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Original Research

Arthroscopic Treatment of Scaphoid Nonunion with Nonvascularized Autogenous Bone Grafting: A Prospective Study of 39 Patients

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Purpose: To evaluate the clinical and radiological outcomes of all-arthroscopic curettage and nonvascularized autogenous bone grafting for the treatment of established scaphoid nonunion.
Methods: Since 2023, 39 consecutive patients (mean age 29.3 years) with scaphoid nonunion were prospectively enrolled. Nonunion was classified according to the Schernberg system: zone 1 in 3 cases (8%), zone 2 in 7 (18%), zone 3 in 24 (62%), and zone 4 in 5 (13%). No humpback deformity was observed. Smoking status was documented: 26 nonsmokers (67%) and 13 smokers (33%). Surgery was performed at a mean of 13.4 months after injury. Bone graft was harvested from the distal radius (mean volume ~0.8 mL per procedure) and delivered arthroscopically via midcarpal portals. Osteosynthesis was achieved with crossed Kirschner wires (1.5 mm [0.059 in] and 1.2 mm [0,047 in]) in 95% of cases.
Results: Union was achieved in 37 of 39 patients (94.8%) at a mean of 4.85 months. All united patients returned to professional activities. No avascular necrosis, tendon, or nerve injury was recorded. Functional assessment in 22 patients at ≥12 months yielded a mean *Quick*DASH (Disabilities of the Arm, Shoulder, and Hand)-inspired score of 12.5 out of 100. Smokers had higher scores (22.3) compared with nonsmokers (8.0).
Conclusions: Arthroscopic bone grafting for scaphoid nonunion yields results comparable to open techniques with reduced soft tissue morbidity. Smoking was associated with worse functional outcomes without preventing union in this series. The technique represents a reliable minimally invasive alternative in appropriately selected patients.
Type of study/level of evidence: Therapeutic III.

The classic treatment for scaphoid nonunion involves an open, often devascularizing approach. The development of arthroscopy, with its minimally invasive nature, has enabled a new approach to the management of scaphoid nonunion. This is a prospective study of 39 patients with scaphoid nonunion who underwent arthroscopic bone grafting.

The classic surgical treatment involves open bone grafting, either with nonvascularized grafts from the distal radius or iliac crest or with vascularized pedicle grafts for cases with proximal pole avascular necrosis. Open techniques, however, carry inherent risks of soft tissue injury, devascularization, postoperative stiffness, and scar-related complications.

The advent of wrist arthroscopy has enabled a less invasive approach to scaphoid nonunion, offering direct intra-articular visualization and preservation of the surrounding soft tissues, ligaments, and vascular supply, while avoiding the morbidity of extensile exposures. Several series have reported promising union rates with arthroscopic techniques, yet most remain retrospective and relatively small.

Since 2023, we have followed 39 consecutive patients with scaphoid nonunions in a prospective longitudinal registry. All nonunions were treated with curettage and nonvascularized autogenous bone grafting performed arthroscopically. Healing was achieved in 94.8% of cases at an average of 4.85 months postoperatively.

The aim of this prospective study was to evaluate the union rate, time to union, and safety of an all-arthroscopic technique using nonvascularized autogenous distal radius bone graft for the treatment of scaphoid nonunion and to compare our results with those in the current literature. To our knowledge, this represents one of the few prospective cohorts evaluating all-arthroscopic treatment of scaphoid nonunion.

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Materials and Methods

Study design and patient population

This prospective single-center cohort study, initiated in January 2023, includes 39 consecutive patients with established scaphoid nonunion. All patients were enrolled in a longitudinal registry and followed until confirmed radiographic union.

Inclusion criteria were radiographically confirmed scaphoid nonunion (absence of bridging trabeculae on plain radiographs and/or computed tomography [CT] scan), skeletally mature patients, and consent for arthroscopic management. Exclusion criteria included active wrist infection and advanced SNAC arthritis (stage III or beyond).

The cohort comprised 39 patients with a mean age of 29.3 years (range 16–58). The occupational distribution included 26% students and 41% manual laborers—a population at high risk for both injury and delayed presentation. Surgery was performed at a mean of 13.4 months (range 6–66 months) after the initial trauma. All procedures were performed by two surgeons with extensive experience in wrist arthroscopy.

