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Original article

Hamate autograft for proximal pole scaphoid fracture: A systematic review

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ABSTRACT

Background: Proximal pole scaphoid fracture is not uncommon and present therapeutic challenges due to impaired perfusion, with risk of secondary non-union, avascular necrosis and wrist degeneration. There is no consensus on surgical techniques for a non-salvageable proximal pole, but proximal hamate autograft to resurface the scaphoid is gaining interest. This systematic review assesses the evidence for proximal hamate autograft in resurfacing non-salvageable scaphoid proximal poles.
Methods: A systematic review searched the Medline, Embase, PubMed and Scopus databases for the period 2000–2024, following PRISMA guidelines. The protocol was registered with PROSPERO. Risk of bias was measured using ROBINS-I (Risk Of Bias In Non-randomized Studies - of Interventions).
Results: Mean duration of non-union at presentation was 50.8 months (n = 10), with a mean follow-up of 15.7 months (n = 10). Mean hamate graft length was 6.7 mm (n = 26). Radiographic union was achieved in 93.3% of patients (n = 30), at a mean 10.6 weeks (n = 26). Mean postoperative wrist flexion-extension was 89.5° (n = 10), averaging 61.4% of the arc for the contralateral hand (n = 8). Pronation and supination recovered contralateral values (n = 5). Postoperative grip strength in the affected hand was 79.8% of the contralateral value (n = 26). Postoperative QuickDASH score and VAS pain rating averaged 25 (n = 8) and 2 (n = 21), respectively. Five patients (16.7%; n = 30) experienced complications.
Conclusions: Hamate autografting for resurfacing non-salvageable scaphoid proximal poles demonstrated satisfactory early-to-medium-term outcomes. Although promising, more research is necessary to confirm the utility of this treatment modality.
Level of evidence: IV (systematic review).

Introduction

The scaphoid bone is the largest of the 8 carpal bones, and the most commonly fractured in adults [1]. Fracture in the proximal region of the scaphoid incurs a significant risk of avascular necrosis (AVN), non-union and consequent radio-carpal osteoarthritis, due to poor and largely retrograde blood supply to the proximal pole [2]. Thus, proximal pole scaphoid fracture presents a particular challenge for management [3].

There is little consensus regarding the ideal resurfacing salvage technique in very proximal scaphoid fracture with little bone stock or a fragmented and non-reconstructable proximal pole. Various options have been trialed, including costo-osteochondral rib graft, medial femoral trochlea (MFT) free flap and joint replacement [4,5]. There has been recent interest in proximal hamate autograft, with claimed advantages of proximity to the scaphoid, similar

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trabecular and articular architecture, and minimal donor site morbidity [6].

The aim of this review was to assess outcomes of proximal hamate autograft to resurface non-reconstructable scaphoid proximal poles.

Methods

This systematic review was registered in PROSPERO (n° CRD42024556327), and followed the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines [7]. The steps followed are summarized in a PRISMA flowchart (Fig. 1) and a checklist (Supplemental Table S1).

Study selection criteria

The search strategy is shown in Table 1. Inclusion and exclusion criteria followed the EQUATOR network recommendations (Table 2) [8]. The population arm focused on terms related to the scaphoid bone, and the intervention arm on the hamate autograft. A control arm was not applicable. No outcomes search was performed, as results were determined not to require limitation. Relevant MeSH terms were used for the search, and free searches were performed if no MeSH terms were found. Exclusion was based on detailed title and Abstract criteria (Table 2). Abstract-only articles and articles in a language other than English were excluded.

Search methods

The MEDLINE (from 1946, using Ovid), Embase Classic + Embase (from 1947, using Wolters Kluwer's Ovid: Alphen aan den Rijn, Netherlands), PubMed and Scopus (using Elsevier's Scopus Search: Amsterdam, Netherlands) databases were searched for the period 1 January 2000 to 1 June 2024. The reference lists in the identified studies were reviewed by the authors for inclusion in the screening process.

Data collection and analysis

The search results were imported into Endnote (Clarivate, London, United Kingdom) with duplicates merged or removed. Titles and Abstracts were independently assessed by authors A.G.

