months from injury.

Questions 1) What are the expected union rates for subacute scaphoid fractures? **2)** What are the expected union times for subacute scaphoid fractures? **3)** Is it worth trialing a period of cast immobilization for these patients?

Methods All isolated sub-acute scaphoid fractures that presented at our institution between 2006 and 2010 were identified. Each subject's health record, CT scans and X-rays were retrospectively reviewed.

Results There were 20 males and 8 females, with a mean age of 30, treated with casting alone. There were 20 waist, 7 proximal and 1 distal pole fracture. The mean casting time was 11 (waist) and 14 (proximal pole) weeks with a union rate of 82% (23/28). Diabetes, comminution and a humpback deformity increased the non-union risk in this cohort. Exclusion of these cases resulted in a 96% union rate (23/24).

Conclusion Subacute scaphoid fractures (presenting within 6 months from injury) can be expected to successfully heal with casting alone, even if the initial diagnosis is delayed. The expected time frame for union with cast treatment is shorter than previously reported.

Level of Evidence IV.

When a scaphoid fracture is diagnosed and treated in a timely fashion, excellent results can be expected with either cast immobilization and/or open reduction internal fixation (ORIF).¹ However, scaphoid fractures can be difficult to diagnose and are often missed on initial X-rays. If a scaphoid fracture is not identified in a timely fashion and is not treated for several weeks, the risk of non-union or delayed union increases.^{2,3} Reports indicate that for certain fractures presenting in a delayed manner (stable, middle-third), union can be expected with cast treatment, although it may take twice as long.³

Unfortunately, there is little literature investigating the outcomes of scaphoid fractures that are initially missed. The few reports that do exist have small sample sizes and use only X-ray to evaluate the scaphoid, a method that is considered

unreliable.^{2–6} Previous limitations in imaging (i.e., plain radiographs) may have contributed to under-estimation of actual healing and may have limited the ability to identify factors that might differentiate those scaphoid fractures that are likely to heal from those most likely to become persistent non-unions as xrays have been shown to be unreliable in assessing scaphoid fractures.⁴

The purpose of this study is to report union rates and union times for sub-acute scaphoid fractures that have been followed with serial CT scans and determine the following:

1. What are the expected union rates for subacute scaphoid fractures that have a delay to diagnosis and treatment?
2. What are the expected union times for subacute scaphoid fractures?

3. Is it worth trialing a period of cast immobilization using a short arm thumb spica cast (SACTSC) for these patients?

We will also determine whether factors predictive of successful non-operative treatment can be identified, allowing surgeons to better predict which cases can be expected to heal successfully with SATSC alone.

Patients and Methods

This retrospective cohort study underwent successful independent research ethics board approval. A search of a local radiology CT database at a tertiary care hand surgery center was conducted, identifying all isolated scaphoid fractures that presented at our institution between 2006 and 2010.

Inclusion Criteria

All fractures presenting between 6 weeks and 6 months from the date of initial injury were defined as sub-acute scaphoid fractures and were included in this study ($n = 36$).

Exclusion Criteria

Fractures that were lost to follow-up before union or non-union could be confirmed ($n = 2$) or those who went immediately to surgery ($n = 6$) were excluded. The cases that went immediately to surgery ($n = 6$) had associated humpback deformities and sclerotic borders at time of first presentation were treated surgically as per the treating surgeons discretion.

Methods

The date of injury was determined based on patient history and a review of the health record (i.e., initial emergency room visits in cases where initial X-rays were incorrectly interpreted as normal). All fractures were initially treated with a short arm thumb spica cast. Each subject's health record, X-rays and CT scans were reviewed to determine injury and treatment details. Clinical data collected included age, history of diabetes, any other significant past medical history, smoking history, length and reason for treatment delay.

All patients received a CT scan of their scaphoid at initial presentation to our clinic and at ~6 weeks afterwards to assess union. Details of the CT protocol have been previously published.⁷ A single observer reviewed all CT scans obtained for each fracture. We determined the percentage union for each scan based on the method described by Singh et al.⁸ The fracture was classified as 'united' if union was determined to be 50% or greater.^{8,9} If at least 50% union was not achieved with casting alone, the fracture was classified as having failed cast treatment. Radiographic assessment also included determination of fracture location (proximal, middle or distal third), presence of comminution (yes/no), fracture translation, the presence of a humpback deformity (yes/no), sclerosis at the fracture margin (yes/no), cystic changes (yes/no) and the presence of any associated injuries. CT scans were taken at first

presentation and subsequently until union was confirmed ($\geq 50\%$), with each patient receiving an average of 3.3 ± 1.9 scans. The length of time patients were immobilized before union was confirmed and was reported in weeks.

