Headless Compression Screw Fixation of Scaphoid Fractures

ABSTRACT

HYPOTHESIS Headless compression screws are the most popular type of fixation used for scaphoid fractures. Two commonly used implants are the Acutrak Headless Compression Screw System (Acumed, Hillsboro, OR) and Synthes Headless Compression Screw (Depuy Synthes, Raynham, MA). We hypothesize that the two implants will have similar odds of union and time to union.

METHODS We retrospectively reviewed all operative scaphoid fractures within a 13-year period (2002-2015) at three hospitals. Demographic and clinical information were recorded. Post-operative radiographs were reviewed by two board-certified hand surgeons for consensus ratings on radiographic union.

RESULTS There were 101 scaphoid fractures and non-unions treated with Synthes or Acutrak screws, with minimum 42 day follow-up. Of the acute fractures, 19 of 28 utilizing Synthes screws united in 67 ± 40 days and 16 of 28 utilizing Acutrak screws achieved union at 112 ± 121 days. Of the non-unions, 6 of 17 utilizing Synthes screws united for a mean time to union of 101 ± 43 days and 11 of 28 utilizing Acutrak screws united for a mean of 153 ± 123 days. The odds of achieving union did not differ between the two groups when controlling for confounders for both primary fixation (P=0.62) or nonunion (P=0.92). The time to union was not significantly different between the two groups for primary fixation (P=0.53) and nonunion (P=0.78).

CONCLUSION Implant choice does not create a difference in radiographic union. Surgeons should choose implants based on comfort with the instrumentation, availability and cost.

LEVEL OF EVIDENCE Level IV Therapeutic Study

KEYWORDS Scaphoid fracture, scaphoid non-union, open reduction and internal fixation, implant choice, headless compression screw, clinical outcomes

Janice J. He, MD[1,2]
Kristen Kuo, BA[2]
Ariana N. Mora, BA[2]
Brandon E. Earp, MD[1,2]
Philip E. Blazar, MD[1,2]

AUTHOR AFFILIATIONS

[1]Harvard Combined Orthopaedic Residency Program, Harvard Medical School, Boston, MA

[2]Department of Orthopaedic Surgery, Brigham and Women's Hospital, Boston, MA

CORRESPONDING AUTHOR

Janice J. He, MD
Department of Orthopaedic Surgery
Brigham and Women's Hospital
60 Fenwood Road
Boston, MA 02114
Phone: (617) 732-5322
jjhe@partners.org

The authors report no conflict of interest related to this work.

The scaphoid is the most commonly fractured bone in the carpus.[1] A sizeable subset of these patients develop non-union, theoretically due to the tenuous vascular supply of the scaphoid.[2] A complimentary explanation to this phenomenon focuses on the biomechanical stability of the fracture, which implies a potentially sizeable role for surgical fixation.[3,4] Scaphoid non-unions have the potential to cause very significant morbidity as they can lead to degenerative disease, deformity, and chronic wrist pain.[5] These fractures are typically operated on to increase their probability of union. Even in cases of surgical fixation, scaphoid fractures frequently require a prolonged period of time to heal and/or necessitate revision surgery.

In the pediatric population, surgical implant type has been shown to have a statistically significant effect on rate of union and the time to union.[6] Implant design has also been shown to affect union rates in scaphoid nonunions.[7] The primary goal of this study is to address if the type of surgical implant used affects the rate of union. Two of the most commonly used implants are the Synthes Headless Compression Screw (Depuy Synthes, Raynham, MA) and the Acutrak Headless Compression Screw (Acumed, Hillsboro, OR). The Synthes screw is partially threaded and uses threads of different pitch on the head and shaft to achieve compression as the head engages with the bone. The Acutrak screw is fully threaded and compresses due to a graduated change in pitch throughout the entire screw. We hypothesize that although they utilize different methods for achieving compression, that the two will have similar rates of union and time to union.

METHODS

All operative scaphoid fractures and non-unions from 2003-2015 in our health care system, which includes two large high volume academic medical centers and an associated community medical center, were identified via our comprehensive fracture billing database. Among these, those with other ipsilateral upper extremity injuries, including perilunate or lunate dislocations, were excluded. We retrospectively reviewed the remaining patients, identifying: patient sex, hand dominance, occupation, BMI, smoking status, history of diabetes, time of injury to treatment, operative treatment and type of implant used. Preoperative radiographs were examined to identify fracture pattern.

Post-operative imaging including: PA, lateral and scaphoid view of the wrist from each post-operative clinic visit was then collected into de-identified, randomly ordered slide decks. These radiographs were reviewed by two hand fellowship trained senior surgeons who determined by consensus whether the patient had achieved radiographic union. Each surgeon was blinded to the identity of the patient, the performing surgeon, and the time post-op when the radiograph was taken. Union was defined as 50% bridging trabeculae on multiple views without evidence of implant loosening.[6] CT scans were not used for assessment.

