RESEARCH ARTICLE

Non-repairable Scaphoid Proximal Pole Nonunion Reconstruction by Hamate Arthroplasty: A Case Series Study

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Abstract

Objectives: Non-repairable scaphoid proximal pole nonunion remains a major challenge. Various reconstructive surgical approaches have been introduced, but each one has some limitations, including microvascular anastomosis, donor site morbidities, and the risk of compromising the scapholunate ligament.

Methods: This prospective interventional case series was performed on five patients. The patients underwent reconstructive surgery using proximal hamate arthroplasty by a single surgeon and were followed up for at least 12 months.

Results: All patients were male and the median age was 28, and the median follow-up time was 24 months. The median Mayo score was 70, and the DASH score was 0 (no disability) in 3 patients and 15 in two patients. The median of postoperative grip strength in the operated hands was 37.3 kg (Range 36.1–39) and in the opposite hands was 42.5 kg (Range 40–45.9). However, there were significant differences between grip strength between operated and opposite hands (P value= 0.008). A reduction of 11.1% and 15% was shown in postoperative flexion and extension compared with preoperative flexion and extension (P value = 0.194, P value = 0.102).

Conclusion: Hamate arthroplasty for nonunion of the scaphoid proximal pole appears to be a viable surgical option with favorable outcomes in terms of union rates, functional recovery, and patient satisfaction.

Level of evidence: IV

Keywords: Arthroplasty, Nonunion, Proximal scaphoid pole fracture, Reconstruction, Scaphoid fracture

Introduction

The surgical management of scaphoid proximal pole fractures remains a major challenge due to the high tendency for potential complications, including avascular necrosis and nonunion.[1,2] Since the radial artery and its dorsal scaphoid branches supply the scaphoid, any traumatic event in this area, especially fracture, may result in serious complications, such as nonunion and even avascular necrosis.[3] Literature review shows the likelihood of nonunion progression in approximately one-third of cases suffering from acute proximal pole fracture, while it may reach 50% in those with concurrent displacement.[4-6] This adverse event may also be affected by other baseline parameters, including mechanisms of trauma (high energy), unsalvageable fragmentation, and the pattern of fracture (oblique).[7] Various reconstructive surgical approaches have been introduced to optimize vascularity in the fracture size, which may increase the chance for faster healing.[8] Employing both vascularized and nonvascularized grafting techniques could lead to a successful union rate ranging from 36% to 100%.[9,10] Despite such promising outcomes, these surgical reconstructive methods are accompanied by some potential limitations, including the necessity for microvascular anastomoses, donor site morbidity, and the risk of compromising the scapholunate ligament.[11,12] In this regard, and recently, the use of a proximal hamate

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osteochondral autograft as a replacement arthroplasty has been described in a proximal pole nonunion setting, especially in the presence of bone loss, carpal collapse, or osteonecrosis.[13,14] This grafting could result in local osteochondral and ligament reconstruction and minimize donor site morbidity. However, the outcome of proximal hamate arthroplasty remains variable in the literature. This study described a series of patients undergoing hamate arthroplasty for reconstructing non-repairable scaphoid proximal pole nonunion, focusing on the postoperative results.

Materials and Methods

The prospective interventional case series included five patients with scaphoid proximal pole nonunion who had been referred to our referral hand surgery center between January 2020 and December 2021. The study protocol was ethically and scientifically approved by our educational medical center (IR.SBMU.MSP.REC.1401.531). All patients provided written informed consent after being informed about the purposes of the researchers in conducting the intervention. Patients with proximal pole nonunion, avascular necrosis, the small size of the proximal pole, and fragmented or non-repairable fragments were included. On the other hand, patients with multiple fractures, scaphoid nonunion advanced collapse, concurrent fractures in other sites, and a history of previous surgery were excluded from the study. All patients underwent anterior-posterior and lateral X-rays and computed tomography (CT) of the wrist [Figures 1, 2].