Statistical Analysis

We then evaluated patient, injury and radiographic factors to determine if any factors predictive of outcome (successful union with casting alone) could be identified based on previous research.¹⁰ Continuous variables were assessed with Students *t*-test or ANOVA where appropriate. Categorical variables assessed with the Chi-square test (or Fishers exact test where appropriate). Statistical significance was defined as $p < 0.05$.

Demographics

Twenty-eight patients were eligible for inclusion in this study. There were 20 males (71.4%) and 8 females (28.6%), two of whom were diabetic. The mean age was 30.3 ± 16.3 years (range 12–65 years). There were 7 proximal pole fractures, 20 scaphoid waist fractures and 1 distal pole fracture. Injuries were sustained in the dominant hand for 13 patients, the non-dominant for 13 patients and hand dominance was unknown in two subjects. We were able to confirm that 15 subjects were non-smokers, 4 were smokers and in 9 subjects the smoking status was unknown.

Results

Two distinct groups were identified, patients who successfully achieved union with cast treatment, despite a delay in both diagnosis and treatment, and patients who did not progress to union with casting. These failures of cast treatment were typically treated with open reduction and internal fixation (with or without bone graft) at the discretion of the treating surgeon. One non-union was accepted as the patient was asymptomatic and declined surgery.

The mean delay between time of injury and initiation of treatment was 10.5 ± 4.3 weeks (range 6–23). There were two primary reasons these fractures were treated in a delayed fashion: either the patient failed to seek appropriate medical attention initially as they underestimated the severity of their injury ($n = 14$) or the original injury radiograph was read incorrectly as normal ($n = 12$). Two subjects had their fractures correctly identified but were non-compliant with treatment and follow-up. They subsequently presented to our clinic due to persistent symptoms.

Twenty-three fractures successfully united with casting alone, resulting in an 82% union rate. The mean length of time in the cast for the scaphoid waist fractures was 11.0 ± 6.5 weeks, and 14.2 ± 8.7 weeks for the proximal pole fractures, with no significant difference in duration of casting between the two ($p = 0.36$). The single subject with a distal pole fracture was casted for 2.5 weeks.

None of the patients in this cohort of non-operatively treated fractures had evidence of sclerosis along the fracture line and all were given a trial of cast treatment. The mean duration of time patients were casted before the

fracture was reassessed with CT was ~7 weeks (proximal poles: 7.2 ± 1.6 weeks, waist: 7.0 ± 3.8 weeks, distal pole: 2.5 weeks). Patients who successfully united without surgery had a mean 38% increase in union after a single trial of immobilization (7 weeks) while those who did not unite with casting had only an 11% increase in union with their first trial of immobilization ($p = 0.02$). This suggests that a short trial of immobilization can be used to predict failure of cast treatment. That is, if union progresses only very little (i.e., ~10%) after 6–7 weeks of immobilization, this is highly suggestive of future non-union. This is further supported by the observation that amongst those that united successfully, 50% healed within 11 weeks and 75% healed within 14 weeks of immobilization (►Fig. 1). Lengthy immobilization is not necessary to make this determination.

Factors that were found to have a significant association with failure of cast treatment included the presence of diabetes ($p = 0.03$), fracture comminution ($p = 0.05$) and a humpback deformity ($p = 0.02$) (►Table 1). The presence of cystic change along the fracture line demonstrated a trend ($p = 0.09$) toward failure of casting but this did not reach statistical significance (►Table 1). Exclusion of diabetics and fractures that were comminuted or had a humpback deformity resulted in a union rate of 96% (23/24). Smoking ($p = 0.79$), gender ($p = 0.60$), translation of fracture fragments ($p = 0.62$), length of treatment delay ($p = 0.55$) and involvement of the proximal pole ($p = 0.63$) were not related to success of cast treatment in this cohort. A detailed outline of relevant patient characteristics, fracture characteristics, and outcomes for each subject are listed in ►Table 2.

