EDITOR'S CHOICE

Factors Associated With Surgical Treatment of Nondisplaced or Minimally Displaced Scaphoid Waist Fractures

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Purpose To determine whether there are identifiable factors associated with the surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures.

Methods We identified 50 patients who underwent nonsurgical treatment and 67 patients who underwent surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures at 2 tertiary care referral centers in a single metropolitan area in the United States between January 2010 and March 2019. Bivariate analysis was used to screen for factors associated with surgical treatment. Multivariable stepwise logistic regression was used to determine factors associated with surgical treatment of a nondisplaced or minimally displaced scaphoid fracture.

Results Multivariable logistic regression analysis showed that male sex (odds ratio = 2.80; 95% confidence interval, 1.20–6.52) and employed status (odds ratio = 3.12, 95% confidence interval, 1.24–7.85) were associated with surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures.

Conclusions Male and employed patients have increased odds of undergoing scaphoid surgery for nondisplaced or minimally displaced waist fractures compared with female and unemployed patients. These differences may represent patient preference, surgeon counseling, or a combination. Further study is needed to understand the etiology of this sex difference. *(J Hand Surg Am. 2021;46(3):209–214. Copyright © 2021 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words Discretionary surgery, elective surgery, minimally displaced, nondisplaced, scaphoid fracture.

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SCAPHOID FRACTURES ARE THE most common carpal fracture, with an incidence of 10/100,000 people per year.[1] A number of randomized controlled trials have compared the efficacy of nonsurgical versus surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures.[2–7] Shorter duration of immobilization, faster return to work, and faster time to union are typically associated with surgical treatment; however, differences in final range of motion, grip strength, and rates of union have not been shown; therefore,

the role of surgery as a treatment for this condition remains controversial.[8–11] The benefits of surgery are weighed against surgical risks and risk for radiographic scaphotrapezial osteoarthritis.[7,10]

Given the current available evidence, the decision for surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures is individualized and hinges on a discussion between the surgeon and the patient. Determinants of surgical treatment of nondisplaced or minimally displaced scaphoid fractures are not well-described. It is not known whether differences exist in patients who undergo surgical treatment of this injury and patients who undergo casting alone. The primary objective of this study was to determine whether there are identifiable patient factors associated with surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures. Our null hypothesis was that no identifiable patient factor would be associated with surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures.

MATERIALS AND METHODS

Study design and patient selection

This study was performed with institutional review board approval. A retrospective chart review was conducted of all scaphoid waist fractures treated at 2 tertiary care referral centers in a single metropolitan area from January 2010 to March 2019. The hospital billing records database was queried using Common Procedural Terminology codes 25622 (closed treatment of carpal scaphoid navicular fracture; without manipulation) and 25628 (open treatment of carpal scaphoid navicular fracture, with or without internal or external fixation) for patients treated nonsurgically and surgically, respectively, within the study period.

The medical records and radiographs of 178 patients who underwent nonsurgical treatment of a scaphoid fracture were screened. We excluded 46 patients for distal third scaphoid fracture, 35 for age less than 18 years, 22 for the presence of another ipsilateral wrist fracture, 19 for delay from injury to presentation of more than 3 weeks, 4 for displaced fracture, and 2 for proximal third scaphoid fracture. A minimally displaced scaphoid fracture was defined as less than 1 mm of maximal displacement on radiographs, computed tomography (CT), or magnetic resonance imaging (MRI). Sixty-one percent of patients had plain radiographs alone, 35% had CT, and 4% had MRI. A final cohort of 50 patients who underwent nonsurgical treatment of a nondisplaced or minimally displaced scaphoid waist fracture was included in the study.

The medical records and available radiographs of 242 patients who underwent surgical treatment of a scaphoid fracture were screened. We excluded 89 patients for displaced fracture, 28 for the presence of another ipsilateral wrist fracture, 19 for delay from injury to presentation of more than 3 weeks, 14 for age less than 18 years, 11 for proximal third scaphoid fracture, 8 for distal third scaphoid fracture, 2 because the index surgery was revision scaphoid surgery, 2 for nondisplaced fracture in the setting of a perilunate or lunate fracture-dislocation, 1 for bilateral scaphoid fractures, and 1 for open mangling injury. A final cohort of 67 patients who underwent surgical treatment of a nondisplaced or minimally displaced scaphoid waist fracture was included in the study.

Response variable and explanatory variables

The response variable was surgical treatment of a nondisplaced or minimally displaced scaphoid waist fracture. A total of 117 scaphoid waist fractures treated by 46 treating providers, including 22 attending surgeons and 24 fully licensed fellows in their hand surgery or trauma surgery specialty training, comprised the cohort (Table E1, available online on the *Journal's* Web site at www.jhandsurg.org).

