Du *et al. BMC Surgery* (2025) 25:232
https://doi.org/10.1186/s12893-025-02961-2

BMC Surgery

RESEARCH

Open Access

Comparison of arthroscopy-assisted versus open reduction and fixation for treating scaphoid fractures

Xiaolong Du[1*], Xuehai Ou[1], Jidong Liang[1], Chao Liu[1], Qianjin Zheng[1] and Shaoyan Shi[1]

Abstract

Objectives Scaphoid fractures represent the most common type of carpal fracture. This study aimed to retrospectively evaluate and compare the therapeutic efficacy of wrist arthroscopy-assisted fixation versus conventional open reduction with fixation for scaphoid fractures.

Methods We conducted a retrospective cohort study involving 159 patients with acute scaphoid fractures. Participants were stratified into two groups: the open reduction with fixation group (underwent open reduction and fixation) and the Arthroscopy group (received wrist arthroscopy-assisted fixation). Comparative analyses included operative duration, hospitalization length, fracture union time, and Visual Analog Scale (VAS) pain scores. Wrist functionality and range of motion were assessed using the Mayo wrist joint function scoring scale. Additionally, patient satisfaction was evaluated through a standardized questionnaire.

Results Following propensity score matching (PSM), 54 matched pairs were analyzed. Baseline characteristics showed no significant intergroup differences. The Arthroscopy group exhibited statistically superior outcomes, including shorter operative time, reduced hospitalization, accelerated fracture union, and lower postoperative VAS scores. Mayo Wrist Scores were significantly higher in the Arthroscopy group, indicating better functional recovery. Furthermore, the Arthroscopy group demonstrated a lower overall complication rate and significantly improved scores in both physical and psychological assessment domains.

Conclusions Wrist arthroscopy-assisted fixation significantly enhances postoperative recovery, yielding superior functional outcomes, reduced complications, and higher patient satisfaction compared to the open reduction with fixation group. This technique represents a promising approach for optimizing scaphoid fracture management.

Keywords Bone, Scaphoid fracture, Wrist arthroscopy-assisted fixation, Open reduction and fixation

*Correspondence:
Xiaolong Du
xiaolongdddu@sina.com
[1]Department of Hand Surgery, Honghui Hospital, Xi'an Jiaotong University, Xi'an, Shaanxi 710054, China

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Introduction

The scaphoid fracture is the most prevalent carpal fracture, disproportionately affecting young males and constituting approximately 2–7% of all systemic fractures and 70–80% of wrist fractures [1–3]. The scaphoid's unique anatomical position and biomechanical properties render it vulnerable to complex stress distributions during wrist motion, predisposing it to fractures [4, 5]. Management of scaphoid fractures remains clinically challenging due to the bone's tenuous vascular supply. The proximal pole relies predominantly on retrograde intraosseous perfusion from radial artery branches, increasing the risk of post-fracture avascular necrosis (AVN) and impaired union [6, 7]. Consequently, selecting an optimal treatment strategy is critical for achieving favorable prognostic outcomes.

Open reduction and fixation have long been the gold standard for scaphoid fracture management [8]. While effective in achieving anatomical reduction, this approach necessitates extensive soft tissue dissection, inevitably compromising the joint capsule and wrist ligament integrity. Such iatrogenic trauma may subsequently impair postoperative functional recovery and elevate risks of delayed union or nonunion [9, 10]. The evolution of minimally invasive techniques has introduced wrist arthroscopy-assisted fixation as a promising alternative [11, 12]. This modality offers distinct advantages, including reduced iatrogenic soft tissue injury, preservation of vascular integrity, enhanced fracture healing kinetics, and decreased immobilization duration. However, its broader clinical adoption requires further validation through long-term outcome studies [13, 14].

Despite the demonstrated advantages of wrist arthroscopy-assisted fixation, its clinical adoption remains limited, and comparative evidence against conventional open reduction and fixation is still insufficient. This study aims to conduct a comprehensive retrospective analysis comparing the therapeutic efficacy of these two surgical approaches for scaphoid fractures. Through systematic evaluation of clinical outcomes, we seek to: (1) delineate the respective advantages and limitations of each technique, (2) establish evidence-based indications for their application, and (3) provide robust scientific data to optimize clinical decision-making in scaphoid fracture management.

