OPERATIVE TECHNIQUE

Lateral Approach for Scaphoid Excision and Capitolunate Arthrodesis in the Treatment of Scapholunate Advanced Collapse and Scaphoid Nonunion Advanced Collapse Wrists: A Case Series

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Objective: The dorsal approach is commonly used in open wrist arthrodesis. However, the extensor compartments and the dorsal wrist capsule need to be opened. We propose and evaluate a lateral approach using a small incision over the scaphoid anatomical snuffbox, which could be more straightforward for performing scaphoid excision and capitolunate arthrodesis in the treatment of scapholunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC).

Methods: Between 2016 and 2021, 10 patients were enrolled retrospectively and underwent the lateral approach for scaphoid excision and capitolunate arthrodesis. We presented the radiographic outcomes, including fusion status, capitolunate angle, and carpal height ratio. The functional outcomes of wrist range of motion, grip strength, visual analog scale (VAS) score for pain, Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) score, and Mayo wrist score were evaluated. The data obtained were analyzed and presented as the mean and standard deviation (SD).

Results: All 10 patients achieved solid bone fusion, and the mean follow-up period was 20.4 (range 12–38; SD 10.1) months. Postoperatively, the mean capitolunate angle and carpal height ratio improved from 18.1° (range 8–34°; SD 8.6°) to 2.9° (range 0–5°; SD 1.9°) and 0.45 (range 0.40–0.49; SD 0.03)% to 0.50 (range 0.46–0.54; SD 0.02)%, respectively. The average preoperative and final follow-up functional results were as follows: flexion-extension arc of 76.5° (range 50–110°; SD 20.0°) and 74.0° (range 65–90°; SD 9.1°); VAS pain score of 5.8 (range 4–7; SD 1.0) and 0.9 (range 0–2; SD 0.6); QuickDASH score of 55.9 (range 40.9–79.5; SD 11.4) and 26.1 (range 18.2–36.4; SD 6.0); and Mayo wrist score of 46.5 (range 25–60; SD 13.8) and 72.5 (range 70–80; SD 3.5), respectively.

Conclusions: The lateral approach for scaphoid excision and capitolunate arthrodesis in treating SLAC and SNAC can provide a straightforward way for performance. This approach does not require disruption of the dorsal wrist capsule and extensor retinaculum. Bony healing can be achieved, and functional outcomes can be improved.

Key words: arthrodesis; capitolunate; partial wrist fusion; scaphoid nonunion advanced collapse; scapho-lunate advanced collapse

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Introduction

The 4-corner arthrodesis (4-CA) was first described by Waton and Ballet[1]. It is mainly indicated for the treatment of scapholunate advanced collapse (SLAC) or scaphoid nonunion advanced collapse (SNAC), as it involves the degeneration of the capitate head. 4-CA combined with scaphoid excision has been reported to have long-term reliability[2,3]. However, capitolunate arthrodesis, as a more limited intercarpal arthrodesis, has been proposed to simplify the arthrodesis procedures and preserve more intercarpal articulations[4,5].

In the open method for partial wrist arthrodesis, the dorsal approach is commonly used. However, its disadvantages mainly include disruption to the dorsal wrist circulation due to the peeling off of the dorsal capsule from the carpal bones. Another disadvantage is the compromise of wrist motion due to dorsal soft tissue scarring after the incision and repair[6,7]. In minimally invasive surgery using arthroscopic partial wrist arthrodesis, the potential advantages include minimal surgical damage to the supporting ligaments and capsular structures of the wrist. This can facilitate bony healing, maximize the remaining carpal motion, reduce postoperative pain, and yield cosmetic benefit owing to the minimal surgical scar formation. Nonetheless, it is more technically demanding[6,8].

In the commonly used dorsal wrist open approach, the dorsal extensor retinaculum and dorsal wrist capsule cannot be avoided; they are opened and repaired later. An inappropriate incision of the dorsal capsule ligaments can worsen wrist instability and cause scarring due to the incision and repair, which might lead to negative effects on wrist motion and function[9]. Hence, we propose a lateral approach with a small incision over the anatomical snuffbox, as this could be a more straightforward method for scaphoid excision and capitolunate arthrodesis. This study aimed to: (i) introduce a lateral approach with incision over the anatomical snuffbox; (ii) evaluate the healing of arthrodesis; (iii) and assess the advantages and functional outcomes after this procedure.