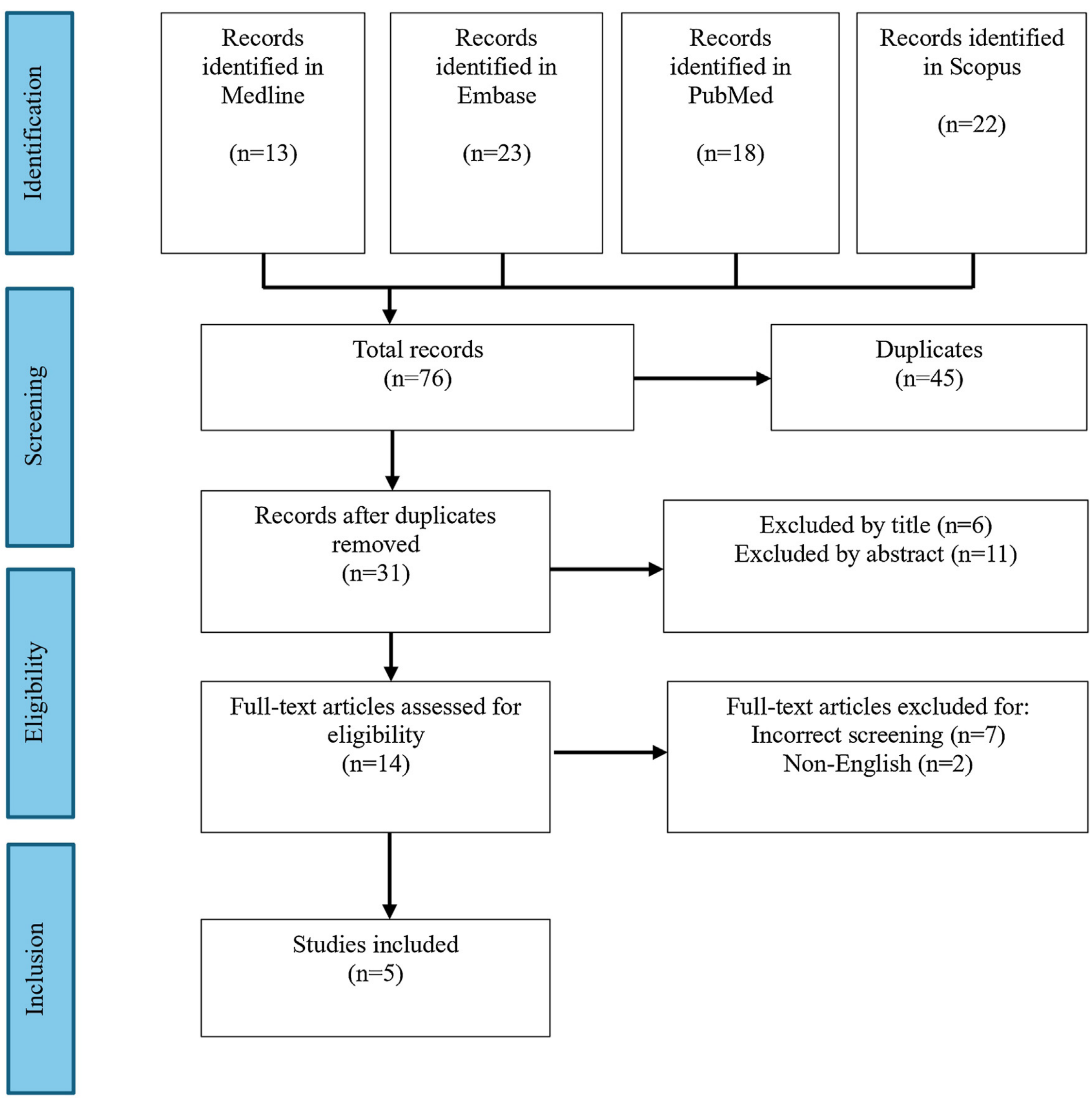

Fig. 1. PRISMA diagram of studies included in the systematic review, based on the EQUATOR network recommendations [7,8]. Seventy-six records were reviewed, based on the search strategy performed through Ovid MEDLINE 1946, Embase Classic + Embase 1947, PubMed and Scopus, after duplicates were removed and exclusion criteria were applied.

Table 1
Search strategy with total results included.

