

Free-vascularized bone grafts for scaphoid non-unions viable as outpatient procedure? No 30-day complications in NSQIP data.

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Objective: To determine if free vascularized bone grafting procedures are considered safe to perform for outpatient treatment in the setting of scaphoid non-union.

Setting: Utilizing The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) scaphoid nonunion cases were isolated and investigated.

Patients/Participants: A total of 50 patients with scaphoid fractures treated with vascularized bone graft were identified.

Intervention: Bone graft with microvascular anastomosis for closed fracture of the scaphoid

Main Outcome Measurements: Length of hospital stay, acute (30 day) complication rates

Results: The average length of hospital stay was 1.2 days and 18 patients (36%) were discharged the same day of surgery. There were no complications reported within the 30-day post-operative period.

Conclusion: The reported early morbidity and mortality rates of free vascularized bone grafting in the setting of scaphoid fractures have been reported to be minimal. These rare early complications include superficial surgical site infections and pin site irritation. In this analysis, there were no reported adverse outcomes. Given the low risks for acute complications, vascularized bone transfer surgery in the setting of scaphoid nonunion can be considered safe and potentially cost effective to perform on an outpatient basis.

Level of Evidence: IV

Keywords: Scaphoid fracture; scaphoid nonunion; free vascularized bone graft; ambulatory surgery; outpatient surgery; cost effectiveness

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INTRODUCTION

In the setting of non-union, scaphoid fractures can be stabilized with internal fixation with or without bone graft augmentation. Free vascularized bone grafts (FVBG) are composite grafts capable of filling voids due to bone loss and often serve to replace articular cartilage surfaces. In addition to higher average union rates when compared to non-vascularized bone grafting, FVBGs have been shown to be superior to local rotation bone flaps in scaphoid non-union surgery.¹ They are not without potential complications with acute and delayed issues occurring at both the donor and recipient sites. Uncontrolled bleeding and thrombosis at the site of anastomosis are both early complications whereas late complications include failed incorporation of the graft and graft hypertrophy.² The average post-operative length of stay following any FVBG procedure ranges from 3 to 24.5 days

with vascularized iliac crest graft procedures associated with longer post-operative stays.^{3,4}

Iliac crest FVBG was often considered the gold standard for FVBG procedures for scaphoid nonunion, however it has lost popularity to the medial femoral condyle (MFC) FVBG due to inferior union rates.⁵ Medial femoral condyle (MFC) FVBG provides a robust blood supply and greater structural support, which can improve hump-back deformities, while distal radial pedicle vascularized bone grafts yielded suboptimal results.^{6,7} Doi et al reported a 100% union rate utilizing MFC FVBG in a cohort of 10 patients with scaphoid non-union.⁸ Similarly, Jones et al successfully used a FVBG from the MFC in nine patients who failed previous scaphoid surgery with all patients achieving non-union healing at an average of 13 weeks.⁹ When directly compared to distal radius vascularized bone pedicles, MFC FVBG has been shown to have higher rate of union and shorter time to healing.¹⁰

Table 1. Demographic information regarding patients who underwent vascularized bone graft to scaphoid nonunion procedure as reported by the NSQIP database from 2010-2017.

Sex	n (%)
Male	41 (82)
Female	9 (18)
Age, mean ± SD	
<30	36 (72)
30-49	13 (26)
50+	1 (2)
BMI, mean ± SD	
<30	39 (80)
≥30	10 (20)
ASA Classification	
1	34 (68)
2	15 (30)
3	1 (2)
Medical Comorbidities	
Smoker	11 (22)
Diabetes	0 (0)
Hypertension	0 (0)

The complexity of a FVBG for treatment of a scaphoid non-union is greater than other treatment modalities. Harvesting from a separate surgical donor site can increase the potential for morbidity and an anastomosed microvascular arterial repair can require laborious post-operative aftercare.