Methods

Patient Enrollment

This was a retrospective study of a consecutive series of patients who underwent scaphoid excision and capitolunate arthrodesis through the lateral approach between 2016 and 2021. Ethical approval was granted by the Institutional Review Board of the Ditmanson Medical Foundation Chia-Yi Christian Hospital. (No. 2021081).

Surgery was performed in patients with stage II or III SLAC or SNAC with midcarpal arthrosis; however, the radiolunate joint was preserved. Our exclusion criteria included young age with open physis at the distal radius and patients with immunological diseases or severe peripheral vascular occlusive problems. We also excluded patients who had undergone previous wrist surgery.

Preoperative Image Evaluation

In our practice, computed tomography is routinely performed before surgery for the bony structures and alignment evaluation. Magnetic resonance imaging is not a routine examination and is only performed when the cartilage or ligamentous conditions need to be further verified.

Surgical Procedure

Anesthesia, Position, Approach, and Exposure

The procedure was performed under general anesthesia with the patient in the supine position. Under tourniquet control, a longitudinal or curved incision of approximately 3–4 cm was made over the area of the anatomical snuffbox, between the extensor pollicis brevis and extensor pollicis longus. Care was taken to protect the superficial branch of the radial nerve and the distal radial artery, both of which lie across the operative field. The division of the wrist capsule, which is placed longitudinally underneath, and the scaphoid were then revealed.

Scaphoid Excision and Radial Styloidectomy

After visualization of the scaphoid, it could be removed as a whole, or it could be cut into pieces to assist the removal process. Scaphoid excision was followed by radial styloidectomy, which was performed from the scaphoid space under fluoroscopy. Releasing part of the corresponding first extensor retinaculum would be helpful for identification of the radial styloid margin.

Capitolunate Joint Preparation and Realignment

The degenerative articular surface and the subchondral sclerotic bone layer were removed for the preparation of capitolunate arthrodesis (Fig. 1). It is important to not remove too much of the subchondral bone because carpal height restoration could then be difficult[10].

Before fusion of the capitate and lunate, it is important to correct the dorsal intercalated segment instability (DISI)[11]. If it is difficult to correct the DISI while simultaneously adjusting the capitate-lunate alignment, the DISI could be corrected first by flexing the patient's wrist to make the lunate position neutral. Then, the lunate position is maintained by transfixing a 1.0-mm or 1.25-mm K-wire from the dorsal cortex of the distal radius to the lunate, with a small incision for protecting the extensor tendons using mosquito forceps.

After correction of the DISI, the capitate-lunate alignment needs to be corrected by translating the capitate ulnarly to sit completely on top of the lunate. A 1.6-mm K-wire is preferred for pushing the capitate on its side from the lateral wound. The capitate was pushed by the K-wire ulnarly, and the capitate-lunate alignment was checked under fluoroscopy to ensure the capitate sitting completely on top of the lunate. Traction of the fingers distally could help increase carpal height. The K-wire was then aimed at the triquetrum and drilled foreword to transfix the capitate-triquetrum. After capitotriquetrum transfixation (Figs. 1 and 2), the relationship