Smoking status was systematically documented. Of 39 patients, 26 were nonsmokers (67%), and 13 were smokers (33%), with daily consumption ranging from 3 to 40 cigarettes per day.

Nonunion location was classified according to the Schernberg system: zone 1 (proximal pole) in 3 patients (8%), zone 2 (proximal waist) in 7 (18%), zone 3 (waist) in 24 (62%), and zone 4 (distal waist) in 5 (13%). No zone 5 (distal pole) non unions were included. No case presented with humpback deformity on presurgical CT. Patient demographics and baseline characteristics are summarized in Table 1.

Table 1
Patient Demographics and Baseline Characteristics

Characteristic	Value / n (%)	Notes
Total patients	39	
Mean age (y)	29.3	Range 16–58
Sex	37 M / 2 F	
Dominant side operated	28 (72%)	
Mean delay fracture–surgery	13.4 months	Range 6–66 months
Occupation		Students 26%; manual laborers 41%; other 33%
Previous surgical treatment	2 (5%)	1 prior K-wire fixation; 1 prior screw
Nonunion location — Schernberg classification*		
Zone 1 — Proximal pole	3 (8%)	
Zone 2 — Proximal waist	7 (18%)	
Zone 3 — Waist	24 (62%)	Most common location
Zone 4 — Distal waist	5 (13%)	
Zone 5 — Distal pole	0	None in this series
Humpback deformity	0	None identified on preoperative CT
Smoking status		
Nonsmokers	26 (67%)	
Smokers	13 (33%)	3–40 cigarettes/day
Mean graft volume	~0.8 mL	1 compacted insulin syringe; supplemental allograft in 1 case (large defect)
K-wire diameter	1.5 + 1.2 mm	Crossed convergent configuration
Fixation method		K-wires 37 (95%); compression screw 2 (5%)
Postoperative immobilization	6 weeks	Splint 4–5 days then removable wrist splint
K-wire removal	Mean 3 months	Outpatient, local anesthesia

AVN, avascular necrosis; CT, computed tomography; K-wire, Kirschner wire.
* Schernberg classification: zone 1 = proximal pole with high AVN risk; zone 2 = proximal pole; zone 3 = waist; zone 4 = distal waist; zone 5 = distal pole.

Surgical technique

Surgery was performed under regional anesthesia with tourniquet control. The procedure was conducted in two sequential steps.

Graft harvest

As shown in Figure 1, cancellous bone was harvested from the distal radius through a dorsal approach centered over Lister's tubercle. The graft was morselized and then tightly packed into a standard 1 mL insulin syringe with a beveled tip. After compaction, the effective graft volume delivered per procedure was approximately 0.8 mL.

Arthroscopic step

As shown in Figure 2, the wrist was positioned in standard traction. A midcarpal ulnar portal was used for visualization and a midcarpal radial portal for instrumentation. No radiocarpal portals were used. A comprehensive articular assessment was performed prior to nonunion treatment, enabling identification of any associated intra-articular pathology.

The nonunion site was exposed and debrided using a motorized shaver, burr, and hand curettes until viable, bleeding cancellous bone was visible on both fragments. The morselized graft, preloaded and compacted in the beveled insulin syringe, was then introduced directly into the nonunion cavity under arthroscopic visualization and further impacted with a probe and spatula. Optimal filling of the defect was confirmed arthroscopically before fixation.

The technique evolved over the study period toward dry arthroscopy, with saline irrigation used only when visualization was compromised or to lavage debris from the nonunion site, consistent with current recommendations advocating for dry arthroscopic techniques in scaphoid surgery.

Osteosynthesis was performed under fluoroscopic guidance (Fig 3). Two crossed Kirschner wires (1.5 mm and 1.2 mm) were used in 37 of 39 cases (95%). Convergent wire placement was preferred over parallel configuration, in accordance with biomechanical data favoring greater rotational stability. A compression screw was used in two patients: one with a very small residual defect and one with a previously implanted screw requiring revision. In one patient with a large bone defect, supplemental allograft cancellous bone was added to augment the autograft volume.

Postoperative management

All patients were immobilized in a plaster splint for 4–5 days postoperatively, followed by a removable wrist splint worn for 6 weeks. This protocol was chosen based on the stability conferred by the crossed K-wire construct and is consistent with shorter immobilization regimens described in recent arthroscopic series. Compression screws were left in situ. Kirschner wires were removed at a mean of 3 months postoperatively under local anesthesia during outpatient follow-up.