Table 1 Potential risk factors associated with failure of casting

	Casting Failed	Casting Successful	p-value
Diabetics	2	0	0.03
Non-Diabetics	3	23	
Humpback	4	4	0.02
No Humpback	1	19	
Comminution	3	3	0.05
No Comminution	2	20	
Cysts	1	15	0.09
No Cysts	4	8	

Discussion

There is a paucity of literature addressing outcomes of subacute scaphoid fractures. The few reports that focus on this topic demonstrate that treatment delays increase the risk of non-union^{2,11} with non-union rates reported as high as 40%² to 88.1%.¹² Time to union has also been shown to be adversely affected by treatment delays. Mean union times reported by Mack et al. were 19 weeks for subacute scaphoid waist fractures and 28 weeks for subacute proximal pole fractures.³ Langhoff also report similar union times in fractures delayed ≥ 4 weeks (proximal pole: 20.7 weeks, displaced waist: 17.4 weeks and undisplaced waist: 12.5 weeks to unite).² These reports however have small sample sizes and

Fig. 1 Comparison of Casting Times for Patients who did and did not heal with Casting.

Table 2 Patient and scaphoid fracture characteristics and outcome

	Patient Factors			Fracture Characteristics				Outcome		
	Age/ Sex	Smoker	DM	Displaced	Cysts	Comminution	Sclerosis	Union (%) after 1 st cast	Total Weeks Casted	Final Union
Proximal Pole	42f	Y	N	N	Y	N	N		No cast	70%
	17m	?	N	Y (2mm)	N	Y	N	88% (6w)	6	88%
	26f	N	N	N	Y	N	N	40% (6w)	8	80%
	24m	N	N	N	Y	N	N	75% (8w)	8	90%
	16m	?	N	Y (3mm)	Y	Y	N	15% (6w)	15*	60%
	21m	?	N	N	Y	N	N	40% (10w)	26	50%
	29m	N	N	Y (2mm, H)	N	Y	N	10% (7w)	ORIF + bone graft	
	18m	?	N	Y (2mm)	N	N	N	50% (4w)	4	50%
Waist	12m	N	N	N	N	N	N	100% (4w)	4	100%
	55m	?	N	N	Y	N	N	50% (4w)	6	50%
	65f	N	N	N	N	Y	N	30% (6w)	6	50%
	53f	Y	N	H	Y	N	N	35% (6w)	9	55%
	28f	N	N	Y (1mm)	Y	N	N	30% (6w)	9	100%
	16m	N	N	N	Y	N	N		9	50%
	23m	?	N	Y (1mm)	N	N	N	65% (7w)	9	65%
	52m	?	N	Y (4mm, H)	Y	N	N	No interim CT	11	100%
	22m	N	N	H	N	N	N	50% (4w)	11	65%
	15m	N	N	Y (1mm, H)	N	N	N	0% (5w)	12	75%
	55m	N	N	N	Y	N	N	40% (7.5w)	14	80%
	17m	N	N	N	Y	N	N	15% (4w)	14	77%
	26m	Y	N	N	Y	N	N	40% (6w)	14	65%
	19m	?	N	N	N	N	N	60% (20w)	20	90%
	46m	N	N	N	N	Y	N	30% (6w)	24 ⁺	85%
	49f	N	Y	Y (2mm, H)	N	Y	N	20% (9w)	Never casted. Asymptomatic nonunion accepted	
	19m	N	N	N	N	N	N	20% (8w)	ORIF, no bone graft	
	17m	?	N	H	Y	N	N	0% (11w)	ORIF + bone graft	
54f	Y	Y	Y (2mm, H)	N	Y	N	15% (8w)	Failed ORIF + bone graft, required fusion		
Distal	13f	N	N	N	Y	N	N	80% (2.5w)	2.5	80%

Abbreviations: ?, unknown; DM, diabetes; f, female; H, humpback; m, male; mm, millimeters; n, no; w, weeks; y, yes.

*patient wanted to avoid surgery.