Materials and methods

Inclusion and exclusion criteria

We conducted a retrospective cohort study analyzing clinical data from patients treated at our institution between January 2019 and January 2024. The study protocol received approval from the Institutional Review Board.

Inclusion criteria ① Radiologically confirmed scaphoid fracture (X-ray, computed tomography (CT), or Magnetic Resonance Imaging (MRI)); ② Surgical treatment with either: Wrist arthroscopy-assisted fixation, or Open reduction and fixation; ③ Age 18–65 years ④ Acute unilateral fracture (time from injury to surgery ≤ 7 days); ⑤ Minimum 6-month follow-up with complete clinical data.

Exclusion criteria ① Pathological fractures or non-acute injuries (> 1 week); ② Concomitant wrist fractures or significant soft tissue damage; ③ Previous wrist surgery or pre-existing wrist dysfunction; ④ Comorbid conditions including: Degenerative arthritis, Osteoporosis (T-score <-2.5), Neoplastic disease, Major organ dysfunction; ⑤ Cognitive or psychiatric disorders affecting compliance.

A total of 159 patients met the above criteria and were included in this study. Patients who underwent open reduction and fixation surgery were included in the Open group ($n = 88$), while patients who underwent wrist arthroscopy-assisted fixation surgery were included in the Arthroscopy group ($n = 71$). This study has been approved by the Ethics Review Committee.

Operative procedure

Wrist arthroscopy-assisted fixation: The patient was positioned in the supine position under brachial plexus anesthesia, with a pneumatic tourniquet applied to the proximal third of the affected limb. Surgical approaches were established through the radial aspect combined with 3–4 and 4–5 portals. A 0.5 cm incision was made, through which a 1.9–2.7 mm wrist arthroscope was inserted for intraarticular visualization. Under arthroscopic guidance, the scaphoid fracture was clearly identified, followed by debridement of intra-articular hematomas and soft tissue interposition. Fracture reduction was achieved and stabilized using a single Acutrak headless compression screw. Final arthroscopic verification confirmed appropriate screw positioning and anatomical fracture alignment. The surgical portals were closed routinely.

Open reduction and fixation: The patient underwent brachial plexus anesthesia with a pneumatic tourniquet applied to the proximal third of the affected limb. A 3–4 cm volar approach centered over the scaphoid tubercle was utilized. The radial artery and flexor carpi radialis tendon were meticulously mobilized and retracted radially to expose the radio scaphoid joint capsule, which was subsequently incised along the longitudinal axis of the scaphoid to facilitate fracture reduction. Definitive fixation was achieved using a single Acutrak headless compression screw under fluoroscopic guidance. Post-reduction imaging confirmed anatomical alignment and optimal screw trajectory. The surgical portals were closed routinely.

All procedures were performed by two fellowship-trained hand surgeons with over 10 years of clinical experience.

Postoperative care

Both groups were immobilized with short-arm casts postoperatively and received standardized prophylactic antibiotic therapy. Supervised rehabilitation, including active-assisted wrist mobilization exercises and regular wound assessment, was initiated 24 h after surgery. All patients underwent postoperative CT within 24 h to verify adequate fracture reduction and optimal implant placement. Sutures were removed at 2 weeks postoperatively. Cast immobilization was gradually discontinued between 2 and 4 weeks based on individual healing progression, followed by progressive functional rehabilitation. Serial radiographic assessments (X-ray and CT) were performed at 4-week intervals to objectively evaluate fracture union status.

Data collection

1) General information: Patients' gender, age, BMI, fracture side, injury mechanism, Herbert type and follow-up time were collected through medical records.
2) Surgical indicators: surgery time, duration of hospital stays, union time of fracture and visual analogue scale (VAS) pain scores [15] before surgery, on the day of surgery and 2 weeks after surgery were collected.
3) Wrist joint function score and range of motion: the modified Mayo wrist joint function score scale [16] was used to evaluate the functional recovery before surgery, 3 months after surgery and 6 months after surgery. The range of motion of the wrist joint was assessed using a protractor before surgery, 3 months after surgery and 6 months after surgery, including flexion, extension, radial deviation and ulnar deviation.
4) Complications: The occurrence of complications such as infection, delayed union, traumatic arthritis, non-union or osteonecrosis will be recorded through follow-up.
5) Quality of life and satisfaction: We used the WHOQOL-BREF scale [17] to assess the quality of life (physiological, psychological, social relationships and environmental) before and 6 months after surgery. Patient satisfaction with treatment outcomes were collected through a questionnaire survey (satisfied, generally satisfied and unsatisfied).