Table 2. Associated CPT, ICD9, and ICD10 codes

	Code	Description	Count
CPT	25440	Repair, revision, and/or reconstruction procedures on the forearm and wrist	33
	25628	Fracture and/or dislocation procedures on the forearm and wrist	3
	25431	Repair, revision, and/or reconstruction procedures on the forearm and wrist	2
	20680	Removal of implant	2
	25645	Fracture and/or dislocation procedures on the forearm and wrist	2
	25825	Arthrodesis, wrist	2
	25999	Other procedures of the forearm or wrist	2
	14040	Adjacent tissue transfer or rearrangement, forehead, cheeks, chin, mouth, neck, axillae, genitalia, hands and/or feet	2
	64782	Excision of neuroma	1
	25320	Repair, revision, and/or reconstruction procedures on the forearm and wrist	1
	15002	Surgical preparation or creation of recipient site by excision of open wounds, burn eschar, or scar (including subcutaneous tissues), or incisional release of scar contracture, trunk, arms, legs	1
	15220	Full thickness graft, free	1
	69990	Operating microscope procedures	1
	20900	Bone graft, any donor area	1
	64772	Transection or avulsion procedures on the extracranial nerves, peripheral nerves, and autonomic nervous system	1
	15271	Skin substitute grafts	1
	15240	Full thickness graft, free	1
	25145	Excision procedures on the forearm and wrist	1
	26055	Incision procedures on the hand and fingers	1
	64721	Neuroplasty and/or transposition	1
25111	Excision of ganglion, wrist (dorsal or volar)	1	
ICD9	733.82	Nonunion of fracture	21
	814.01	Closed fracture of navicular [scaphoid] bone of wrist	5
	719.53	Stiffness of joint, not elsewhere classified, forearm	1
	733.49	Aseptic necrosis of bone, other	1
716.93	Unspecified arthropathy involving forearm	1	
ICD10	S62.0 series	Unspecified fracture of navicular [scaphoid] bone	18
	M93.1	Kienböck's disease of adults	1
	M92.211	Osteochondrosis (juvenile) of carpal lunate [Kienböck], right hand	1
	M87.9	Osteonecrosis, unspecified	1

With increasing costs of healthcare, the feasibility of performing procedures in a cost efficient manner is of increasing importance.^{11,12} Outpatient or ambulatory surgery, has been rising in prevalence.¹³ Advantages to treating patients in the outpatient surgical setting include increased patient satisfaction, less burden on hospital capacity and cost savings.¹⁴⁻¹⁶ A 2015 systematic review by Crawford et. al found a reduction of up to 60% in mean total cost when comparing outpatient to inpatient surgeries.¹⁷

The purpose of this paper is to review the demographics of those undergoing FVBG for scaphoid non-union, investigate the 30-day morbidity and mortality associated with surgery and determine the aftercare observational requirements for these patients. We hypothesize the patient population will be young with low morbidity and mortality accompanied by short hospital stays, making the

procedure attractive as an ambulatory surgery with concomitant reduction in medical costs.

METHODS

After Institutional Review Board approval, The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database was queried using the CPT code for “bone graft with microvascular anastomosis” (CPT 20962 n=143) with exclusion of CPT code 25430 “insertion vascular pedicle into carpal bone” from 2011-2017. Scaphoid cases were isolated by an additional ICD9 code of 814.01 (closed fracture of scaphoid bone), ICD10 code S62.0 series (subtypes of scaphoid fractures) or CPT code 25440 (repair, revision, and/or reconstruction procedures on the forearm and wrist). Patient-specific factors including demographic data and medical comorbidities were recorded (Table 1). In addition, surgical characteristics were also collected, including total operative time, length of stay,

local and systemic complications, and overall morbidity and mortality (Table 3). Associated CPT, ICD9, and ICD10 codes were recorded and reported as well (Table 2).

Minor systemic complications included urinary tract infection, deep venous thrombosis, pneumonia, and renal insufficiency. Major systemic complications included pulmonary embolism, unplanned intubation, post-operative sepsis, cerebrovascular accident, acute renal failure, myocardial infarction, and cardiac arrest. Minor local complications included superficial wound infection or wound disruptions. Major local complications included deep wound infection and surgical site infection.^{18,19}

Patient-based predictors included medical comorbidities, age (categorized as <30, 30-49, and ≥50 years-old), sex, BMI (<30.0 and ≥30 kg/m²), and ASA classification. Operative time was reported as an average time in minutes.

RESULTS

Fifty patients were identified who underwent a free vascularized bone graft for scaphoid non-unions. Most patients were males (82%) at an average age of 26.8 ± 9.1 years. Most of the patients were under the age of 50 years (98%) with 72% of all patients being under the age of 30 years. Most patients were considered ASA 1 classification (68%) with the remaining being ASA 2 (30%) or ASA 3 (2%). The most common comorbidity was smoking (22%). There were no other medical comorbidities reported (Table 1). The average length of operation was 242 minutes \pm 123.6 minutes. The average length of stay was 1.2 days \pm 1.2 days with 18 (36%) patients being discharged the same day of surgery. There were no complications nor deaths reported within the 30-day post-operative period (Table 3).

