Ten-Year Minimum Follow-Up of 4-Corner Fusion for SLAC and SNAC Wrist

HAND
2017, Vol. 12(6) 568–572
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DOI: 10.1177/1558944716681949
hand.sagepub.com

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Abstract

Background: Scapholunate advanced collapse (SLAC) of the wrist is the most common degenerative condition of the wrist. Four-corner fusion (4CF) is performed as salvage surgery, though there is limited information on its long-term results. We hypothesized that 4CF is a durable surgery with good clinical long-term function. **Methods:** A retrospective chart review of patients undergoing 4CF as well as an interview and recent radiographs were obtained. Patients with a follow-up period of less than 10 years were excluded. Long-term evaluation included standard wrist radiographs, wrist range of motion, and the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire. Radiographs were evaluated and described by the Kellgren-Lawrence classification. **Results:** Four hundred eighty-nine wrists underwent a 4CF for SLAC wrist from 1982 to 2003. Twelve patients (15 wrists) were available for follow-up. Average age at surgery was 49.1 years (range, 25–67 years). Average follow-up postsurgery was 18 years (11–27). Scapholunate advanced collapse was the etiology in 13 wrists and scaphoid nonunion advanced collapse in 2 wrists. Average extension/flexion arc was 68.6° (0°–96°), and radial/ulnar deviation arc was 32.9° (0°–5°). QuickDASH scores averaged 7.8 (range, 0–32.5), with only 1 score above 16. Seventy-three percent of radiographs showed minimal to moderate joint destruction, and 27% showed severe joint destruction. **Conclusions:** Scaphoid excision and 4CF remains a reliable procedure for patients with advanced wrist arthritis. Functional results were good at long-term follow-up despite radiographic changes in the radiolunate joint in 73% of patients. Patient satisfaction was high, and functional impairment was low.

Keywords: follow-up, 4-corner, fusion, long term, osteoarthritis, wrist

Introduction

Scapholunate advanced collapse (SLAC), the most common form of degenerative arthritis of the wrist, is the final common pathway for a variety of conditions such as trauma, scaphoid nonunion, and osteoarthritis.^{8,23} Whatever the cause, abnormal joint loading produces degenerative changes beginning at the radial styloid (stage I), progressing to the proximal scaphoid (stage II), the capitolunate joint (stage III), and sometimes the radiolunate joint. The treatment of this form of wrist arthritis has been surgically managed by two main motion sparing salvage procedures: proximal row carpectomy (PRC) and 4-corner fusion (4CF). The decision to use one method over the other has historically been based on surgeon experience and preference because long-term results were not clearly elucidated in the literature. Recently, there has been an effort in the literature to examine longer-term results.^{3,11} The impression is that though PRC may provide better motion, 4CF may be more longlasting.^{1,7,16,17,22}

The purpose of this study was to examine the long-term outcome of 4CF performed in our practice. We hypothesized

that this is a durable procedure with good clinical long-term function.

Materials and Methods

All patients treated with a 4CF from 1982 to 2003 in a private practice operated on by a single hand surgeon were retrospectively reviewed. The indications for a 4CF were patients with a symptomatic SLAC or scaphoid nonunion advanced collapse (SNAC) wrist (grade 2 and above). Institutional review board (IRB) approval was obtained prior to study commencement.

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Figure 1. Posteroanterior and lateral view of a wrist 15 years following a 4-corner fusion.

Note. The flexion extension arc was 75°, radio-ulnar deviation 45°, and the Disabilities of the Arm, Shoulder and Hand score was 5. The radiolunate joint does demonstrate sclerosis and narrowing but maintenance of a joint space.