The primary results of the study were defined radiographic union, non-union at six months post-operatively, or revision surgery. With these data, we constructed a multivariable logistic regression model looking at the primary outcome of non-union while controlling for variables related to patient and clinical factors. Additionally, we constructed a multivariate regression looking at time to union, while controlling for these same factors. Data analysis carried out using StataIC 15 (StataCorp, College Station, Texas).

RESULTS

A total of 208 cases of fixation of acute scaphoid fractures and fixation for scaphoid non-unions in adult patients, by seven different surgeons, were identified and 147 of those were isolated scaphoid injuries. Of these, 101 were fixed using either the Acutrak Headless Compression Screw System (Acumed, Hillsboro, Oregon) or the Synthes 3.0 Headless Compression Screw System (Depuy-Synthes, Raynham, Massachusetts) and had minimum 42 days of follow-up. Indications for surgery included nonunion from prior nonoperative treatment, fracture displacement of more than 1mm assessed by preoperative CT, proximal pole fractures and rarely, patient preference in cases of minimally displaced fractures.

Of the surgeries for non-union, 6 of 17 utilizing Synthes screws united for a mean time to union of 101 ± 43 days and 11 of the 28 utilizing Acutrak screws united for a mean of 153 ± 123 days. Of those who did not achieve radiographic union, 5 from the Synthes group and 2 of the Acutrak group were revised. Of the surgeries for acute fracture, 19 of the 28 utilizing Synthes screws united in 67 ± 40 days and 16 of the 28 utilizing Acutrak screws achieved union at 112 ± 121 days. Of those who did not achieve radiographic union, 3 from the Synthes group and 1 from the Acutrak group were revised. Indication for revision surgery in each of these cases was an ununited fracture at more than 6 months from index surgery. The odds of achieving union did not differ between the two hardware groups when controlling for confounders for both primary fixation (P=0.62) or non-union (P=0.92). The time to union was also not significantly different between the two groups for both primary fixation (P=0.53) or non-union (P=0.78).

Cohort demographics, fracture and surgery characteristics are listed in **Tables 1 and 2**. Many independent variables were excluded

TABLE 1 Patient Characteristics

	Acute Fracture	Nonunion
Sex	79% Male	82% Male
Age	35 ± 16 years	27 ± 13 years
Diabetes	3%	7%
Smoking Status	20%	22%
Hand Dominance	90% Right	90% Right

TABLE 2 Fracture and Surgical Characteristics

	Acute Fracture	Nonunion
Proximal Pole	2%	11%
Side	46% Right	51% Right
Presentation >4 weeks From Injury	20%	NA
Approach Used	55% Dorsal	31% Dorsal
Bone Graft Used	14%	87%
Implant	48% Acutrak	64% Acutrak

in our regression analysis due to collinearity. The independent variables included in our analysis are listed in **Table 3.** The full results of our regression analysis are listed in **Table 4**.

DISCUSSION

Chronic non-union of the scaphoid, due to missed injury or failure to heal despite treatment, can lead to significant disability for the patient. Scaphoid non-unions predictably progress to advanced collapse, carpal arthritis, with associated chronic pain, and loss of range of motion and function.[5,8] For these reasons, the key to treatment of scaphoid fractures is to achieve union prior to the onset of these complications. While patient related factors, such as diabetes, and injury related factors, such as time to presentation, cannot be controlled, the choice of implant is selected by the treating surgeon.

Over the past twenty years, there have been significant changes in the implants used in scaphoid fracture surgery. The advent of the headless compression screw in the 1980s was a crucial advance in scaphoid surgery, as it allowed for both compression and rigid fixation. Headless compression screws remain the most popular form of fixation today. Building on the original screws, there are now a large number of implants available. Two of the most commonly used include the Acutrak screw and Synthes screw, which achieve compression via different means. The Acutrak screw is a headless, fully threaded cannulated screw which provides interfragmentary compression via the variable pitch across the entire screw. The variable pitch confers compression as the screw is inserted. Because it is fully threaded, it theoretically provides greater surface area for fixation between the screw and bone. The Synthes screw is also a headless, cannulated screw. Its partially threaded design allows it to act as a lag screw across the fracture site. This allows the surgeon to control the amount of compression during final tightening.

While these two screws do achieve compression differently, they have been shown to produce the same amount of compression in a biomechanical study.[9] This corroborates the results of our study, which do not show a statistically significant difference in the rate of union or time to union between these two screws, both in acute fractures and in revisions for nonunion. This suggests that while implant choice may be significant in a pediatric population as a previous study suggested,[6] that implant choice likely does not make a clinical difference in a skeletally mature, adult population.