Propensity score matching (PSM)

To address potential selection bias, PSM was used to match two groups of patients based on gender, age, BMI, fracture side, injury mechanism, and baseline characteristics of Herbert fracture type, to reduce the influence of confounding factors on the results. The specific steps include calculating the propensity score for each patient, setting the matching tolerance to 0.02 and performing a 1:1 match between the two groups using the nearest neighbour matching method.

Statistical analysis

All statistical analyses were performed using SPSS version 27.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro-Wilk test. Normally distributed data were expressed as mean ± standard deviation (SD) and analyzed using independent samples t-tests. Non-normally distributed data were presented as median (interquartile range [IQR]: Q1-Q3) and compared using the Mann-Whitney U test (Wilcoxon rank-sum test). Categorical variables were reported as frequencies (percentages) and analyzed using Pearson's chi-square test or Fisher's exact test, as appropriate. A two-tailed p-value < 0.05 was considered statistically significant for all analyses.

Results

Patient characteristics before and after PSM

Table 1 summarizes the baseline characteristics of patients in the arthroscopy-assisted fixation group (Arthroscopy group) and open reduction internal group (Open group) both before and after PSM.

Prior to PSM, the Arthroscopy group was significantly older than the Open group (33.21 ± 5.80 years vs. 31.07 ± 5.92 years, $P = 0.023$). While not statistically significant, the Open group had higher proportions of male patients (46.6% vs. 32.4%, $P = 0.070$) and right-sided fractures (60.2% vs. 45.1%, $P = 0.057$) compared to the Arthroscopy group. No significant differences were observed between groups for body mass index, injury mechanism, Herbert fracture classification, or follow-up duration (all $P > 0.05$).

Following 1:1 PSM, 54 well-matched patient pairs were included in each treatment group. All baseline characteristics demonstrated excellent balance between groups after matching, with no statistically significant differences remaining (all $P > 0.05$). Standardized mean differences for all covariates were reduced below 0.1, indicating successful achievement of covariate balance between treatment groups.

Table 1 Baseline characteristics before and after PSM

Characteristics	Before matching (*n* = 159)			After matching (*n* = 108)		
	Open (*n* = 88)	Arthroscopy (*n* = 71)	*P* value	Open (*n* = 54)	Arthroscopy (*n* = 54)	*P* value
Gender			0.070			0.693
Male	41 (46.6%)	23 (32.4%)		22 (40.7%)	20 (37%)	
Female	47 (53.4%)	48 (67.6%)		32 (59.3%)	34 (63%)	
Age (years)	31.07 ± 5.92	33.21 ± 5.80	0.023	32.41 ± 5.88	32.74 ± 5.55	0.763
BMI (kg/m^2)	24.40 ± 2.89	24.72 ± 2.59	0.468	24.63 ± 2.86	24.60 ± 2.75	0.960
Fracture side			0.057			0.847
Left	35 (39.8%)	39 (54.9%)		27 (50%)	26 (48.1%)	
Right	53 (60.2%)	32 (45.1%)		27 (50%)	28 (51.9%)	
Injury mechanism			0.562			0.797
Traffic accident	30 (34.1%)	24 (33.8%)		19 (35.2%)	20 (37%)	
Fall during sports	30 (34.1%)	18 (25.4%)		16 (29.6%)	15 (27.8%)	
Fall from a height	15 (17%)	14 (19.7%)		9 (16.7%)	12 (22.2%)	
Others	13 (14.8%)	15 (21.1%)		10 (18.5%)	7 (13%)	
Injury to operation time (d)	2.5 (1, 3)	3 (2, 4)	0.283	2 (1, 3)	2.5 (2, 3.5)	0.324
Herbert type			0.498			0.549
B1	28 (31.8%)	27 (38%)		17 (31.5%)	18 (33.3%)	
B2	32 (36.4%)	29 (40.8%)		23 (42.6%)	23 (42.6%)	
B3	18 (20.5%)	9 (12.7%)		12 (22.2%)	8 (14.8%)	
B4	10 (11.4%)	6 (8.5%)		2 (3.7%)	5 (9.3%)	
Follow-up time (m)	11.5 (9, 14)	12 (9, 14)	0.924	12 (9.25, 14.75)	11.5 (8, 14)	0.179