Operative Technique

The operative technique has been previously published and remains the standard approach to 4CF in our practice. The approach includes a transverse dorsal exposure. Subsequent piecemeal excision of the scaphoid followed by a limited wrist arthrodesis incorporating capitate, lunate, hamate, and triquetrum is performed with supplemental bone graft obtained from the distal radius of the operative hand. This is taken from a slightly more proximal transverse incision. Correction of the dorsal intercalated segment instability of the lunate (DISI) is routinely performed as well as extensive excision down to cancellous bone, including the dorsal capitate and lunate. Following excision of the scaphoid, the capitate is pulled ulnarly as far as possible over the lunate. The lunate is positioned in a volar flexed position to prevent impingement of the fusion mass on the dorsal lip of the distal radius during extension of the wrist. We believe this is important to optimize motion once fusion has been achieved. Fixation is achieved using multiple Kirschner wires and casting for 6 weeks following surgery. At 6 weeks following the surgery, postoperative wrist radiographs are assessed for bony union. In the presence of union, the Kirschner wires are removed. In smokers, the Kirschner wires are left in place for an additional 2 weeks.

Patients with less than a 10-year follow-up were excluded from the study. Demographic material and preoperative status were collected from the patient charts. Patients eligible for the study were identified using the clinic's patient database. Retrieval of current contact information was attempted through the clinic's database in addition to the patient's chart. Multiple attempts were made to contact all of the 470 patients.

The patients were called multiple times (at least 3), and a letter was sent to the address in the chart. The patients were contacted by an independent examiner and brought in to the office for reevaluation. An independent examination team (not involved in the original surgical management of the patients) examined patients who were available for follow-up. Patients were questioned in regard to satisfaction and work status. Patients were sent for follow-up radiographs and were examined for wrist active range of motion (AROM), as well as function, using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) questionnaire.¹² We did not examine for pronation/supination as these movements should not be affected by a fusion of the midcarpal joint.

Radiological Evaluation

Posterioranterior (PA) and lateral wrist radiographs were performed. The radiographs were examined for the following:

1. Bony fusion: Fusion was determined by the presence of a continuous bone mass and bridging trabeculae seen on a PA radiograph.
2. Status of the radiolunate joint: Osteoarthritis was documented based on the existence of osteophytes, subchondral sclerosis, periarticular cysts, and joint space narrowing with or without cystic changes in multiple bones (present in 2 patients who had a previous silicone implant).

The severity of osteoarthritic degeneration specifically involving the radiolunate joint was documented. This was done using the Kellgren-Lawrence classification.¹³

ROM was measured using a standardized hand-held goniometer technique with extension, flexion, and radial and ulnar deviation measurements.⁶

Results

A total of 470 patients underwent a 4CF between 1982 and 2003. Many of these patients were lost to follow-up due to change of contact information, physical inability to visit our main institution for follow-up, unwillingness to participate, or death. Twelve patients (15 wrists) were available for comprehensive follow-up. Three of the patients available for follow-up were bilateral but had not had surgery concomitantly. Of this group, the average age at surgery was 49.1 years (range, 25-67 years). Average years postsurgery was 18 (range, 11-27 years) (Table 1). SLAC was the etiology of degenerative arthritis in 13 wrists (87%), and SNAC was the etiology in 2 wrists (13%). Sixty-seven percent of wrists were dominant, and 100% of patients returned to normal preoperative activities.

Table 1. Preoperative Characteristics of Our Series.

S. No.	Age	Gender	Dominant wrist = operated wrist	Indication for surgery	Surgery previous to index 4-corner fusion	SLAC grade before surgery
1	63	Female	Yes	SLAC	None	3
2	67	Male	No	SLAC	None	3
3	56	Male	Yes	SLAC	Wrist Arthrotomy	2
4	45	Male	No	SLAC	Arthrotomy elsewhere	3
5	54	Male	Yes	SLAC	None	2
6	52	Male	Yes	SLAC	SLAC, CTR elsewhere	2
7	53	Male	Yes	SLAC	None	2
8	31	Male	Yes	SLAC	None	2
9	39	Male	Yes	SNAC	Bone graft elsewhere	2
10	50	Male	Yes	SLAC	None	3
11	25	Male	Yes	SLAC	ORIF scaphoid and radius fracture elsewhere	2
12	59	Male	No	SLAC	None	2
13	60	Male	Yes	SLAC	None	2
14	56	Male	Yes	SLAC	CTR	2
15	26	Male	Yes	SNAC	None	3

Note. SLAC = scapholunate advanced collapse; CTR = carpal tunnel release; SNAC = scaphoid nonunion advanced collapse; ORIF = open reduction and internal fixation.