Figure 1. Preoperative radiographs

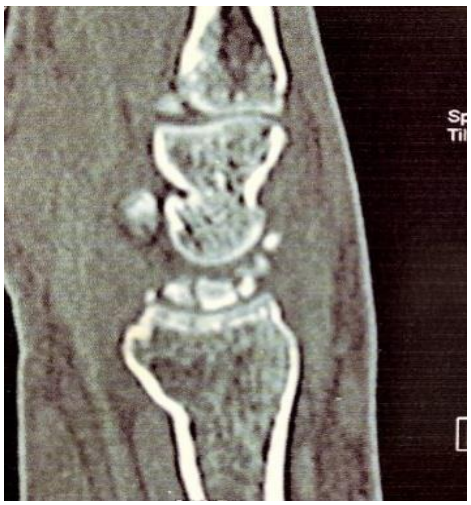

Figure 2. Pre-operative sagittal CT scan

All surgical procedures were performed by a single surgeon. A dorsal approach was utilized under regional anesthesia with tourniquet control. After sparing, the extensor ligament capsulotomy was used to access the nonunion site. The non-repairable fragments of the proximal pole were excised, and the other side of the nonunion was fresh between the 2nd and 4th extensor compartments. The proximal pole of the hamate was harvested based on the size of the defect between the 4th and 5th extensor compartments. We tried to maintain the capitohamate and triquetrohamate ligaments as much as possible. The harvested graft was then rotated until the capitohamate articular surface became the articular surface with the lunate. The graft was reshaped by a saw to have the same size as the defect of the scaphoid [Figure 3]. Finally, the graft was reduced to the scaphoid using a provisional pin. The location of the graft was evaluated with periarticular surface joints, and a second pin was placed in the correct location. The compression screw was fixed in all cases. Additional capitolunate Kirschner was applied after keeping the lunate in neutral alignment [Figure 4]. In the last step, we repaired the capitohamate ligament to the scapholunate ligament with PDS 3-0 thread. After the surgery, the Sugar Tong forearm splint was performed for patients, sutures were removed two weeks later, and a short thumb Spica cast was applied. The capitolunate pin was removed after 2 months [Figures 5, 6].

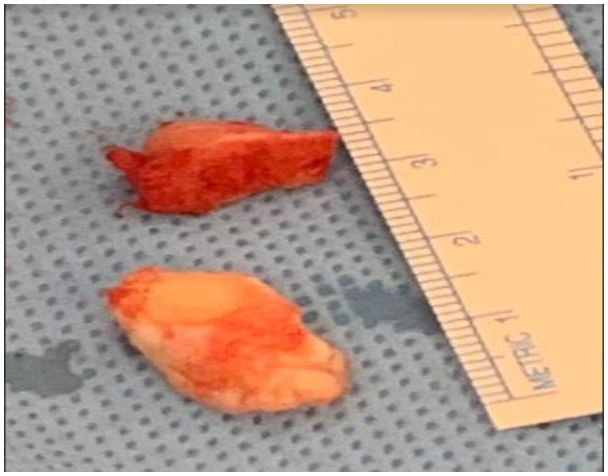

Figure 3. Harvested graft versus proximal pole of scaphoid

Figure 4. Early postoperative radiograph

Figure 5. Post-operative radiograph after 3 months

Figure 6. Post-operative radiograph after 12 months

The patients were visited after 2, 4, 6, and 12 months to evaluate the following parameters. Local pain severity was assessed by the Visual Analog Scale. Additionally, range of motion (ROM) was measured using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, and hand disability was assessed using the modified Mayo questionnaire. Grip strength, scapholunate distance, and union were assessed through wrist CT scans.

Statistical analysis

Analyses were conducted using median, minimum, and maximum. A non-parametric Mann-Whitney U test was used to determine a significant difference between two independent groups of data. Non-parametric Wilcoxon tests were employed to compare the differences before and after the surgery, with 95% confidence intervals for point estimates. All analyses were performed using R (version 4.4.1).

Results

All patients were male, with a median age of 28 years (range 26-29). Four patients had evaluations over the 20-month postoperative period, and just one patient had a 1-year follow-up. In three patients, the injured hands were dominant, and in two patients, the hands were non-dominant. The duration of non-union varied from 5 to 12 years, with a median of 8 years. The median preoperative flexion-extension ROM was 45 degrees (range 30-70) and 50 degrees (range 40-60) [Table 1]. The median surgical operation time was 130 min (range 120-150) [Table 2]. The median Mayo score was 70 (range 50-90), and DASH was 0 (no disability) in 3 and 15 in two patients. The median postoperative grip strength in the operated hands was 37.3 kg (range 36.1-39), while it was 42.5 kg in the opposite hands (range 40-45.9). However, there were significant differences between grip strength in both hands (P=0.008). The median post-operative flexion-extension ROM was 40 degrees (range 30-75) and 35 degrees (range 10-60). Postoperative flexion and extension demonstrated a decrease of 11% and 15%, respectively, when compared to preoperative levels (P=0.194, P=0.102). Scapholunate distance varied from 0.5 to 1.7 mm with a median of 0.8 [Table 3].