Comparison of multiple clinical indicators between the arthroscopy group and the open group

After PSM, the Arthroscopy group demonstrated clinically meaningful improvements in several outcomes compared to the Open group (Table 2). The surgery time in the Arthroscopy group was 52.07 ± 6.39 min, which was shorter than that in the Open group 70.37 ± 7.30 min ($P < 0.05$). The median duration of hospital stay was 6 days shorter in the Arthroscopy group than in the Open groups (4 (3, 4) days vs. 10 (9, 12) days; $P < 0.05$). In addition, the median fracture union time was accelerated by 3 weeks in the Arthroscopy group (10 (9,12) weeks vs. 13 (12,15) weeks; $P < 0.05$). Besides, the VAS pain scores of the two groups were similar on day 0 after surgery (8 (8, 9) vs. 8 (7, 8)), but the VAS score of the Arthroscopy group was lower at 2 weeks after surgery (3 (3, 4) vs. 5 (4,5), $P < 0.05$).

The modified Mayo score in the Arthroscopy group and Open groups before surgery were 52.76 ± 4.55 and 52.94 ± 4.07, respectively, with no significant difference ($P > 0.05$). However, the scores in the Arthroscopy group at 3 and 6 months after surgery were 80.47 ± 6.78 and 90.35 ± 2.99, which were higher than that in the Open groups (75.54 ± 6.69 and 81.19 ± 2.78, $P < 0.05$), indicating better recovery of wrist joint function in the Arthroscopy group. For the range of motion, in terms of flexion, extension, radial deviation and ulnar deviation, the Arthroscopy group was better than the Open groups at 3 and 6 months after surgery ($P < 0.05$). The Arthroscopy group demonstrated a lower overall incidence of complications ($P < 0.05$), especially specific complications such as infection, traumatic arthritis and non-union or osteonecrosis (5.6%) than the Open group (20.4%).

Comparison of quality of life and satisfaction between two groups of patients

At 6 months postoperatively, the Arthroscopy group reported modest but consistent improvements in quality of life (Table 3). There were no significant differences between the two groups in the physiological, psychological, social relationships, and environmental domains of the WHOQOL-BREF scores before surgery ($P > 0.05$). However, at 6 months postoperatively, the Arthroscopy group showed higher scores across both physiological and psychological domains compared to the Open group (16.54 ± 1.07 vs. 15.12 ± 1.39 and 18.45 ± 1.46 vs. 17.39 ± 1.56, $P < 0.05$), indicating greater improvements in quality of life. For social relationships, although the scores in the Arthroscopy group were higher than those in the Open group, the difference was not significant (19.01 ± 1.33 vs. 18.56 ± 1.42, $P = 0.095$). For the environmental domains, the scores of the Arthroscopy group and Open group were 17.73 ± 1.30 and 17.55 ± 1.44 at 6 months after surgery, with no significant difference ($P = 0.490$). In addition, the level of patient satisfaction, overall satisfaction (including satisfied and generally satisfied), was higher in the Arthroscopy group (94.4%) than in the Open group (83.3%, $P = 0.066$).