+patient had multiple lower extremity injuries and was casted for a lengthy time as it helped with weightbearing.

do not use any advanced imaging to assess union, relying only on plain X-ray, a modality that has been shown to be unreliable in evaluating scaphoid fractures and scaphoid union.^{4,13}

In our cohort, the observed non-union rate was 17.9% with cast treatment when the diagnosis was delayed between 6 weeks and 6 months. Not only does this suggest that the potential for healing with conservative management is higher than anticipated, but, we were able to identify factors that increased the risk of non-union. In our cohort, diabetes, fracture comminution and/or the presence of a humpback deformity resulted in a significantly higher likelihood of failure of cast treatment. When cases with these risk factors were excluded, our union rate was found to be reasonable at ~96% (23/24) suggesting there may be a subset of delayed fractures that might benefit from delayed conservative management. We were also able to demonstrate that subacute scaphoid fractures can successfully heal after ~11–14 weeks of casting (11.0 ± 6.5 weeks for scaphoid waist fractures and 14.2 ± 8.7 for proximal poles) (→Fig. 2). This is shorter than reports in the literature described above.

We suspect one of the reasons for the improved union rates and union times in this cohort is a result of the detailed CT assessment of each fracture. CT has been shown to allow a detailed initial assessment of the fracture and also a more accurate assessment of union.^{13,14} This can help avoid instances where an established scaphoid non-union is mistaken for a subacute scaphoid fracture, as sometimes patients can be unaware of an existing non-union and the new injury merely exacerbates an already existing condition. CT also allows for a more accurate assessment of union, allowing us to discontinue immobilization at an earlier time frame with confidence.

Limitations of this study include the relatively small sample size, retrospective design and lack of standardized treatment. In addition, we were likely underpowered to detect influences of certain risk factors on outcomes (i.e., smoking) and the lack of standardized follow-up intervals did not optimize the detection of early union. In addition, there was no comparison arm so we cannot comment on whether union rates or times would have been better with surgery.

Chen et al. reported on the surgical treatment of a cohort of 30 subacute scaphoid fractures. They report a union rate of 97% after 10–12 weeks.⁵ With the exclusion of established risk factors, the results reported by Chen are very similar to those seen in this cohort of conservatively treated subacute injuries as we had a 96% union rate in a subset of this cohort (exclusion of diabetics and those with humpback deformities) and union times of ~11 weeks.

This study helps to support a recommendation for a trial of immobilization for subacute scaphoid fractures when they are first identified, even if the diagnosis has been delayed up to 6 months, as successful union can be expected in the absence of risk factors (diabetes, comminution, humpback). In addition, prolonged immobilization is not necessary to establish whether casting will be successful as we observed that those that successfully united with casting showed on average a 38% increase in union after the first trial period of immobilization (~7 weeks) while those that were unsuccessful with casting did not show any significant improvement in union (11%) in that same time frame ($p = 0.02$).

Working within a Canadian health care system, we often find that a patient may wait up to 1–2 weeks to be seen by an orthopedic surgeon and potentially a few additional weeks to be assessed by a hand specialist; thus, leading to a potential

Fig. 2 a) Scaphoid X-ray obtained 11 weeks after a fall onto outstretched wrist b) initial CT scan demonstrating cystic resorption along fracture line c) CT scan taken after 12 weeks of casting, demonstrating union.

further treatment delay. As a result, we feel that it is worthwhile casting patients when the fracture is first recognized as there is a chance that progression of union can be demonstrated while the patient awaits definitive treatment. While we understand that prolonged casting is difficult, avoiding unnecessary surgery is also desirable from both a patient and health care resource perspective. Further work on cost analysis would be helpful to understanding the societal costs of casting versus surgery.

The choice between surgical and non-surgical treatment for the treatment of subacute scaphoid fractures is difficult. The surgeon must weigh the probability of union, duration of treatment, and risk of complications. The infrequency of this clinical presentation makes it inherently difficult to develop strong clinical studies that delineate which patients would most benefit from a trial of non-operative management prior to intervening surgically.

In this study, we found that CT scans can provide valuable information at initial assessment, identifying risk factors that are associated with a higher non-union risk. If no risk factors are present, a trial of cast immobilization could be considered as expected union rates are high (96%) and mean time to union is ~11 weeks. In addition, there is little downside to a trial period of cast immobilization as a favorable initial response can be expected to predict ultimate success with casting.

We feel that subacute scaphoid fractures should be assessed by a surgeon experienced in treating scaphoid non-unions to determine their candidacy for surgery. However, before planning an operation, we recommend careful assessment of the fracture with CT as there is a high likelihood that union may progress and surgery can be avoided in many cases, even when treatment is delayed up to 6 months.

Conflict of Interest
None

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