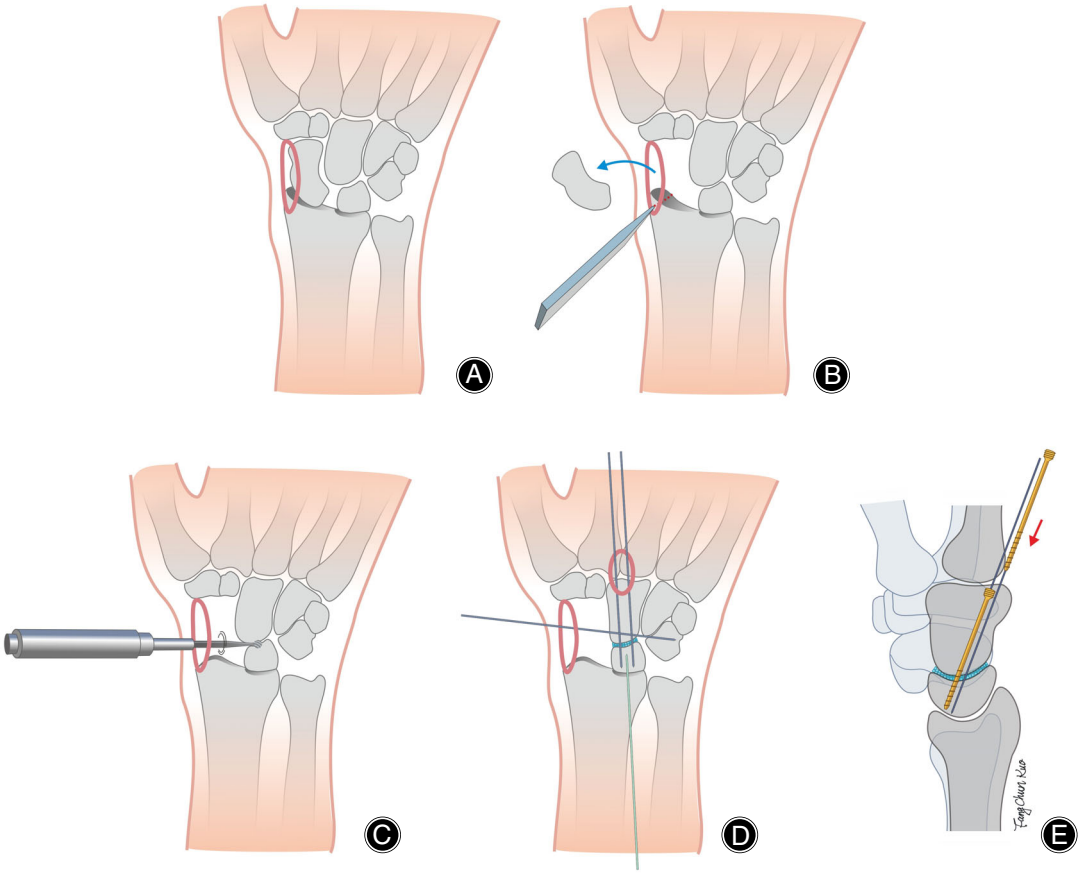

Fig. 1 (A) Lateral approach wound over the anatomical snuffbox. (B) Scaphoid excision and radial styloidectomy. (C) Remove the articular surface of the capitate and lunate. (D) Reduce the dorsal intercalated segment instability (DISI) and radiolunate transfixation if needed (light-colored K-wire). Align the capitate on the lunate and retrogradely set the K-wires from the capitate to the lunate. Fill the bone graft into the capitolunate space. (E) Set the headless screws *via* the guide pins.

between the proximal and distal carpal row could be maintained.

Following this, the bone graft could be stuffed into the capitolunate junction for arthrodesis. The resected scaphoid can be used as a bone graft. If the scaphoid is not of sufficient amount to be used as bone graft, more cancellous bone grafts can be harvested from the bone window of radial styloidectomy or other bone substitutes can also be an option. In our experience, bone grafts from the resected scaphoid are sufficient for patients with SLAC. However, additional bone graft harvesting from the distal radius *via* the radial styloidectomy bone window is needed for patients with SNAC.

Capitolunate Fixation

During this procedure involving the lateral approach, we suggest the capitolunate screw fixation in a retrograde manner, as the entry points are easier to access than that of antegrade fixation.

With a small longitudinal incision of approximately 1–1.5 cm over the capitometacarpal joint, the extensor tendons were identified and protected. Under fluoroscopy, two K-wires of larger diameters (1.25 mm or 1.6 mm) could be used to insert from the distal-dorsal corner of the capitate retrogradely to the lunate. Because it would be beneficial for direction control. Then, one of the two K-wires with larger diameter was replaced with the guide pin of a headless screw, and the headless screw was fixed thereafter. The second headless screw was set in the same manner (Figs. 1 and 2).

Setting the K-wire(s) or guide pin(s) through the proximal dorsal cortex of the third metacarpal would sometimes be a way to get better entry points of the distal capitate. The endpoint of the headless screw fixation should be located between the middle and anterior halves of the lunate. It is important to ensure sufficient bone purchase by the screws of both the capitate and lunate (Figs. 3 and 4).