Table 2 Clinical indicators after PSM

Indicators	Open (*n* = 54)	Arthroscopy (*n* = 54)	*P* value
Surgery time (min)	70.37 ± 7.30	52.07 ± 6.39	< 0.001
Duration of hospital stay (d)	10 (9, 12)	4 (3, 4)	< 0.001
Union time (w)	13 (12, 15)	10 (9, 12)	< 0.001
VAS score			
Preoperative	7 (6, 7)	6.5 (5.25, 8)	0.828
Postoperative day 0	8 (8, 9)	8 (7, 8)	0.039
Postoperative 2 week	5 (4, 5)	3 (3, 4)	< 0.001
Modified Mayo score			
Preoperative	52.91 ± 4.07	52.76 ± 4.55	0.859
Postoperative 3 month	75.54 ± 6.69	80.47 ± 6.78	0.002
Postoperative 6 month	81.19 ± 2.78	90.35 ± 2.99	< 0.001
Range of motion (°)			
Flexion			
Preoperative	28.93 ± 5.97	29.03 ± 4.59	0.929
Postoperative 3 month	44.94 ± 6.12	48.02 ± 7.46	0.021
Postoperative 6 month	48.75 ± 4.08	57.12 ± 4.37	< 0.001
Extension			
Preoperative	28.67 ± 4.29	28.58 ± 4.30	0.907
Postoperative 3 month	47.05 ± 5.78	49.93 ± 6.81	0.020
Postoperative 6 month	50.35 ± 4.45	56.85 ± 5.24	< 0.001
Radial deviation			
Preoperative	13.47 ± 2.47	13.79 ± 2.66	0.516
Postoperative 3 month	15.08 ± 3.69	16.46 ± 2.94	0.034
Postoperative 6 month	17.04 ± 3.20	20.69 ± 3.68	< 0.001
Ulnar deviation			
Preoperative	17.40 ± 5.43	16.92 ± 5.37	0.873
Postoperative 3 month	19.67 ± 4.17	21.83 ± 5.32	0.021
Postoperative 6 month	21.86 ± 3.50	24.93 ± 3.65	< 0.001
Complications	11 (20.4%)	3 (5.6%)	0.022
Infection	6 (11.1%)	2 (3.7%)	0.270
Delayed union	1 (1.9%)	1 (1.9%)	1.000
Traumatic arthritis	2 (3.7%)	0 (0%)	0.475
Nonunion or osteonecrosis	2 (3.7%)	0 (0%)	0.475

Table 3 Patient quality of life and satisfaction after PSM

Indicators	Open (*n* = 54)	Arthroscopy (*n* = 54)	*P* value
WHOQOL-BREF score			
Physiological			
Preoperative	11.36 ± 0.96	11.33 ± 1.03	0.908
Postoperative 6 month	15.12 ± 1.39	16.54 ± 1.07	< 0.001
Psychological			
Preoperative	13.40 ± 0.91	13.76 ± 0.92	0.046
Postoperative 6 month	17.39 ± 1.56	18.45 ± 1.46	< 0.001
Social relationships			
Preoperative	14.88 ± 0.69	14.82 ± 0.98	0.706
Postoperative 6 month	18.56 ± 1.42	19.01 ± 1.33	0.095
Environmental			
Preoperative	15.72 ± 0.91	15.62 ± 0.92	0.584
Postoperative 6 month	17.55 ± 1.44	17.73 ± 1.30	0.490
Satisfaction level	45 (83.3%)	51 (94.4%)	0.066
Satisfied	26 (48.1%)	32 (59.3%)	0.247
Generally satisfied	19 (35.2%)	19 (35.2%)	1.000
Unsatisfied	9 (16.7%)	3 (5.5%)	0.066

Discussion

The blood supply system of scaphoid fracture is unique, and improper early treatment can easily lead to delayed healing or non-healing of fractures, thereby affecting wrist joint function [4, 18]. At present, wrist arthroscopy-assisted fixation has shown satisfactory results in the clinical treatment of navicular fractures due to its minimally invasive advantages [19]. However, there is currently limited research comparing arthroscopic wrist arthroscopy-assisted fixation with open reduction and fixation. Our results indicated that compared with the Open group, the surgery time (52.07 ± 6.39 min vs. 70.37 ± 7.30 min) and duration of hospital stay (4 (3, 4) days vs. 10 (9, 12) days) in the Arthroscopy group were shorter, and the VAS score at 2 weeks after surgery was lower than that in the Open group (3 (3,4) points vs. 5 (4, 5) points), indicating that wrist arthroscopy-assisted fixation helps reduce patient pain and medical resource consumption. In addition, the Arthroscopy group had shorter fracture union time (10 (9, 12) weeks vs. 13 (12, 15) weeks), which may be why it caused less damage to surrounding tissues and resulted in a faster postoperative recovery. Hu et al. [6] obtained similar research results to this study: for acute scaphoid fracture with fracture displacement > 1 mm, arthroscopic assisted internal fixation results in shorter fracture union time and better recovery of wrist joint function. In addition, research has reported that wrist arthroscopy-assisted fixation treatment for navicular fractures facilitated early postoperative wrist function exercise and promoted wrist function recovery [20]. Meanwhile, our study found that the incidence of serious complications such as infection, non-union or osteonecrosis was lower in the Arthroscopy group, further demonstrating the safety of wrist arthroscopy-assisted fixation.