Outcome assessment

The primary outcome was radiographic union, defined as bridging trabeculae across the nonunion site on plain anteroposterior and lateral wrist radiographs. In cases of doubt, CT scan was used as the definitive imaging modality. Secondary outcomes included time to union, return to professional activities, and complications (avascular necrosis, neurovascular injury, hardware failure, infection).

Functional outcomes were assessed using a self-administered questionnaire inspired by the *Quick*DASH

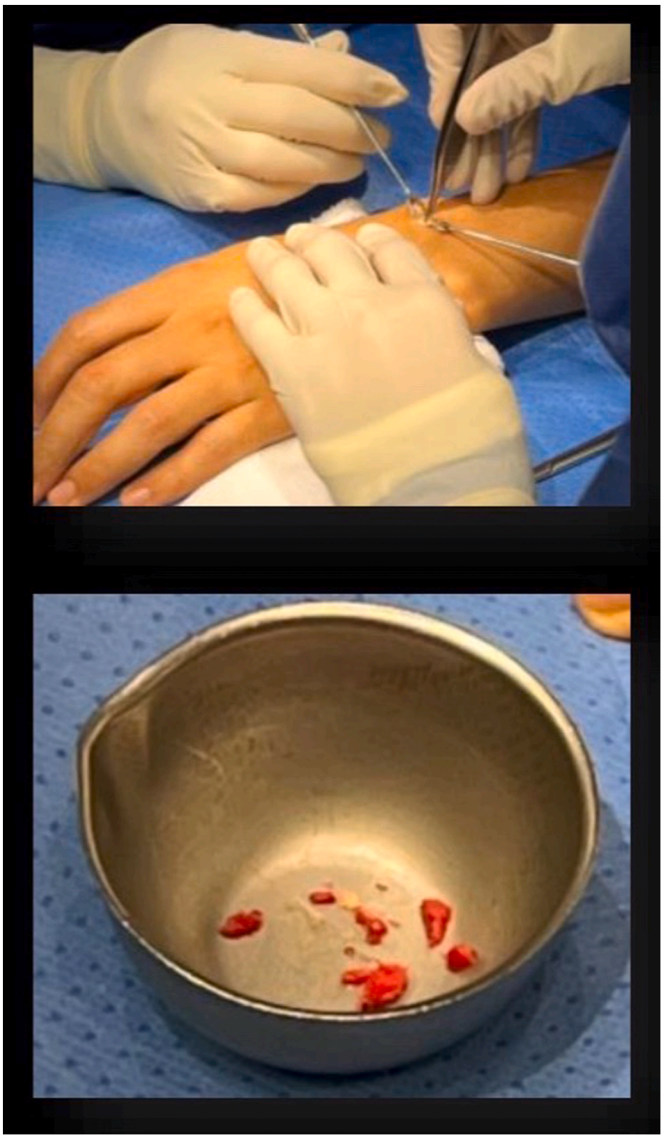

Fig 1. Technique for cancellous bone harvest from the distal radius.

(Disabilities of the Arm, Shoulder, and Hand) and Patient-Rated Wrist Evaluation instruments (hereafter referred to as *Quick*-DASH-inspired score), distributed to all 39 patients at a minimum of one year postoperatively. Twenty-two patients (56%) returned a completed questionnaire. The questionnaire included four activity items (scored 1–5), pain at rest and on loading (visual analog skill 0–10), grip strength and wrist mobility self-assessment (percentage of contralateral side), and ability to bear weight on the palm. Potential prognostic factors for union were compared between united and non-united patients (Table 2).

Results

Union rate and time to union

Union was achieved in 37 of 39 patients, corresponding to a union rate of 94.8%. Consolidation occurred at a mean of 4.85 months (approximately 19.4 weeks) postoperatively. All patients who achieved union returned to their prior professional activities without restriction.

Failures

Two patients (5.2%) did not achieve union. The first presented with a large volumetric bone defect; despite supplemental allograft cancellous bone, consolidation was not obtained. The second had a complex perilunate dislocation with a previously osteosynthesized scaphoid fracture, representing an unfavorable biological and mechanical environment. Both patients declined further surgical intervention. At final follow-up, both were tolerating their nonunion with pre-existing signs of early wrist arthritis and no acute deterioration of function.