Postoperative Management

All patients were subjected to the same postoperative care protocol. After the surgery, a short-arm splint was used for 1 month. Then, a removable wrist brace was used, and gentle

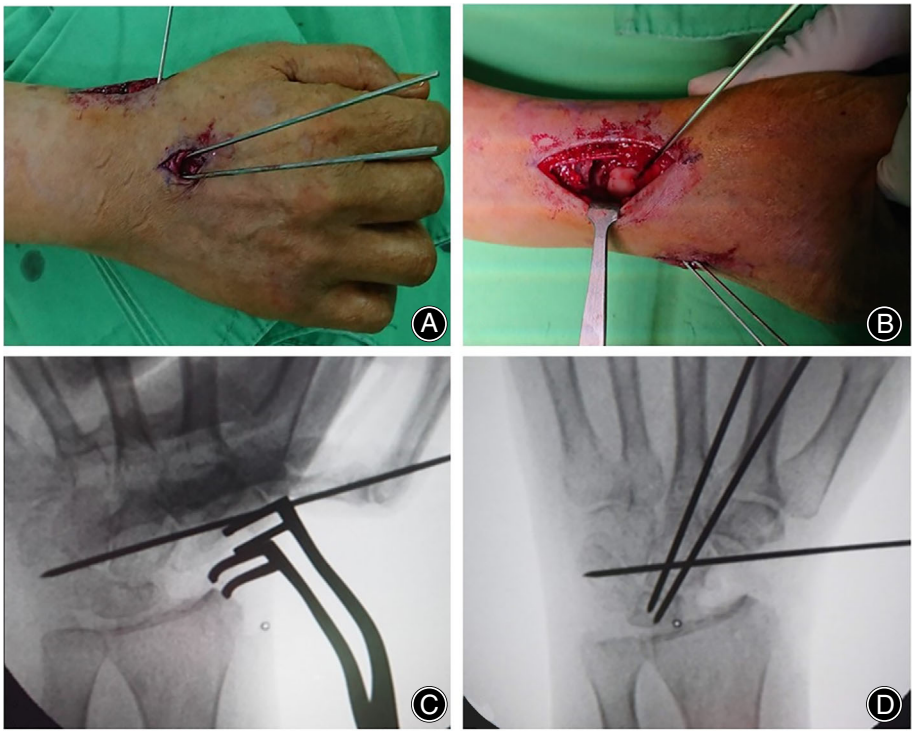

Fig. 2 Photographs showing (A) the lateral approach wound and the dorsal wound for capitolunate arthrodesis. (B) Bone graft was stuffed in the capitolunate junction. (C) Radiographs showing temporary capitate-triquetrum transfixation to maintain the reduced relationship of the capitate and lunate. (D) Transfixatin of the capitate and lunate.

Fig. 3 A 70-year-old female. Radiograph showing (A) and (B) stage III SLAC of her left wrist; (C) and (d) 1 month after lateral approach for scaphoid excision and capitolunate arthrodesis.