DISCUSSION

This retrospective review of the NSQIP database identified 50 cases of vascularized bone transfer procedures reported for scaphoid fracture non-union between the years of 2011-2017. Most patients were males with a normal BMI under the age of thirty who lacked significant medical comorbidities. The most reported medical comorbidity was tobacco use (22%), and there were no reported complications utilizing vascularized bone graft transfer procedures for scaphoid fracture non-union within 30 days post operatively. The average length of hospitalization was 1.2 days with over one third of patients being discharged the same day. These findings are consistent with the low rates of early onset morbidity and mortality rates of FVBG in the setting of scaphoid fracture nonunion.

Scaphoid fractures are most common in males between the ages of 15 and 40 years.^{20,21} The primary risk factors for subsequent non-union include the degree of fracture displacement, delayed diagnosis, inadequate treatment, fracture location and smoking.²²⁻²⁴ The patients of the present analysis were primarily males under the age of 30, and even though 22% used tobacco, our cohort suffered no complications despite the theoretical increase in risk.

Table 3. Metrics and 30-day post-operative outcomes for vascularized bone graft for scaphoid nonunion as reported by the NSQIP database from 2010-2017.

Outcomes	Number of patients (%) (Total n = 50)
Length of operation, minutes	242.3 \pm 123.6
Length of stay, days	1.2 \pm 1.2
Minor local complications	0 (0)
Major local complications	0 (0)
Minor systemic complications	0 (0)
Major systemic complications	0 (0)
Overall morbidity and mortality	0 (0)

Due to the nature of our data set, we could only capture the first 30 days after the procedure and did not identify any complications; however, there have been complications reported when utilizing vascularized bone grafts in the setting of scaphoid non-union.^{7,25,26} In a retrospective study of 48 patients who received 1,2 intercompartmental supratretinacular artery pedicled vascularized bone grafting, Chang et al. reported eight complications post operatively including graft extrusion (4), superficial infection (2), failure of fixation (1), and deep infection (1).⁷ Pulos et al. reported that among 49 patients who received a MFC FVBG, eight patients underwent subsequent treatment for superficial site infection (2), hardware prominence (1) and ultimate salvage procedure (5).²⁷ Arora et al. utilized a free vascularized iliac bone graft in treating scaphoid nonunion 21 patients with minor complications occurring in including prominent K-wire (1) and superficial site infection (3).²⁶ In accordance with this study, it appears that acute complications of vascularized bone grafting procedures in the setting of scaphoid non-union are minimal and the majority of complications are chronic in nature. Therefore, it is unlikely that performing the procedure on an outpatient basis would increase the risk of these complications.

The prospect of performing orthopedic procedures in the outpatient setting is attractive on multiple levels, and include increased patient satisfaction, less burden on hospital capacity and cost savings.¹⁴⁻¹⁶ Many common orthopedic procedures, which have historically been inpatient, have safely been transitioned to outpatient surgeries. Total hip arthroplasty and total knee arthroplasty as ambulatory surgeries have both demonstrated safety, similar patient outcomes and substantial savings to the healthcare system.^{16,28-30} Similarly, knee arthroscopy and specifically anterior cruciate ligament reconstruction, have shown significant cost-effectiveness and increased patient satisfaction in the ambulatory setting.³¹⁻³³ To date, there has not been a cost analysis study on inpatient versus outpatient surgery for FVBG in scaphoid non-unions. However, this study has demonstrated its safety, and the benefits to the patient can be expected to be similar to those found in the arthroplasty and sports surgery literature.

CONCLUSION

Performing a microvascular anastomotic arterial repair can be daunting, especially when considering potential acute complications typically found in free tissue transfers. This study highlights that the 30-day morbidity and mortality rates of free vascularized bone grafting in the setting of scaphoid fractures were nonexistent in this patient cohort and over one third of patients were discharged same-day. These factors indicate that FVBG for scaphoid non-unions is likely a safe surgery to perform on an outpatient basis for many patients. Although there is no published data comparing costs for inpatient and outpatient performance of this surgery, literature regarding outpatient surgery indicates there would be a significant cost savings if FVBG for scaphoid non union was transitioned to an outpatient surgery.

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