Complications

No cases of proximal pole avascular necrosis were observed. There were no tendon lacerations, nerve injuries, superficial or deep infections, or hardware-related complications requiring unplanned repeat surgery. The dorsal approach to the distal radius for graft harvest was well tolerated in all cases, with no donor-site morbidity reported.

Functional outcomes

Functional questionnaires were returned by 22 of 39 patients (56%) at a mean of 12 months following confirmed union. Mean *Quick*DASH-inspired score was 12.5 out of 100 (range 0–56.2), indicating mild overall functional impairment. Mean pain at rest was 1.4 out of 10 and mean pain on loading was 2.9 out of 10.

Grip strength was self-assessed as 100% of the contralateral side in 10 patients (45%), 75% in 7 (32%), 50% in 1 (5%), and less than 25% in 4 (18%). These four patients with severely reduced grip all achieved radiographic union; their functional limitation reflects delayed rehabilitation rather than nonunion. Wrist mobility was self-assessed as 100% in 4 patients (18%), 75% in 13 (59%), 50% in 4 (18%), and less than 25% in 1 (5%).

Weight-bearing on the palm was performed without difficulty by 6 patients (27%), was painful but possible in 7 (32%), and was reported as impossible in 9 (41%). Several patients in the "impossible" subgroup demonstrated 0 out of 10 pain at rest and good grip recovery, suggesting that limitations in weight-bearing reflect ongoing rehabilitation rather than failure of consolidation.

Smokers demonstrated worse functional outcomes compared with non-smokers: mean *Quick*DASH-inspired score 22.3 versus 8.0 and mean pain on loading 4.1 out of 10 versus 2.1 out of 10. However, both union failures occurred in nonsmokers (large volumetric defect and complex perilunate injury), suggesting that smoking did not prevent union but may have impaired functional recovery. Functional outcomes are summarized in Table 3.

Analysis of prognostic factors

Union was achieved in 12 of 12 smokers (100%) and 25 of 27 nonsmokers (92.6%). Fisher exact test did not demonstrate a significant association between smoking status and union ($P = 1.000$). Comparison of potential prognostic factors between united and nonunited patients is presented in Table 2. Because only two nonunions occurred, formal multivariate analysis was not feasible; these comparisons are descriptive only and should be interpreted with caution.

Discussion

Scaphoid nonunion is a common complication of untreated or unstable scaphoid fractures. Numerous techniques have been developed to achieve union. Pinder et al[1] conducted a 2015 meta-

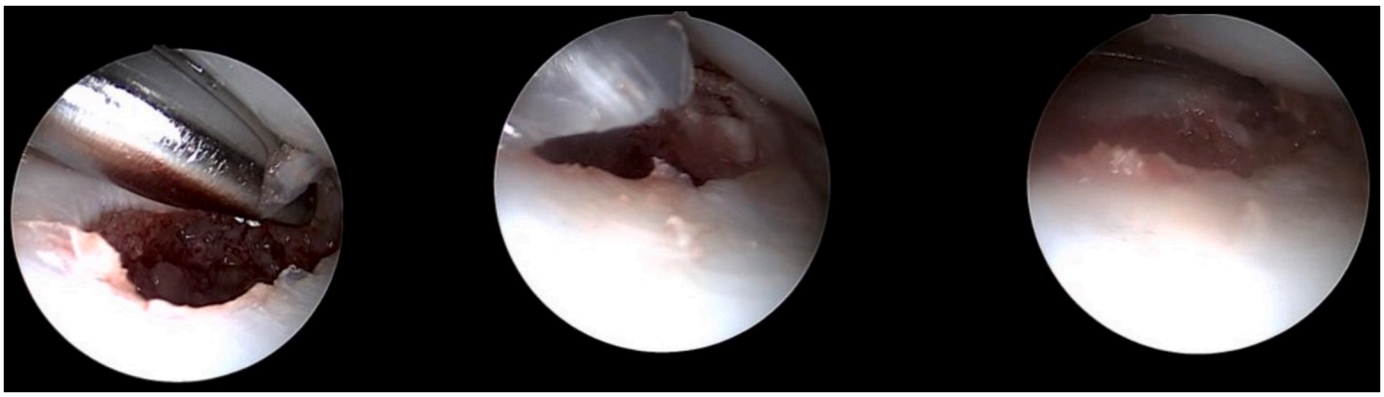

Fig 2. Midcarpal portal placement for arthroscopic bone grafting.