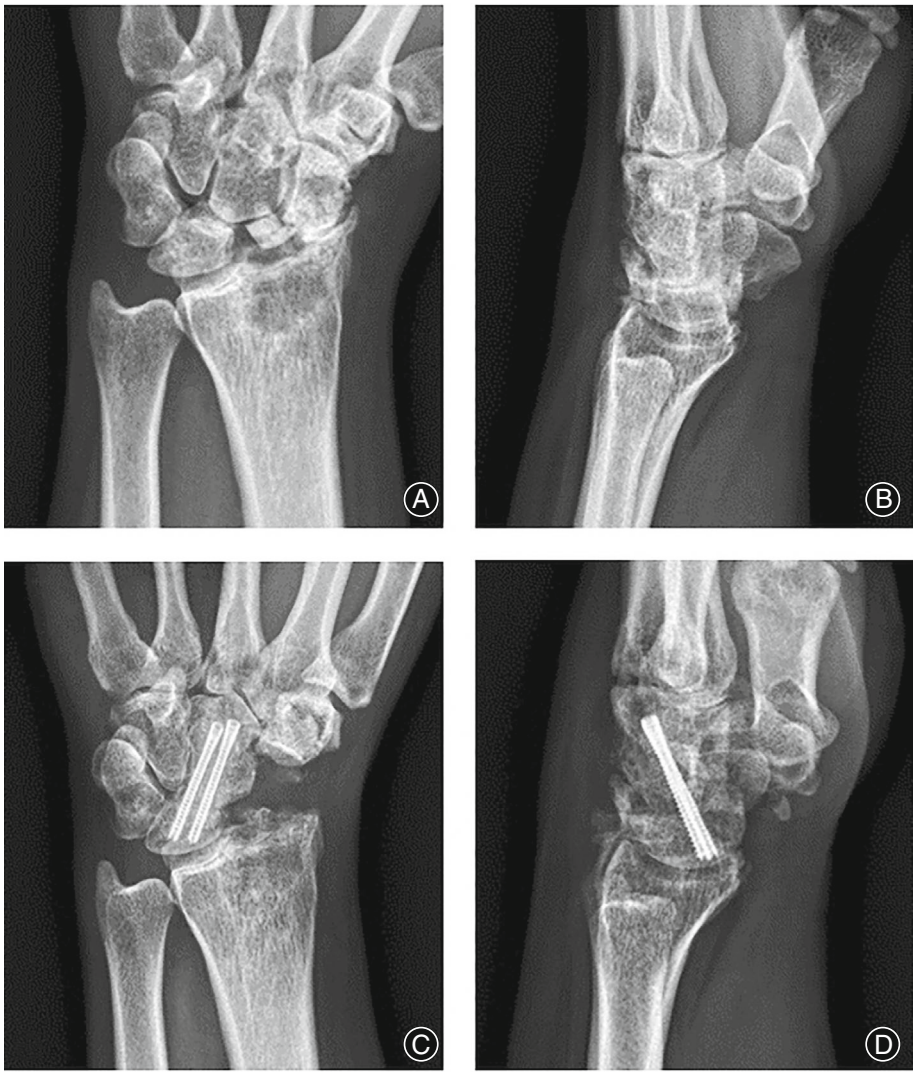

Fig. 4 A 39-year-old female. Radiograph showing (A) and (B) stage III SNAC of her left wrist; (C) and (D) 12 months after lateral approach for scaphoid excision and capitolunate arthrodesis.

wrist motion rehabilitation was started until bone healing. Strengthening and advanced motion rehabilitation were started when bone healing was confirmed. Weight-bearing work or activities were allowed 3 to 6 months postoperatively depending on the healing condition and functional recovery.

Outcome Measurements

Follow-up was scheduled biweekly for the first month after surgery, and once every month thereafter until the bone healing was noted. Patients were then followed twice every 3 months and annually thereafter.

Wrist range of motion, grip strength, the visual analog scale (VAS) for pain (where 0 = no pain; 10 = worst pain), the Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire, and the Mayo wrist score were used as the functional evaluations[12,13]. Radiograph images were taken at every follow-up after postoperative 1 month. The capitolunate angle was measured using the lateral radiographic view, and the carpal height ratio, which was calculated by dividing the carpal height by the length of the third metacarpal, was evaluated using the anteroposterior radiographic view[10,14]. In addition, we evaluated the condition of scar formation according to chart review. We used the Vancouver Scar Scale (VSS) to evaluate scars, which rates vascularity, pigmentation, pliability, and height with a sum of total scores ranging from 0 to 13 (0 representing normal skin)[15]. Radiographic images and functional outcomes were evaluated by two hand surgeons who were not involved in the treatment and follow-up of the patients.

The data obtained were analyzed and presented as the mean and standard deviation (SD) using SPSS software (IBM SPSS Statistics for Windows. Version 24.0. Armonk, NY: IBM Corp, 2016).

Results

Patient Demographics and Outcomes

Ten patients (three women, and seven men) were enrolled in this study. The average age at the time of surgery was 54.2