	Population	Intervention	
	1. Scaphoid 2. Fracture* 3. Break* 4. Nonunion 5. Necrosis 6. Osteonecrosis 7. Collapse 8. 2 OR 3 OR 4 OR 5 OR 6 OR 7 9. 1 AND 8	10. Hamate 11. Autograft* 12. Reconstruction 13. 11 OR 12 14. 10 AND 13	
MEDLINE	4,192	94	13
Embase	5,765	123	23
PubMed	4,247	162	18
Scopus	4,032	121	22
	15. 9 AND 14	**Total:**	76

Population, intervention, and outcome had search terms implemented in Ovid MEDLINE® 1946, Embase Classic + Embase 1947, PubMed and Scopus using free-text search terms and MeSH terms where possible for the period 1 January 2000 to 1 June 2024. Tabulated record numbers were included, with duplicates unable to be excluded.
Syntax.
Population: Scaphoid AND (fracture* OR break* OR nonunion OR necrosis OR osteonecrosis OR collapse).
Intervention: Hamate AND (autograft* OR reconstruction).
All: (Scaphoid AND (fracture* OR break* OR nonunion OR necrosis OR osteonecrosis OR collapse)) AND (Hamate AND (autograft* OR reconstruction)).

and Z.D. Two selection rounds were performed to select articles for final inclusion, with any discrepancies independently evaluated for inclusion or exclusion by authors B.S. and D.G. Data were extracted from the selected studies by author Z.D., with final tables evaluated by all authors.

Included studies were assessed for time to radiographic union, range of motion (ROM) as percentage of contralateral values, grip strength, patient-reported outcome measures (Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score [9], Mayo wrist score and pain rating on visual analog scale (VAS). Complications during clinical follow up were also assessed: non- or mal-union, infection, severe stiffness, AVN, and requirement for surgical revision. Simple summary statistics were performed where appropriate [10]. Due to inconsistent outcome reporting, the number of patients per metric is shown in brackets.

Risk of bias analysis

Risk of bias was assessed based on the ROBINS-I tool (Risk Of Bias In Non-randomized Studies - of Interventions) [11,12]: relevance, reproducibility, consideration of risks of bias, statistical methods, and appropriate reporting. Confidence and heterogeneity in cumulative evidence were assessed following the GRADE guidelines [12].

Results

The search yielded a total of 76 studies from all databases. Thirty-one duplicates were removed, and 18 studies were excluded, leaving 14 full-text articles assessed for eligibility; 9 were excluded (Fig. 1), and 5 studies were finally included in the review [13–17]: 3 retrospective cohort studies and 2 case reports, for a total of 30 patients (Table 3). There was risk of bias in all included studies, shown in a risk-of-bias graph and risk-of-bias summary (Fig. 2); overall, there was moderate risk of bias in most studies.

Table 2
Inclusion and exclusion criteria used during the screening process.

	Inclusion	Exclusion
Article	Peer-reviewed publication	Abstract only
Design	Randomised controlled trial Prospective and retrospective cohort studies Case series Case reports Guidelines	Review article Book chapter Opinion
Definition	Scaphoid fracture or nonunion	
Intervention	Hamate autograft	Any other treatment modality
Cohort	Human, living	Cadaver Animal
Description of protocol	Well described intervention Treatment measured adequately	
Statistics	Valid statistical analysis of results Appropriate statistical methods	Lack of thoroughness in analysis of results Inappropriate statistical methods

Two separate authors (A.G. and Z.D.) independently used the criteria to review all records using Endnote, with numbers excluded summarised in Fig. 1. with reasons for exclusion included. Any discrepancies were independently evaluated by author B.S. and excluded or included appropriately. All included studies were required to be published in a peer-reviewed journal and not redacted.

Table 3
Patient demographics and preoperative data.

Article	Study Design	Patients, n	Mean age, yr (range)	Male sex, n (%)	Injured side L/R	Previous surgery, n (%)	Mean nonunion time, mo (range)	Mean length of hamate graft, mm (range)	Mean wrist F/E ROM arc°	Mean P/S ROM arc°	Mean grip strength, % contralateral	Mean VAS (range)
Tabl 2023 [13]	Retrospective cohort	20	29 (19–42)	12 (60)	ND	ND	ND	6 (4–9)	ND	ND	53.7	8 (6–10)
Rodriguez-Fontan 2023 [14]	Retrospective cohort	4	24 (18–35)	3 (75)	3/1	2 (50)	47 (8–108)	9.5 (8.0–10.6)	ND	ND	ND	ND
Merkow 2022 [15]	Case report	1	24	0 (0)	1/0	0 (0)	60	7	ND	ND	ND	ND
Saruhan 2021 [16]	Retrospective cohort	4	25.7 (22–35)	3 (75)	1/3	1 (25)	62 (12–90)	ND (8–10)	ND	ND	ND	ND
Elhassan 2016 [17]	Case report	1	18	1 (100)	1/0	1 (100)	12	10	30	ND	ND	ND

F/E, flexion/extension; P/S, pronation/supination; ROM, range of motion; VAS, Visual Analog Scale.