The following explanatory variables were studied: age, body mass index (BMI), sex, race, dominant hand injury, employment status, manual occupation, primary health insurance, social deprivation, diabetes mellitus, smoking status, American Society of Anesthesiologists Physical Status Classification (ASA), treatment by a subspecialty-certified hand surgeon, and use of advanced imaging (CT or MRI). We determined ASA based on medical comorbidities through a thorough review of the electronic medical records. The BMI closest to the date of surgery, within 1 year before or after treatment, was used for analysis. Social deprivation was measured by the Area Deprivation Index using self-reported address of residence. The Area Deprivation Index is a validated, neighborhood-based tool for assessing social deprivation composed of 17 US Census variables that account for metrics such as poverty, housing, employment, and education.[12] Since its development, the Area Deprivation Index has been correlated with a number of health outcomes, including life expectancy at birth, infant mortality rate, and cancer survivorship.[13] We reported the Area Deprivation Index both as a US national percentile and a

TABLE 1. Characteristics of Study Groups (n = 117)*

Variable	Patients (n = 117)	Nonsurgical (n = 50)	Surgical (n = 67)
Age, y (mean [SD])	38.7 (16.8)	41.8 (18.2)	36.3 (15.4)
Area Deprivation Index (mean [SD])			
National percentile	18.9 (19.6)	20.2 (20.6)	18.1 (19.0)
State decile	4.1 (2.6)	4.3 (2.6)	4.0 (2.7)
BMI (mean [SD])	26.1 (4.6)	27.0 (4.6)	25.7 (4.5)
ASA (median [interquartile range])	2 (1–2)	2 (1–2)	2 (1–2)
Women, n (%)	41 (35.0)	23 (46.0)	18 (26.9)
Race, n (%)			
White	87 (74.4)	37 (74.0)	50 (74.6)
Black	9 (7.7)	3 (6.0)	6 (9.0)
Asian	5 (4.3)	3 (6.0)	2 (3.0)
Hispanic	5 (4.3)	3 (6.0)	2 (3.0)
Other	4 (3.4)	2 (4.0)	2 (3.0)
Unknown	7 (6.0)	2 (4.0)	5 (7.5)
English-speaker, n (%)	112 (95.7)	46 (92.0)	66 (98.5)
Diabetes mellitus, n (%)	2 (1.7)	2 (4.0)	0 (0)
Tobacco use, n (%)	16 (13.7)	6 (12.0)	10 (14.9)
Dominant hand injury, n (%)	48 (45.3)	18 (43.9)	30 (46.2)
Employed, n (%)	77 (73.3)	27 (61.4)	50 (82.0)
Manual employment, n (%)	20 (19.0)	5 (11.4)	15 (24.6)
Insurance, n (%)			
Private	91 (77.8)	39 (78.0)	52 (77.6)
Medicare	8 (6.8)	4 (8.0)	4 (6.0)
Medicaid or state equivalent	8 (6.8)	4 (8.0)	4 (6.0)
Self-pay	5 (4.3)	3 (6.0)	2 (3.0)
Workers' compensation	3 (2.6)	0 (0)	3 (4.5)
Motor vehicle coverage	2 (1.7)	0 (0)	2 (3.0)
Treatment by hand surgeon, n (%)	91 (77.8)	37 (74.0)	54 (80.6)
Use of advanced imaging, n (%)	42 (35.9)	14 (28.0)	28 (41.8)

*Data were partially available for area deprivation index national percentile (n = 116), race (n = 110), area deprivation index state percentile (n = 106), hand dominance (n = 106), employment (n = 105), manual employment (n = 105), and BMI (n = 104).

state decile in the state in which the study was performed, such that lower percentiles represent less social deprivation.

Statistical analysis

Descriptive statistics for explanatory variables were calculated for the study cohort. All explanatory variables had at least 90% data completeness, with the exception of 89% data completeness for BMI. All variables were analyzed using the data available; missing data were excluded (Table 1). Bivariate analysis was used to screen for factors associated with surgical treatment of a nondisplaced or minimally displaced scaphoid waist fracture. Student *t* test was used for continuous variables, Mann-Whitney U test was used for ordinal variables and Fisher exact test was used for categorical variables. We included variables with $P < .05$ in the multivariable logistic regression model. The final multivariable model was selected by stepwise regression modeling to avoid overfitting. We assessed for multicollinearity among significant dichotomous variables in the bivariate analysis by calculating the tolerance and variation inflation factor and used a conservative cutoff of tolerance less than 0.2 or a variation inflation greater than 5 to indicate multicollinearity.