Minimally invasive surgery is an advanced surgical technique that has many advantages over traditional surgery [21]. In addition to minimal trauma, mild pain, shorter recovery times and fewer complications, improving quality of life is also a key consideration for many patients [22]. There were reports that compared with open reduction and internal fixation, wrist arthroscopy-assisted fixation improves patients' quality of life [23]. Similarly, this study found that both physiological and psychological outcomes were better in the Arthroscopy group compared to the Open group at 6 months postoperatively, indicating some aspects of quality of life have improved. In addition, the overall satisfaction of the Arthroscopy group was slightly higher than that of the Open group. These findings emphasized the advantages of minimally invasive surgery in the treatment of scaphoid fractures.

In conclusion, wrist arthroscopy-assisted fixation can significantly shorten surgical time, hospital stay, and fracture union time, reduce postoperative pain, accelerate joint function recovery, and partially improve patients' quality of life and satisfaction compared with open reduction and fixation. These findings demonstrate the advantages of minimally invasive surgery in the treatment of scaphoid fractures.

Although this study achieved satisfactory results, there are certain limitations. (1) The relatively small sample size may limit the generalizability and statistical power of the results. (2) The follow-up time was relatively short. Although the short-term treatment effect is significant, the long-term effects (such as stability of fracture healing, sustained recovery of joint function, etc.) still need to be observed. (3) The results of this study may be influenced by the region, hospital, and the technical level of the surgeon. (4) In the future, we will consider expanding the sample size, extending follow-up time, adopting a prospective design, and taking into account the influence of other factors to more comprehensively evaluate treatment efficacy.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12893-025-02961-2.

Supplementary Material 1

Supplementary Material 2

Author contributions

Xiaolong Du and Shaoyan Shi contributed to the study conception and design. Xiaolong Du wrote the first draft of the manuscript. Material preparation and Data collection were performed by Xuehai Ou, Jidong Liang and Chao Liu. Formal analysis and Software were performed by Qianjin Zheng and Shaoyan Shi. All authors commented on previous versions of the manuscript, read and approved the final manuscript.

Funding

This study was supported by Shaanxi Science and Technology Project Plan (NO. 2023-YBSF-644) and Xi'an Science and Technology Project Plan (NO. 23YXYJ0073).

Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

This study was approved by The Ethics Committee of Honghui Hospital (NO. 2025-KY-028-1). Written informed consent was obtained from each participant for the participation in the study.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