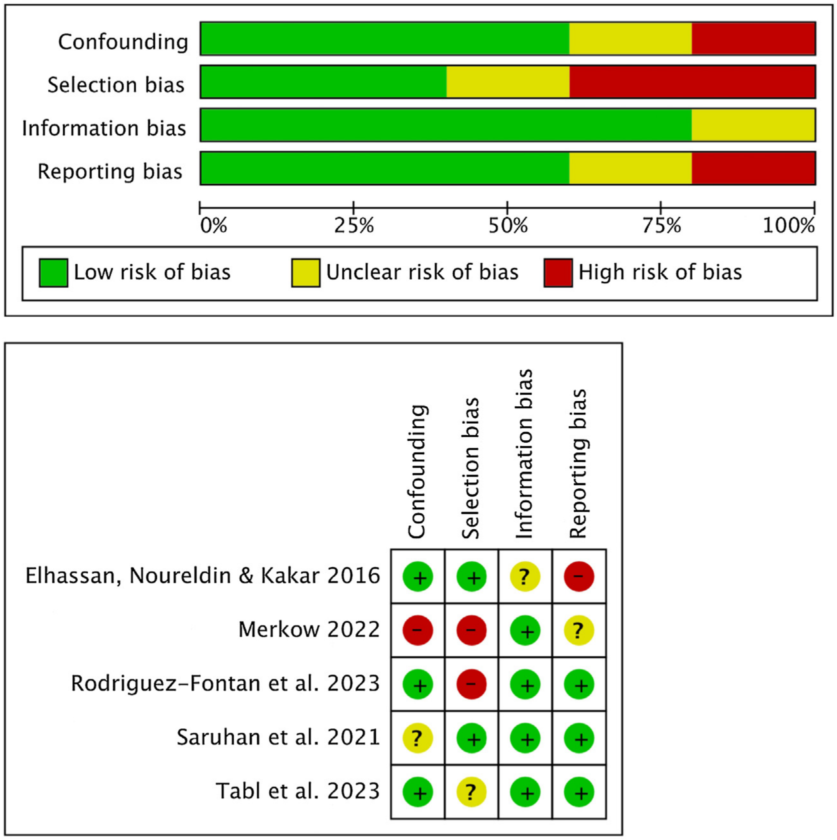

Fig. 2. Risk of bias graph and summary created in RevMan, based on the ROBINS-I tool [11]: confounding factors, selection bias, information bias and reporting bias in studies included in the systematic review. Risk of bias was assessed by several of the present authors and divergent opinions were mediated by an independent author. Five studies were included in this risk-of-bias analysis. There was significant risk of selection bias, due to 2 of the included studies being case reports. However, robust reporting standards were used, alleviating confounding, information and reporting bias.

Patient demographics

The dataset reported 30 patients with proximal pole scaphoid fracture who underwent resurfacing with hamate autograft. Patient demographics are detailed in Table 3. Mean age was 27.4 years (data for n = 30; range, 18–42 years), with 19 men and 11 women. Four patients had undergone prior surgical intervention (data for n = 10). Mean non-union time at presentation was 50.8 months (n = 10; range, 8–108 mo). Mean follow-up was 12.6 mo (n = 30; range, 6–22 mo). Mean hamate graft length was 6.7 mm (n = 26; range, 4–10.6 mm).

Outcomes

Radiographic union was achieved in 93.3% of patients, at a mean 10.6 weeks (n = 26; range, 9–12 weeks) (Table 4), as determined on either plain radiographs or CT scan with 3D reconstruction. At follow-up, mean wrist flexion-extension arc was 89.5° (n = 10), at 61.4% of the contralateral value (n = 8); pronation-supination was comparable to the contralateral value (n = 5). Mean grip strength was 79.8% of the contralateral value (n = 26). Mean QuickDASH score was 25 (n = 8; range, 13.6–52.2) and mean VAS rating was 2 (n = 21; range, 0–5). Five complications were reported (n = 30):

Table 4
Outcomes.