A convenience sample was used. The standard significance criterion of $\alpha = 0.05$ and standard power

TABLE 2. Multivariable Stepwise Logistic Regression Analysis for Surgical Treatment of Nondisplaced or Minimally Displaced Scaphoid Waist Fracture

	Multivariable Stepwise Logistic Regression	
Variable	OR	95% Confidence Interval
Male sex	2.80*	(1.20−6.52)*
Employed	3.12*	(1.24−7.85)*

*Statistically significant.

criterion of $(1 - \beta) = 0.80$ was employed for all statistical tests.

Patient demographics

Mean age of the 117 patients in the study was 39 years, mean BMI was 26, and 35% were women. Median ASA was 2. Two percent had diabetes mellitus and 14% used tobacco at the time of injury. Most patients were white (74%), followed by black (8%), Asian (4%), and Hispanic (4%). Mean Area Deprivation Index was in the 19th national percentile, and median Area Deprivation Index was in the 13th national percentile (interquartile range, eighth percentile to 23rd percentile), representing a relatively affluent patient population. Ninety-six percent of patients were English speakers. The dominant hand was injured in 45% of patients. Seventy-three percent of injured patients were employed and 19% had a manual occupation. Most patients had private insurance (78%), followed by Medicare (7%), and Medicaid or a state equivalent (7%). Seventy-eight percent of patients were treated by a subspecialty-certified hand surgeon, and 36% of patients received preoperative advanced imaging (Table 1).

RESULTS

Of 117 patients in the study, 67 underwent surgical treatment of a nondisplaced or minimally displaced scaphoid waist fracture (57%). Bivariate analysis showed that male sex, active employment, manual occupation, use of advanced imaging, primary health insurance type, and race were associated with surgical treatment ($P < .05$). These 6 variables met criteria for stepwise selection for the multivariable logistic regression model. No variable was excluded for multicollinearity (Table E2, available online on the *Journal's* Web site at www.jhandsurg.org). Age, BMI, dominant hand injury, social deprivation, diabetes mellitus, smoking status, ASA, and treatment by a subspecialty-certified hand surgeon were not associated with surgical treatment.

Multivariable logistic regression analysis showed that male sex (odds ratio [OR] = 2.80; 95% confidence interval, 1.20−6.52) and employed status (OR = 3.12; 95% confidence interval, 1.24−7.85) were associated with surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures (Table 2). *Post hoc* power analysis showed that a sample size of 117 had greater than 80% power to detect a significant OR of 2.9 in dichotomous variables assuming a 1:1 variable outcome and a surgery rate of 57%.

DISCUSSION

Current evidence for surgical treatment of nondisplaced or minimally displaced fractures of the scaphoid waist suggests that the decision for or against surgery is discretionary, in the sense that it is individualized and hinges on a discussion between the surgeon and the patient. Insofar as surgery is at the discretion of the surgeon and the patient, it is important to understand whether there are differences between patients who undergo surgery and those who do not. In this study, we have shown that male patients and patients who were actively employed had higher odds of surgical treatment of nondisplaced or minimally displaced scaphoid waist fractures compared with female patients and unemployed patients.

The cause of these differences in the use of scaphoid fracture surgery is likely multifactorial and depends on patient preference, surgeon influence, or an interplay of both. Factors that may influence patient preference for surgical treatment include the duration of immobilization, time to return to work, cost of lost wages, and willingness to undergo an invasive procedure. Alternatively, surgeon attitudes and surgeon counseling may influence the decision for surgical treatment. For example, surgeons may preferentially advise employed patients to undergo surgery with the intent to hasten return to work. Further studies are warranted into factors that drive decision-making for discretionary scaphoid fracture surgery. It is particularly important to ensure that surgeons' implicit bias does not lead to differing surgical counseling for the sexes.

A recent conjoint analysis of treatment preferences for nondisplaced scaphoid fractures provided insight into how and why people decide to have discretionary scaphoid fracture surgery. Shammas et al[14] showed that cost had the greatest influence on choice of

treatment; discomfort, duration of immobilization, and risk for nonunion played into the decision-making. Similarly, van der Gronde et al[15] showed that insurance type may influence the choice of discretionary surgical treatment. Our study did not show insurance type to be a significant predictor of discretionary scaphoid fracture surgery. In our study, sex and employment status were significant predictors of discretionary scaphoid fracture surgery, independent of insurance and manual labor demands.