TABLE 1 Characteristics and final follow-up outcomes of the 10 patients

Case	Age	Sex	Pathology	side	Follow-Up (MO)	Capitolunate Angle (°) Pre-Op/Post-Op	Carpal Height Ratio Pre-Op/Post-Op	Grip (Kg) Pre-Op/Post-Op	Radio-Ulnar deviation arc (°) Pre-Op/Post-Op	Extension-Flexion arc (°) Pre-Op/Post-Op	Pain (VAS) Pre-Op/Post-Op	QuickDASH Pre-Op/Post-Op	Mayo wrist score Pre-Op/Post-Op
1	76	M	SLAC II	R	13	+ 8/ + 2	0.48/0.50	23/33	45/50	80/70	5/1	54.5/31.8	60/70
2	70	F	SLAC III	L	30	+ 34/ + 4	0.42/0.52	8/11	40/50	100/70	6/2	79.5/36.4	35/70
3	57	M	SNAC III	L	38	+ 17/ + 5	0.47/0.51	21/33	35/45	50/65	7/1	54.5/25.0	25/70
4	62	M	SLAC III	R	35	+ 18/ + 3	0.40/0.54	18/30	35/50	50/80	7/1	47.7/31.8	25/70
5	52	M	SLAC II	L	16	+ 17/ + 3	0.49/0.51	31/44	55/50	110/85	5/0	40.9/18.2	60/75
6	45	F	SLAC III	R	20	+23/0	0.41/0.46	13/25	50/50	90/80	6/1	61.4/27.3	45/70
7	60	M	SNAC III	L	12	+30/0	0.42/0.48	21/26	40/45	75/70	5/1	43.2/18.2	55/75
8	48	M	SNAC III	R	15	+ 10/ + 2	0.45/0.52	35/46	45/45	80/90	6/0	59.1/22.7	60/80
9	33	M	SLAC III	R	13	+ 14/ + 5	0.46/0.47	20/28	40/45	70/65	4/1	52.3/22.7	50/75
10	39	F	SNAC III	L	12	+ 10/ + 5	0.45/0.49	24/28	40/45	60/65	7/1	65.9/27.3	50/70
Mean (SD)	54.2 (13.5)				20.4 (10.1)	+ 18.1 (8.6)/ + 2.9 (1.9)	0.45 (0.03)/0.50 (0.02)	21.4 (7.8)/ 30.4 (9.9)	42.5 (6.3)/ 47.5 (2.6)	76.5 (20.0)/74.0 (9.1)	5.8 (1.0)/0.9 (0.6)	55.9 (11.4)/ 26.1 (6.0)	46.5 (13.8)/ 72.5 (3.5)

Note: QuickDASH, shortened disabilities of the arm, shoulder, and hand questionnaire; VAS, visual analog scale

(range 33–76; SD 13.5) years and the follow-up duration was 20.4 (range 12–38; SD 10.1) months. The dominant hand was involved in six patients. Seven patients presented with SLAC, while three had SNAC. The average operative time was 88.5 (range 53–148, SD 31.9) min; three operations were completed more than 90 min, five operations were between 60 min and 90 min, and two operations within 60 min.

The radiographic and functional outcomes of the 10 patients are presented in Table 1. All arthrodesis healed uneventfully, and all patients returned to work or routine activities within 6 months after surgery.

There were three patients (cases No. 1, 2, and 10) who had available data for scar evaluation after arthrodesis healing. All of their lateral wounds were similar to or more scarred than the dorsal wound, as their lateral wound scars presented VSS of 2, 0, and 4, respectively. (Fig. 5).

Complications

After the index surgery, five patients had temporary numbness in the dermatome of the superficial branch of radial nerve, which were all relieved completely within 6 months. Two patients had injury to the branch of the radial artery and the healing of their wounds in the anatomical snuffbox were delayed until 3 weeks after the surgery due to the prolonged oozing and discharging. However, no additional surgical procedures were required for any of the patients.

Discussion

Feasibility and Results of the Lateral Approach

All 10 capitolunate arthrodesis procedures achieved bone healing when performed using the lateral approach. The capitolunate angle, carpal height ratio, pain, and functional outcomes could be improved. The complications were minor. The operative time could be less than 60 min after a short learning curve.

Idea of Lateral Approach

This idea of a lateral approach was derived from performing arthroscopic capitolunate arthrodesis and scaphoidectomy. As in the arthroscopic approach, scaphoid excision is a time-consuming step. Incorporation of larger-sized arthroscopic burr or direct Rongeur removal from the enlarged portal can be of great help[6,7]. The anatomical snuffbox of the scaphoid indicates that the scaphoid waist is directly underneath the skin. Approach to the scaphoid from the anatomical snuffbox seems to be a more direct way to facilitate scaphoid excision[16]. We found that the scaphoid in both the proximal and distal parts could be removed easily using this lateral approach.