Article	Mean follow-up, mo (range)	Radiographic union achieved, n (%)	Mean time to radiographic union, wk (range)	Mean wrist F/E ROM arc° (% contralateral)	Mean P/S ROM arc° (% contralateral)	Mean grip strength % contralateral (range)	Mean QuickDASH (range)	Mean VAS (range)	Complications, n (%)	Mayo score (range)
Tabl 2023 [13]	11 (9–14)	18 (90)	10.2 (9–14)	ND	ND	89 (80–95)	ND	2 (0–5)	5 (25)†	93.1 (79–98)
Rodriguez-Fontan 2023 [14]	12.8 (6–20)	4 (100)	11.5 (10–12)	107.5 (67.5)	161.3 (100)	ND	17.6 (2.3–29.5)	1 (0–4)	0 (0)	ND
Merkow 2022 [15]	8	1 (100)	16	85	170	75	ND	ND	0 (0)	ND
Saruhan 2021 [16]	14 (9–22)	4 (100)	ND	65 (55.3)	ND	32.3 (8–51)	32.3 (13.6–52.2)	ND	0 (0)	ND
Elhassan 2016 [17]	42	1 (100)	10	120	ND (100)	91.7	ND	ND	0 (0)	90

F/E, flexion/extension; P/S, pronation/supination; QuickDASH, Quick Disabilities of Arm, Shoulder and Hand; ROM, range of motion; VAS, Visual Analog Scale.
† Complications due to attrition of finger extensor tendons due to capitolunate wiring (n = 3) and nonunion (n = 2).

3 cases of digital extensor tendon injury due to capitolunate wiring, and 2 of persistent non-union.

Discussion

This study reviewed the literature and presents short-to-medium-term outcomes in a cohort of 30 patients who underwent articular resurfacing for a non-reconstructable scaphoid proximal pole. Radiographic union was achieved in most patients, with satisfactory sagittal plane motion, grip strength and functional scores. Five complications were reported:3 cases of digital extensor tendon injury, not requiring reconstruction; and 2 of non-union with radio-scaphoid osteoarthritis [13]. One patient with non-union underwent limited wrist fusion; the other had declined further surgery at the time of reporting [13].

Proximal scaphoid fracture incurs high risk of non-union, AVN and subsequent osteoarthritis due to retrograde blood supply to the proximal pole, and management can be challenging [18]. The rate of union in this region is markedly low: Jaminet reported a 81.6% union rate for proximal fracture, in contrast to 97.3% and 92.6% for middle and distal fracture, respectively, in a cohort of 286 patients over 10 years' follow-up [19]. When the proximal pole is not reconstructable, resurfacing options comprise costo-osteochondral rib graft, MFT free flap or joint replacement

Costo-osteochondral rib grafting for scaphoid non-union was first described by Sandow in 1998, with promising results in terms of ROM, grip strength and pain, in 22 patients [20]. Later studies proved more equivocal. A prospective review of 14 patients treated with rib arthroplasty showed some cases of reduced grip strength, with only marginal overall improvements in ROM [21]. A recent case series of 21 patients reported a 15° increase in wrist flexion-extension arc, and a 21% increase in grip strength relative to the contralateral hand [22]. This is in contrast to the present study, which found a 90° increase in flexion-extension (n = 10) [17] and a 35.3% increase in grip strength relative to the contralateral hand (n = 20) [13]. Some case reports [23] and smaller case series [24,25] reported reasonable functional improvement following costo-osteochondral rib grafting, with mean postoperative QuickDASH scores (where reported) higher than the 17.3 found in the present series (n = 24) [22,24]. However, costo-osteochondral rib grafting may be suitable only for highly motivated younger patients, given a greater likelihood of secondary operations and donor site cosmetic concerns [23].