Our findings may represent a sex disparity. There is a considerable body of literature examining sex disparities in orthopedic surgery. In the field of arthroplasty, total knee replacements are performed more than threefold less in women compared with men. When total joint replacements are performed, on average, women have more advanced arthritis than do men.[16] In a cross-sectional study of work-related shoulder injuries, women were more than 3 times less likely to be referred for a surgical consultation and nearly 3 times less likely to have surgery. In the surgical group, women exhibited longer time from injury to surgery and longer time from the date of consent to date of surgery.[17] Conversely, women have been shown to be more likely than men to undergo discretionary surgery for trigger finger.[18] Sex disparities in orthopedic surgery likely differ by diagnosis.

This study had limitations. First, the study was performed in a single metropolitan area in the United States. Preferences for discretionary surgery are partly influenced by society and culture, which limits the generalizability of the study. Second, the study was performed retrospectively. We were unable to control for all factors that might have influenced a patient's decision for discretionary scaphoid fracture surgery, such as education level. We were also unable to control for avocation, hobbies, or sports, which might have influenced the choice of treatment. Some of the sex difference that we found in the study might be explained if male patients placed higher importance on these extracurricular interests. Missing data were a limitation of the retrospective review. Analyses were performed with available data, for instance, with 90% data completeness for explanatory variables such as employment and manual occupation. It is possible that we were unable to detect an association between medical comorbidity and nonsurgical treatment if there was under-documentation of medical comorbidities in the group treated nonsurgically. Furthermore, not all patients in the study underwent the same diagnostic imaging; this might have introduced ascertainment bias if patients with more severe injuries were more likely to undergo advanced imaging (CT or MRI) as well as surgical treatment. We have mitigated against the risk of ascertainment bias by including the use of advanced imaging as an explanatory variable in the study, and in our cohort, obtaining advanced imaging was not associated with surgical treatment. Although diagnostic imaging was not standardized in this study, this is reflective of actual practice and may add to the external validity of the findings.

Finally, the study included a heterogeneous group of surgeons. It has been shown that variations in recommendations for surgical treatment for discretionary hand conditions are seen among surgeons.[19] Whereas some variation may be attributed to surgeon personality[20] or implicit bias,[21] this variation in treatment is largely unexplained. In the current study, we were unable to determine the effect of different surgeons on the choice for discretionary scaphoid fracture surgery, owing to the large number of treating providers with various subspecialty backgrounds and levels of experience, a proportion of whom were fully licensed fellowship trainees; this is a limitation of the study. The experience levels of the treating surgeons might have influenced their attitudes toward surgical treatment, and the attitudes of this group of surgeons may differ from other institutions. However, our inclusion of a broad group of treating surgeons added to the external validity of the findings and allowed for the evaluation of actual standard medical practice. Smits et al[19] showed that decision support and evidence-based guidelines may be helpful in limiting practice variation for discretionary upper-extremity conditions.

We have shown that male sex and employment are associated with higher rates of surgical treatment for nondisplaced or minimally displaced scaphoid waist fractures. This study was unable to conclude whether these differences are driven by patient preference, surgeon attitudes, or a combination. Future studies may focus on the role that preoperative counseling has in discretionary scaphoid waist fracture surgery use and on ensuring that surgeon implicit bias is not the source of a sex disparity.

REFERENCES

1. Dy CJ, Kazmers NH, Baty J, Bommarito K, Osei DA. An epidemiologic perspective on scaphoid fracture treatment and frequency of nonunion surgery in the USA. *HSS J*. 2018;14(3):245–250.
2. Adolfsson L, Lindau T, Arner M. Acutrak screw fixation versus cast immobilisation for undisplaced scaphoid waist fractures. *J Hand Surg Br*. 2001;26(3):192–195.