Received: 6 December 2024 / Accepted: 13 May 2025
Published online: 28 May 2025

References

1. Sabbagh MD, Morsy M, Moran SL. Diagnosis and management of acute scaphoid fractures. Hand Clin. 2019;35(3):259–69.
2. Gray RRL, Halpern AL, King SR, Anderson JE. Scaphoid fracture and nonunion: new directions. J Hand Surg Eur Vol. 2023;48(2suppl):s4–10.
3. Hughes TB. Acute scaphoid waist fracture in the athlete. Clin Sports Med. 2020;39(2):339–51.
4. Zaraa M, Ben Slama S, Mahjoub S, Sehli H, Hadj Salah M, Mbarek M. The head to foot screw fixation. A new technique of percutaneous screw fixation of the scaphoid bone. Tunis Med. 2017;95(1):60–6.
5. Aruse O, Immerman I, Badir O, Haj ME, Volk I, Luria S. Scaphoid fracture displacement is not correlated with the fracture angle. J Hand Surg Eur Vol. 2021;46(6):607–15.
6. Hu H, Teng X, Li X, Li M, Chang S. Comparison of two different percutaneous screw fixations for treating Herbert B2-Type acute scaphoid fractures. Orthop Surg. 2022;14(12):3187–94.
7. Basso MA, Smeraglia F, Ocampos-Hernandez M, Balato G, Bernasconi A, Corella-Montoya F. Scaphoid fracture non-union: a systematic review of the arthroscopic management. Acta Biomed. 2023;94(5):e2023194.
8. Baumbach SF, Böcker W, Polzer H. [Open reduction and internal fixation of posterior malleolus fractures]. Oper Orthop Traumatol. 2021;33(2):112–24.
9. Oh WT, Choi YR, Kang HJ, Koh IH, Lim KH. Comparative outcome analysis of Arthroscopic-Assisted versus open reduction and fixation of Trans-scaphoid perilunate fracture dislocations. Arthroscopy. 2017;33(1):92–100.
10. Kaiser P, Brueckner G, Kastenberger T, Schmidle G, Stock K, Arora R. Mid-term follow-up of surgically treated and healed scaphoid fractures. Hand Surg Rehabil. 2021;40(3):288–92.
11. Cheng YB, Yang S. [Wrist arthroscopy assisted open reduction and volar ligament reconstruction through osseous internal fixation for the treatment of distal radius Fernandez type IV fractures]. Zhongguo Gu Shang. 2022;35(6):566–71.
12. Yu F, Pang B, Liu Y, Zhang C, Deng Z, Zhang D, Liu X, Yang W. Wrist Arthroscopy-Assisted reduction for distal radius fracture and its associated injuries: clinical observation of triangular fibrocartilage complex injuries. Ann Ital Chir. 2024;95(1):78–90.
13. Shih YC, Wu CC, Shih JT. Arthroscopic treatment of stable nonunion, unstable nonunion, or nonunion of the scaphoid with early degenerative radioscaphoid arthritis. J Orthop Surg Res. 2023;18(1):123.
14. Tomori Y, Kodera N, Nanno M, Majima T. Dorsal radiocarpal dislocation with radial styloid fracture treated with Arthroscopy-Assisted reduction and internal fixation: A report of two cases. J Nippon Med Sch. 2024;91(2):241–8.
15. Singh V, Tang A, Bieganowski T, Anil U, Macaulay W, Schwarzkopf R, Davidovitch RI. Fluctuation of visual analog scale pain scores and opioid consumption before and after total hip arthroplasty. World J Orthop. 2022;13(8):703–13.
16. Yeh KT, Wu WT, Wang JH, Shih JT. Arthroscopic foveal repair with suture anchors for traumatic tears of the triangular fibrocartilage complex. BMC Musculoskelet Disord. 2022;23(1):634.
17. Skevington SM, Lotfy M, O'Connell KA. The world health organization's WHOQOL-BREF quality of life assessment: psychometric properties and results of the international field trial. A report from the WHOQOL group. Qual Life Res. 2004;13(2):299–310.
18. Cohen A, Claessen T, van den Berg C, Siebelt M, Hagenaars T, Kraan GA, Waarsing JH, Reijman M, Colaris JW. Morphological risk factors for scaphoid fracture: a case-control study. Eur J Trauma Emerg Surg. 2023;49(1):133–41.
19. Cheng YB, Yang S. [Wrist arthroscopy assisted open reduction and bone graft through bone window internal fixation for the treatment of distal radius Die-punch fractures]. Zhongguo Gu Shang. 2019;32(8):731–5.
20. Moatshe G, Godin JA, Chahla J, Cinque ME, Kennedy NI, Sanchez G, Beaulieu-Jones BR, LaPrade RF, Provencher MT. Clinical and radiologic outcomes after scaphoid fracture: injury and treatment patterns in National football league combine athletes between 2009 and 2014. Arthroscopy. 2017;33(12):2154–8.
21. Speth J. Guidelines in practice: minimally invasive surgery. Aorn J. 2023;118(4):250–7.
22. McWilliam JR, Schipper ON, Siddiqui NA, Clements JR, Truitt Cooper M. Minimally invasive surgery. Foot Ankle Spec. 2021;14(2):153–7.
23. Kim JP, Lee JS, Park MJ. Arthroscopic treatment of perilunate dislocations and fracture dislocations. J Wrist Surg. 2015;4(2):81–7.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.