Fig 3. Fluoroscopic guidance for Kirschner wire osteosynthesis.

analysis of 48 studies involving 1,602 patients, comparing different techniques: graft type (radial or iliac), vascularized or non-vascularized grafts, and osteosynthesis with screws or wires. Union rates were 92% for vascularized grafts and 88% for non-vascularized grafts, with iliac grafts associated with more complications.

Although nonvascularized open grafting remains the gold standard, arthroscopic techniques may offer a less invasive alternative with comparable results in selected indications. Open techniques with bone grafting and osteosynthesis yield good results but at the cost of significant tissue morbidity (postoperative stiffness, pain, scar issues). Wrist arthroscopy allows for minimally invasive treatment with direct visualization of the nonunion site. The radial graft enables regional anesthesia, avoiding the need for general anesthesia and donor-site pain associated with iliac grafts.

Nonunion location and Schernberg classification

In the present series, zone 3 (waist) nonunions predominated (62%), consistent with the known epidemiology of scaphoid fractures. Zone 4 (proximal pole) accounted for 13%, and no zone 5 nonunions were included, thereby excluding cases with the highest risk of avascular necrosis. No humpback deformity was observed, which likely contributed to the favorable union rate, as deformity correction through an arthroscopic-only approach is technically demanding and may require an anterior portal as described by Kaempf et al.[2]

Prognostic factors

Slade et al[3] proposed arthroscopic assistance for displaced scaphoid fractures in 2008 to preserve vascularization and avoid extensive approaches that could damage vessels and ligaments. Gvozdenovic et al[4] compared arthroscopic and open surgery in 54 patients (27 arthroscopic, 27 open), finding a higher union rate and faster union (8 weeks vs 14 weeks) in the arthroscopic group. In our series, analysis of the two failure cases identified large volumetric bone defect and complex injury pattern (prior perilunate dislocation with previous osteosynthesis) as the main risk factors for nonunion (Table 2). Surgical delay averaged 18 months in united patients, whereas one failure case had an exceptional 30-year chronicity. Lautenbach et al[5] suggest that intervention within 2 years yields better success rates, consistent with our findings. Because only two nonunions occurred, meaningful multivariate analysis was not possible; potential prognostic factors should therefore be interpreted with caution.

Vascularization

Le Mapihan et al[6] studied scaphoid vascularization, emphasizing its preservation as a key factor for successful nonunion treatment. In our series, we used midcarpal radial and midcarpal ulnar portals exclusively, avoiding radiocarpal portals. For two patients with large defects, union was not achieved. An anterior approach, as proposed by Kaempf et al[2] for large scaphoid deformities with palmar bone defects using a trans-scaphoid portal, could have been considered in these cases. These two cases highlight the importance of careful patient selection and preoperative CT-based assessment of defect geometry and fragment viability.

Table 2
Comparison of Potential Prognostic Factors Between United and Nonunited Patients

Factor	United (n = 37)	Nonunited (n = 2)	*P* Value
Patient characteristics			
Age (y), mean ± SD	28.6 ± 11.2	42.0 ± 7.1	NS
Sex (male)	36/37 (97%)	1/2 (50%)	NS
Smoking status (smokers)	12/37 (32%)	0/2 (0%)	1.000*
Previous surgical treatment	0/37 (0%)	1 / 2 (50%)	NS
Fracture and nonunion characteristics			
Delay fracture to surgery (mo), mean	18.1	≥360 (30 years)	—
Schernberg zone†, mean ± SD	2.8 ± 0.8	3.0 ± 0.0	NS
Schernberg zone distribution†	Z1: 3 (8%), Z2: 7 (19%), Z3: 22 (59%), Z4: 5 (14%)	Z3: 2 (100%)	NS
Humpback deformity	0/37 (0%)	0/2 (0%)	—
Bone defect (large defect)	0/37 (0%)	1/2 (50%)	—
Surgical factors			
Fixation with K-wires	35/37 (95%)	2/2 (100%)	NS
Fixation with compression screw	2/37 (5%)	0/2 (0%)	NS
Supplemental allograft	0/37 (0%)	1/2 (50%)	—
Time to union (mo), mean (range)	5.0 (3–10)	—	—

NS, not significant.
* Fisher's exact test ($P = 1.000$).
† Schernberg zone (Z): Because only two nonunions occurred, formal multivariate analysis was not feasible; comparisons are descriptive only and should be interpreted with caution. The nonunited patient with a 30-year delay had an exceptional chronicity precluding inclusion in mean delay calculations. Bone defect size was assessed intraoperatively and classified as large when a single insulin syringe volume was insufficient to fill the defect.