Functional Outcomes

Calandruccio *et al*. reported that restricting the number of fused carpal joints can lead to less scarring and preserved wrist motion. A shorter operative time could also be

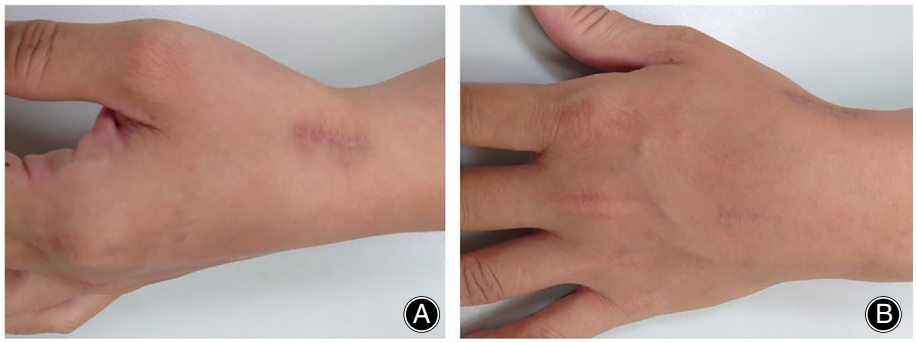

Fig. 5 Photographs (Case 10) taken 6 months after the surgery, showing the length, location, and scar condition of the incisions. The lateral wound scar (A) is more evident than the dorsal wound scar (B). This lady had a minor complication with delayed lateral wound healing until 3 weeks after the surgery owing to prolonged oozing and discharging.

achieved[17]. With the compression technique for capitolunate arthrodesis, the union rate can be similar to that of four-corner fusion, and the functional outcomes are even better[4,5,18–20]. Trail *et al.* reported the results of 4-CA for 110 patients (116 wrists) from a dorsal approach, with an average follow-up of 9.3 years. The VAS pain score, extension/flexion arc, and median QuickDASH score averaged 1.9, 60°, and 37.4, respectively[21]. Traverso *et al.* reported the results of 4-CA for 12 patients (15 wrists), with an average follow-up of 18 years. Their results showed that the average extension/flexion arc was 68.6° and the QuickDASH scores averaged 7.8[3]. Similar to the reported outcomes of 4-CA, the use of the lateral approach for capitolunate arthrodesis achieved comparable results with average extension/flexion arc of 74.0°, VAS pain score of 0.9, and QuickDASH scores of 26.1.

Manner of Screws Fixation

For capitolunate screw fixation, it would be not be easy to achieve the antegrade fixation without open the dorsal wrist capsule. In addition, after scaphoid excision and capitolunate fusion, the load would preferentially transfer to the radiolunate joint[21]. The injury to the lunate cartilage from an antegrade lunocapitate fixation could influence the durability of the radiolunate joint in the long term[20,22,23].

Benefits from Lateral Approach

Arthroscopy for limited wrist fusion can be a choice as a minimally invasive procedure. However, arthroscopic management is technically demanding, and the removal of the scaphoid may be time-consuming for most surgeons. In addition, realignment of the capitate onto the lunate is not easy under the arthroscopic management.

This lateral approach method combined the advantages of open and arthroscopic methods. Scaphoid removal, capitolunate realignment, bone grafting, and screw fixation are as easy as to perform as in open procedures. Like the arthroscopic method, there is no disruption to the dorsal capsule, leading to preservation of the blood supply and proprioception and minimization of scar formation from the dorsal site incision and repair[7].

Limitations of this Study

The limitations of this study include its retrospective nature, lack of long-term follow-up, low case numbers, and a heterogenous small group. As a less invasive technique, the paucity of scar evaluation is also the main limitation of this study. Comparison with the other method was not performed in this study. Therefore, the conclusions based on our results are difficult to extrapolate.

Conclusions

The lateral open approach for scaphoid excision and capitolunate arthrodesis has the advantage of easy access to the scaphoid and capitolunate joint, which is similar to that noted in the open method, but without the need of opening the extensor compartments and dorsal wrist capsule. Its potential benefits include reduced operative time and preservation of the surrounding circulation.

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AUTHOR CONTRIBUTIONS

Hui-Kuang Huang and Jung-Pan Wang performed the operations. Hui-Kuang Huang and Yi-Chao Huang drafted the manuscript. Chin-Hsien Wu, Cheng-Yu Yin, and Wei-Chen Hung collected the data and completed the functional evaluations. Chin-Hsien Wu, Yi-Chao Huang, and Jung-Pan Wang critically revised the manuscript. All authors have read and approved the manuscript.

ETHICS STATEMENT

Ethical approval was granted by the Institutional Review Board of the Ditmanson Medical Foundation Chia-Yi Christian Hospital. (No. 2021081).

CONFLICT OF INTEREST

All authors declare no conflict of interests.

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