The medial femoral trochlea provides a source of vascularized osteochondral tissue which can be used to resurface the proximal scaphoid. A recent systematic review of MFT resurfacing of the proximal scaphoid reported that, despite improvement in functional outcome and radiographic aspect, 12.3% of patients underwent non-scheduled return to theatre [4]. Union rates and changes in motion, pain on VAS and QuickDASH scores for MFT resurfacing were similar to those reported in the present study [26,27]. As with costo-osteochondral rib grafting, donor site morbidity is a concern when raising an MFT flap. Patients may report knee discomfort for up to a year following MFT harvesting [28] and there are long-term concerns regarding donor site osteoarthritic degeneration [26]. Butler reported knee pain and functional impairment in 25% of patients at a minimum 2 years after MFT flap harvesting [29]. Similarly, Windhofer reported that 22% of patients experienced intermittent knee pain at 27 ± 17 mo' follow-up [28]. Iatrogenic femoral fracture following MFT flap harvesting was also reported, and in 1 case required total knee arthroplasty [30–32]. Although an independent vascular supply via a free flap is theoretically appealing, Sivakumar reported a union rate of 94.4% when the MFT was used to resurface the proximal scaphoid, which is not dissimilar to the union rate found in the present review [4].

The pyrocarbon Adaptive Proximal Scaphoid Implant (APSI®) partly restores scaphoid geometry, using a synthetic alternative [33]. A 10-year retrospective review of 39 patients receiving APSI reported only a negligible 4% improvement in sagittal motion [34]. The complications rate was 27%, with the majority of cases (78%) requiring revision surgery [34]. Complications comprised implant dislocation (44%), progressive carpal degeneration (33%), joint sepsis (11%), and radio-scaphoid impingement (11%) [34]. Grip strength (21% improvement relative to the contralateral side) and functional outcome (QuickDASH score of 19.5) were better than in our review, while axial motion and VAS pain scores were equivalent [34]. A larger study, comprising 71 patients, reported better sagittal motion arc and grip strength than with hamate autograft, at respectively 132.4° and 83.7% of the contralateral value. Other studies reported similar results [33,35,36].

Cadaveric morphometric analysis showed the proximal hamate to be similar to the proximal scaphoid in depth, width and sagittal curvature radius [37]. Anthropometric assessment of 29 cadaveric specimens found 69% of hamate autografts to show good fit, with the remaining 31% primarily showing discrepancies in the radio-scaphoid region, liable to induce dorsal radial impaction [38]. Good anthropometric fit was likely when the radio-ulnar width of the hamate and scaphoid was less than 10 mm [38]. Cadaveric studies also showed that proximal scaphoid resurfacing by hamate autograft almost perfectly restored wrist biomechanics, with scapholunate kinematics preserved during wrist sagittal and coronal motion [39,40]. In spite of dissimilar contact areas, radio-scaphoid facet contact pressures were equivalent to native wrist mechanics [41].

The present review has several limitations. The small sample sizes and retrospective designs of the identified studies restricted the ability to determine causal relationships and to generalize the results. Preoperative were lacking, restricting assessment of functional improvement provided by the operation. Moreover, outcome measures were heterogeneous, and important metrics were often unreported. There were inconsistencies in the reporting of donor site morbidity; future studies should report donor site pain and clinical or radiographic evidence of mid-carpal osteoarthritis. Broadening patient-reported outcome measures to encompass quality of life and satisfaction would also allow more comprehensive assessment. This paucity of data limits comparison of hamate autografting versus alternative resurfacing techniques.

The present study does, however, present encouraging preliminary data favoring the growing confidence in hamate autografting for proximal pole scaphoid fracture. The findings suggest that hamate autografting yields either superior or equivalent outcomes in terms of postoperative pain and disability, wrist flexion and extension and complications compared to other modalities. A key advantage is the absence of donor site morbidity.

Hamate autografting is a promising surgical technique for non-salvageable scaphoid proximal poles, with low rates of postoperative non-union, complications and donor site morbidity, and functional outcomes that are comparable to or better than with other treatment modalities. Despite limitations in the existing literature, this systematic review underscores the potential of hamate autografting to optimize both patient- and clinician-reported outcome measures. Further studies with long-term follow up would be beneficial.

CRediT authorship contribution statement

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

Declaration of informed consent

There is no information (names, initials, hospital identification numbers or photographs) in the manuscript that could be used to identify patients.

Declaration of ethical approval

Non-applicable.

Declaration of Generative AI and AI-assisted technologies in the writing process

AI and AI-assisted technologies were not used in writing this manuscript.

Declaration of funding

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Declaration of competing interest

The authors have no potential conflicts of interest with respect to this manuscript.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.hansur.2025.102129.

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