Our study does have limitations owing to its retrospective design. Although our original sample size is large, we did have significant loss to follow up, which negatively impacted the union rate in our study. A large number of patients who showed signs of healing

TABLE 3 Variable Definitions

Continuous Variables	
Age	Age of patient at time of surgery
Binary Variables	
Implant	Fixation using Acutrak screw = 1, Synthes = 0
Sex	Male gender of patient = 1, female = 0
Bone graft	Whether bone graft of any kind was used for surgery
Proximal pole	Whether the fracture was in the proximal pole
Displaced	Whether the fracture was 1mm or more displaced

TABLE 4 Results

Odds of achieving union			Time to union		
	Odds Ratio (P)*			Net effect in days (P)*	
	Primary	Nonunion		Primary	Nonunion
Implant	1.66 (0.62)	1.10 (0.92)	**Implant**	18.68 (0.53)	23.49 (0.78)
Age	1.05 (0.043)	1.07 (0.54)	**Age**	0.63 (0.29)	-1.08 (0.75)
Sex	4.34 (0.18)	0.38 (0.13)	**Sex**	-22.52 (0.26)	67.66 (0.39)
Bone graft	0.20 (0.204)	--	**Bone graft**	-20.11 (0.10)	-30.64 (0.76)
Proximal pole	--	1.027 (0.98)	**Proximal pole**	-18.74 (0.21)	-7.62 (0.91)
Displaced	1.33 (0.83)	2.17 (0.41)	**Displaced**	146.25 (0.24)	57.30 (0.38)

* In our implant variable, Acutrak = 1 and Synthes = 0. Thus the odds ratio and net effect in days reflect the difference between the two implants, rather than absolute values. I.e. the odds of union for a fracture achieving union was 1.66x that of Synthes.

on early post-operative radiographs with associated reassuring clinical exam did not return for final follow up. Presumably, these patients recovered and were loss to follow up as they were doing well. However, this cannot be confirmed owing to the study's design.

Additionally, the nonunion group was heterogeneous and included patients with known nonunions who were previously treated nonoperatively, as well as patients who had a missed injury and presented late. These two groups likely present distinct clinical entities.

There was also a shift from using Acutrak to Synthes implants in our system over the course of the study period. As some notes and radiographs were missing from the earliest group of patients, this may have more negatively impacted both the union rate and the time of union the Acutrak group. In the future, a prospective randomized study comparing the two implants would be able to better investigate any differences in outcome. A randomized design will help address confounding factors and improved follow up rates would provide more statistical power to evaluate factors such as fracture location.

In conclusion, we do not believe that implant choice confers a difference in radiographic union in the treatment of scaphoid fractures in an adult population. Thus, we recommend that implant choice be made based on surgeon comfort with the instrumentation, availability and cost.

REFERENCES

1. Garala K, Taub NA, Dias JJ. The epidemiology of fractures of the scaphoid: impact of age, gender, deprivation and seasonality. J Bone Joint Surg Br. 2016 May;98-B(5):654-9.

2. Steinman SP, Bishop AT, Berger RA. Use of the 1,2 intercompartmental supraretinacular artery as a vascularized pedicle bone graft for difficulty scaphoid non-union. J Hand Surg Am. 2002 May;27A:391-401.

3. Werner FW, St-Amand H, Moritomo H, Sutton LG, Short WH. The effect of scaphoid fracture site on scaphoid instability patterns. J Wrist Surg. 2016 Mar;5(1):47-51.

4. Allon R, Kramer A, Wollstein R. Intramedullary screw and kirschner wire fixation for unstable scaphoid non-union. J Hand and Microsurg. 2016 Dec;8(3)150-1545.

5. Merrell GA, Wolfe SW, Slade JF III. Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. J Hand Surg Am. 2002 Jul;27(4):685-91.

6. Gholson JJ, Bae DS, Zurakowski D, Waters PM. Scaphoid fractures in children and adolescents: contemporary injury patterns and actors influencing time to union. J Bone Joint Surg Am. 2011 Jul 6;93(13):1210-9.

7. Wu J, Tay SC, Shin AY. The effect of screw design on union rates in scaphoid nonunions. Hand Surg. 2015; 20(2):273-9.

8. Duppe H, Johnell O, Lundborg G, Karlsson M, Redlund-Johnell I. Long-term results of fracture of the scaphoid. A follow-up study of more than thirty years. J Bone Joing Surg. 1994; 76(2):249-252.

9. Pensy RA, Richards AM, Belkoff SM, Mentzer K, Andrew Eglseder W. Biomechanical comparison of two headless compression screw for scaphoid fixation. J Surg Orthop Adv. 2009;18(4):182-188.