Table 3
Functional Outcomes: Self-Administered Questionnaire (n = 22 Respondents at ≥12 Months Postunion)

Outcome	All Respondents (n=22)	Notes
Mean *Quick*DASH score (0–100)	12.5	Range 0–56.2; lower = better
Non-smokers (n = 14)	8.0	
Smokers (n = 7)	22.3	Significantly higher than non-smokers
Mean pain at rest (VAS 0–10)	1.4	Nonsmokers 1.1; smokers 2.1
Mean pain on loading (VAS 0–10)	2.9	Nonsmokers 2.1; smokers 4.1
Grip strength (self-assessed vs contralateral)*		
100% (identical)	10/22 (45%)	
75% (mild reduction)	7/22 (32%)	
50% (moderate reduction)	1/22 (5%)	
<25% (severe reduction)	4/22 (18%)	All 4 achieved union; prolonged rehabilitation
Wrist mobility (self-assessed vs contralateral)*		
100%	4/22 (18%)	
75% (mild stiffness)	13/22 (59%)	Most common outcome
50% (moderate stiffness)	4/22 (18%)	
<25% (severe stiffness)	1 / 22 (5%)	
Weight-bearing on palm		
Without difficulty	6/22 (27%)	
Painful but possible	7/22 (32%)	
Impossible	9/22 (41%)	Several recent consolidations/ongoing rehab

QuickDASH, inspired by the Disabilities of the Arm, Shoulder and Hand – Quick form (4 activity items, scored 1–5, converted to 0–100 scale; 0 = no disability); VAS, visual analog scale.
* Grip and mobility assessments are patient-reported, expressed as percentage of the contralateral (unaffected) side. The 4 patients with grip <25% all achieved radiographic union; limitation reflects delayed rehabilitation.

Dry arthroscopy

The technique evolved over the study period toward dry arthroscopy, with saline used only to improve visibility or clear debris. This approach advocated by Amundsen et al[7] reduces the risk of graft washout, improves visualization in the midcarpal space, and may contribute to more reliable graft compaction.

Fixation technique

Quemener et al[8] compared series with wire placement before and after grafting, finding a higher union rate when wires were placed after grafting (96% vs 80%), supporting our technical sequence. We preferred wire osteosynthesis over screws to avoid graft expulsion during screw tightening. Hoosakian et al[9] recommend crossing wires rather than using parallel wires for better rotational stability. Waitayawinyu et al[10] used olecranon grafts with screw fixation; in our series, only radial grafts were used. Karthik et al[11] found that arthroscopy allows for more precise assessment of associated injuries. Kang et al[12] studied the effects of debridement of partial ligament injuries on repair outcomes and found no significant difference. Only two patients in our series underwent screw fixation, precluding any meaningful statistical comparison with K-wire fixation regarding union rate or time to union.

Smoking

Smoking status was systematically documented: 26 nonsmokers (67%) and 13 smokers (33%). Union was achieved in all 13 smokers (100%) and 24 of 26 nonsmokers (92.3%). Fisher exact test did not demonstrate a significant association between smoking and union ($P = 1.000$). Both union failures occurred in nonsmokers with specific adverse anatomical factors, consistent with the findings of Burnier et al,[13] who in the largest arthroscopic series to date (77 patients) also did not identify smoking as a significant risk factor for nonunion. The absence of an observed effect of smoking on union should nevertheless be interpreted cautiously given the small number of nonunions. However, functional outcomes were notably worse in smokers (mean *Quick*DASH-inspired score 22.3 versus 8.0 and pain on loading 4.1 versus 2.1 out of 10), suggesting smoking may impair soft tissue healing and rehabilitation even when osseous consolidation is achieved.