3. Bond CD, Shin AY, McBride MT, Dao KD. Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. *J Bone Joint Surg Am*. 2001;83(4):483−488.
4. Dias JJ, Dhukaram V, Abhinav A, Bhowal B, Wildin CJ. Clinical and radiological outcome of cast immobilisation versus surgical treatment of acute scaphoid fractures at a mean follow-up of 93 months. *J Bone Joint Surg Br*. 2008;90(7):899−905.
5. McQueen MM, Gelbke MK, Wakefield A, Will EM, Gaebler C. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomised study. *J Bone Joint Surg Br*. 2008;90(1):66−71.
6. Ram AN, Chung KC. Evidence-based management of acute nondisplaced scaphoid waist fractures. *J Hand Surg Am*. 2009;34(4):735−738.
7. Saedén B, Törnkvist H, Ponzer S, Höglund M. Fracture of the carpal scaphoid: a prospective, randomised 12-year follow-up comparing operative and conservative treatment. *J Bone Joint Surg Br*. 2001;83(2):230−234.
8. Vinnars B, Pietreanu M, Bodestedt A, Ekenstam Fa, Gerdin B. Nonoperative compared with operative treatment of acute scaphoid fractures: a randomized clinical trial. *J Bone Joint Surg Am*. 2008;90(6):1176−1185.
9. Bhandari M, Hanson BP. Acute nondisplaced fractures of the scaphoid. *J Orthop Trauma*. 2004;18(4):253−255.
10. Buijze GA, Doornberg JN, Ham JS, Ring D, Bhandari M, Poolman RW. Surgical compared with conservative treatment for acute nondisplaced or minimally displaced scaphoid fractures: a systematic review and meta-analysis of randomized controlled trials. *J Bone Joint Surg Am*. 2010;92(6):1534−1544.
11. Alnaeem H, Aldekhayel S, Kanevsky J, Neel OF. A systematic review and meta-analysis examining the differences between nonsurgical management and percutaneous fixation of minimally and nondisplaced scaphoid fractures. *J Hand Surg Am*. 2016;41(12).1135.e1−1144.e1.
12. Singh GK. Area deprivation and widening inequalities in US mortality, 1969-1998. *Am J Public Health*. 2003;93(7):1137−1143.
13. Singh GK, Lin CC. Area deprivation and inequalities in health and health care outcomes. *Ann Intern Med*. 2019;171(2):131−132.
14. Shammas RL, Mela N, Wallace S, Tong BC, Huber J, Mithani SK. Conjoint analysis of treatment preferences for nondisplaced scaphoid fractures. *J Hand Surg Am*. 2018;43(7):678.e1−678.e9.
15. van der Gronde BATD, Crijns TJ, Ring D, Leung N. Discretionary surgery: a comparison of workers' compensation and commercial insurance. *Hand (N Y)*. 2019;14(1):95−101.
16. Novicoff WM, Saleh KJ. Examining sex and gender disparities in total joint arthroplasty. *Clin Orthop Relat Res*. 2011;469(7):1824−1828.
17. Razmjou H, Lincoln S, Macritchie I, Richards RR, Medeiros D, Elmaraghy A. Sex and gender disparity in pathology, disability, referral pattern, and wait time for surgery in workers with shoulder injury. *BMC Musculoskelet Disord*. 2016;17(1):401.
18. Crijns TJ, Bernstein DN, Ring D, Gonzalez R, Wilbur D, Hammert WC. Factors associated with a discretionary upper-extremity surgery. *J Hand Surg Am*. 2019;44(2):155.e1−155.e7.
19. Smits LJH, Wilkens SC, Ring D, Guitton TG, Chen N. Science of Variation Group. Variation in nonsurgical treatment recommendations for common upper extremity conditions. *J Am Acad Orthop Surg*. 2019;27(15):575−580.
20. Teunis T, Janssen SJ, Guitton TG, Vranceanu AM, Goos B, Ring D. Surgeon personality is associated with recommendation for operative treatment. *Hand (N Y)*. 2015;10(4):779−784.
21. Borkhoff CM, Hawker GA, Kreder HJ, Glazier RH, Mahomed NN, Wright JG. The effect of patients' sex on physicians' recommendations for total knee arthroplasty. *CMAJ*. 2008;178(6):681−687.

TABLE E1. Treatment of Nondisplaced or Minimally Displaced Scaphoid Waist Fractures, by Provider (n = 46)

Provider	Total	Nonsurgical	Surgical
1	33	16	17
2	31	24	7
3	25	13	12
4	9	2	7
5	7	4	3
6	6	4	2
7	4	0	4
8	4	0	4
9	4	0	4
10	3	2	1
11	3	2	1
12	3	2	1
13	3	3	0
14	2	2	0
15	2	1	1
16	1	1	0
17	1	1	0
18	1	1	0
19	1	1	0
20	1	1	0
21	1	1	0
22	1	1	0
23	1	1	0
24	1	1	0
25	1	1	0
26	1	1	0
27	1	1	0
28	1	1	0
29	1	1	0
30	1	1	0
31	1	1	0
32	1	1	0
33	1	1	0
34	1	1	0
35	1	1	0
36	1	0	1
37	1	0	1
38	1	0	1
39	1	0	1
40	1	0	1
41	1	0	1
42	1	0	1
43	1	0	1
44	1	0	1
45	1	0	1
46	1	0	1

TABLE E2. Assessment for Multicollinearity Among Explanatory Variables

Provider	Tolerance	Variance Inflation Factor
Sex	0.97	1.04
Employment status	0.89	1.12
Manual employment	0.88	1.14
Use of advanced imaging	0.97	1.03