Table 1. Characteristics of participants

Case ID	Gender	Age	Side	Hand dominance	Non-union duration (years)	Previous operation	Pre-op ROM (F/E) *	Time of surgery (minute)	Graft fixation	Iliac bone graft
1	Male	28	Right	Right	12	None	70/50	120	Screw	None
2	Male	28	Left	Right	5	None	45/60	150	K-wire	None
3	Male	29	Left	Right	10	None	60/45	150	Screw	Yes
4	Male	28	Right	Right	7	None	45/60	120	Screw	None
5	Male	26	Right	Right	8	None	30/40	130	Screw	None

* Pre-operative Range of Motion (Flexion/Extension)

Table 2. Patients' treatment data

Case ID	Follow-up (month)	Mayo[1]	DASH[2]	VAS[3]	Grip strength (kg)		Post-op ROM (degree) (F/E) *	SLD (millimeter)**
					Operated hand	*Opposite hand*		
1	28	90	0	0	36.1	45.9	75/50	1.7
2	24	70	0	0	39	41	35/10	0.5

Table 2. Continued

3	22	55	15	3	37.3	40	50/35	0.9
4	32	50	15	1	36.9	42.5	40/60	0.8
5	12	90	0	0	38.5	43.1	30/30	0.5

[1]Mayo Wrist Score; [2]Disabilities of the Arm, Shoulder, and Hand; [3]Visual Analog Scale pain
* Post-operative Range of Motion (Flexion/Extension)
** Scapholunate Dissociation (Millimeter

Table 3. Follow up and Clinical outcome

Case ID	Follow up (month)	Mayo[1]	DASH[2]	VAS[3]	Gripp strength		Post-op ROM (F/E) *	SLD**
					Operated hand	*Opposite hand*		
1	28	90	0	0	36.1	45.9	75/50	1.7
2	24	70	0	0	39	41	35/10	0.5
3	22	55	15	1-3	37.3	40	50/35	0.9
4	32	50	15	1-3	36.9	42.5	40/60	0.8
5	12	90	0	0	38.5	43.1	30/30	0.5

[1]Mayo Wrist Score, 2Disabilities of the Arm, Shoulder and Hand, 3Visual Analog Scale (VAS) pain.
* Post-operative Range of Motion (Flexion/Extension)
** Scapholunate Dissociation (Millimeter)

Discussion

The management of scaphoid proximal pole nonunion presents a significant challenge due to the risk of complications, such as avascular necrosis and persistent nonunion. This prospective case series offers valuable insights into the use of hamate arthroplasty as a reconstructive technique to address this issue. The findings suggest promising outcomes in terms of union rates, functional recovery, and patient-reported outcomes, thereby highlighting the potential efficacy of this approach.

Several techniques have been explored for the management of scaphoid proximal pole nonunion, such as anchor suture fixation, costo-osteochondral autograft reconstruction, Medial Femoral Trochlea Osteochondral Graft, and distal radius vascularized bone grafts. Each technique has a good outcome with its advantages and limitations.[15-23]

Introduced by Elhassan et al., hamate arthroplasty offers several benefits, including ease of execution, absence of complex microsurgical procedures, minimal donor site morbidity, and morphological similarity between the hamate autograft and the proximal pole of the scaphoid.[11]

Saruhan et al. reported four other cases that were treated using this procedure. In their study, three out of four patients had complete relief of pain, union was achieved in all patients, and none exhibited any instability.

In our study, complete union was achieved in four of five cases that underwent surgery using the hamate arthroplasty technique. The ROM, compared with preoperative examination, showed no significant improvement. In one case, we encountered nonunion and a significant reduction in wrist extension after the surgery.

Despite the promising outcomes reported in this study, several limitations warrant consideration. The relatively small sample size and the lack of a control group limited the generalizability of the findings. In addition, the short- to mid-term follow-up period might not have captured long-term outcomes and potential complications associated with hamate arthroplasty. Future studies with larger sample sizes and longer follow-up durations are required to further validate the efficacy and safety of this technique.

Conclusion

Hamate arthroplasty for nonunion of the scaphoid proximal pole appears to be a viable surgical option with favorable outcomes in terms of union rates, functional recovery, and patient satisfaction. This technique offers various advantages, such as minimal donor site morbidity and avoidance of microvascular anastomosis, making it an attractive alternative to conventional reconstructive approaches. However, continued research and long-term follow-up are necessary to definitively establish its long-term efficacy and safety.

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