Postoperative immobilization

All patients were immobilized for 4–5 days in a rigid splint followed by a removable splint for 6 weeks. Because all patients

Table 4
Comparison With Published Series on Arthroscopic Bone Grafting for Scaphoid Nonunion

Author (year)	n	Design	Union Rate	Time to Union	Fixation	Graft
Zappaterra et al (2026)	39	Prospective	94.8%	4.85 months	K-wires (95%); Screw (5%)	Distal radius autograft
Burnier et al[13] (2023)	77	Retrospective	88.3%	~5 months	Various	Distal radius autograft
Stein et al[19] (2025)	31	Retrospective	~90%	NR	K-wires	Distal radius autograft
Gvozdenovic et al[4] (2023)	27	Comparative	~92%	8 weeks	Screw	Distal radius autograft
Li et al[15] (2025)	NR	Comparative	Similar to open	Faster than open	Various	Autograft
Waitayawinyu et al[10] (2022)	NR	Retrospective	~90%	NR	Screw	Olecranon autograft
Cognet et al[17] (2017)	23	Retrospective	100%	NR	K-wires	Distal radius autograft
Liu et al[16] (2019)	NR	Retrospective	100%	NR	NR	Autograft
Panagiotis et al[18] (2023)	NR	Case series	82%	NR	NR	NR
Karthik et al[11] (2019)	NR	Retrospective	NR	NR	Various	Various
Pinder et al[1] (2015)*	1602	Meta-analysis	88% to 92%	NR	Mixed	Vascular and nonvascular (open) — reference standard

NR: not reported; K-wires: Kirschner wires.
* Pinder et al[1] is a meta-analysis of open techniques included as the reference standard.

followed the same postoperative immobilization protocol, no correlation analysis between immobilization duration and union rate could be performed. Some authors have advocated for shorter immobilization periods following arthroscopic repair; in our series, the favorable union rate (94.8%) suggests the 6-week protocol was effective. However, whether shorter immobilization would yield comparable results cannot be determined from this single-arm study.

Scaphoid nonunion and arthritis

Zhu et al[14] showed that scaphoid reconstruction is still an option even in prearthritic stages, without worsening arthritis in their series. Li et al[15] suggest that arthroscopic grafting may consolidate faster than open surgery, with similar union rates.

Our results are consistent with those of major series (Table 4) on arthroscopic scaphoid nonunion repair in terms of union rate and time to union.[1,4,10,11,13,15–19] Union rates in the literature range from 100%, with most series reporting around 90%.[16–19] The largest series is by Burnier et al.[13]

This prospective series of 39 patients demonstrates that all-arthroscopic nonvascularized bone grafting for scaphoid nonunion achieves a union rate of 94.8%, which is consistent with or exceeding the results of most published series, both open and arthroscopic (Table 4). These findings reinforce the growing body of evidence supporting arthroscopic techniques as a viable and effective alternative to open surgery in selected patients.

The principal strength of this study lies in its prospective design. To our knowledge, this represents one of the few prospective cohorts evaluating all-arthroscopic treatment of scaphoid nonunion, making prospective data collection its primary scientific contribution. The questionnaire used was inspired by the *Quick*DASH and Patient-Rated Wrist Evaluation instruments but was not a formally validated tool; results should be considered as a *Quick*DASH-derived approximation rather than a standardized score. The absence of a control group precludes direct randomized comparison with open techniques. Functional scores were not systematically collected at predefined timepoints, and the 56% questionnaire response rate introduces a potential selection bias in the functional analysis. The follow-up period ended at radiographic union for primary outcomes, without long-term surveillance for secondary arthritis or recurrence. Future prospective comparative studies with standardized functional outcomes, objective grip and range-of-motion measurements, and longer follow-up are needed.

Arthroscopic nonvascularized autogenous bone grafting for scaphoid nonunion achieves union rates and consolidation times comparable to open surgery, with the added benefits of reduced soft-tissue morbidity, preservation of scaphoid vascularization and ligamentous structures, and no donor-site pain when using a distal radius graft. In this prospective series of 39 patients, a union rate of 94.8% was obtained at a mean of 4.85 months postoperatively, with no cases of avascular necrosis or neurovascular complications. Nonunion was predominantly located at the waist (Schernberg zone 3, 62%), and no humpback deformity was observed. Smoking was not associated with union failure but correlated with worse functional outcomes. These findings support arthroscopic treatment as a relevant and reproducible first-line surgical option in appropriately selected patients with scaphoid nonunion.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the author(s) used Gemini in order to translate into English and improve the text (already written), and Claude (Anthropic) to assist with manuscript revision and data integration in response to peer review. After using these tools/services, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Conflicts of Interest

Dr. Chihab Taleb reports an association or financial involvement with Athrex Company. The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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