The average extension/flexion arc was 68.6° (range, 0°-96°), and the average radial/ulnar deviation arc was 32.9° (range, 0°-55°). These did not include the fused wrist, which had no motion postoperatively. DASH scores averaged 7.8 (range, 0-32.5), with only 1 score above 16. There were no cases of nonunion. The majority of wrists (73%) demonstrated zero to grade 3 (moderate) findings; 27% showed advanced joint space narrowing, including one wrist with particulate synovitis and one that progressed to require a total wrist fusion (see Table 2 and Figure 1). Of the patients with advanced and total joint space destruction, only 1 patient has a DASH score higher than 16. This patient developed particulate synovitis from a previous silicone implant and had a DASH score of 32.5.

Discussion

Our ability to treat wrist degenerative arthritis is still evolving. For the extremes of pathology, we have in our armamentarium a total wrist fusion and the new generations of total wrist arthroplasty.^{5,24} Each of these modalities carries its specific problems and disadvantages, and neither of these are good functional solutions for the relatively young/high-demand patient. At this time, therefore, we are left with either a partial wrist fusion or a PRC as possible solutions for the active patient. The importance of long-term outcome data is particularly important for the younger patient. In this study, the youngest patient was only 25 years old.

When comparing our results with other series describing the long-term outcome of 4CF, there may be differences in population characteristics, in addition to differences in

surgical techniques and postoperative management. Cha et al⁷ performed a retrospective review of 40 cases in China⁴ with a mean follow-up period of 12.2 years. Despite a different population, their technique was similar to ours and their results similar except that they described minimal radiologic changes. It is not clear how their radiographs were evaluated but it is possible that the method of evaluation differed; therefore, they describe a different radiological outcome. Although some studies support a relationship between increasing age and increasing prevalence of degenerative arthritis, it is not clear that this can explain the difference between the 2 groups.¹⁵ Neubrech et al¹⁷ also found a very high percentage of radiographic changes despite good clinical results in their review of 572 4CFs. Even with only 6.7% wrist fusions, they found radiographic changes in 67% of their patients.

In our cohort, most radiographs (73%) demonstrated some evidence of radiographic changes (osteophytes and/or joint space narrowing). However, 27% of radiographs demonstrated advanced/severe degrees of joint destruction. Radiological changes are found in most studies evaluating long-term outcomes of 4CF.⁶ They are also reported in most studies evaluating PRC.^{4,17} Uniformly, a significant relationship between radiological changes and functional outcome has not been found.^{7,17}

We found that despite the radiological changes, the vast majority of wrists were highly functional based on range of motion (ROM) measurements and QuickDASH assessment tools. This is consistent with recent publications on long-term results of 4CF though our follow-up period was significantly longer, and as stated, there are differences in

Table 2. Outcomes.

S. No.	Follow-up (y)	Postoperative complications	Concurrent surgical procedures	Surgical procedures post index procedure	Radiographic stage postoperative KL
1	17	None	None	None	3
2	12	None	None	None	2
3	23	None	None	None	4
4	18	None	None	None	2
5	20	None	None	Total wrist Fusion	4
6	22	None	None	None	2
7	19	None	Matched ulnar arthroplasty	None	1
8	15	None	None	None	1
9	27	None	None	None	4
10	11	None	None	Excision carpal boss, TILT procedure	2
11	24	None	None	None	4
12	14	None	None	None	3
13	13	None	None	None	1
14	14	None	None	None	3
15	24	None	None	None	1

Note. KL = Kellgren-Lawrence classification; TILT = triquetral impingement ligament tear.

surgical technique and population between our cohort and the published cohorts.^{10,17,22}

We did not have any cases of nonunion in our series. This may be due to the small number of patients available for follow-up. It is possible that those patients whom we were able to bring back for follow-up were preferentially those patients that had a good result. However, a previous study indicated a nonunion rate of 3% versus higher rates documented, for example, by Trail et al.^{2,22} This may be due in part to technique. We did not use circular plates which, especially the older generation, do not always succeed in applying compression.²¹ The series by Cha et al⁷ used a technique similar to ours and they reported no nonunions. We also routinely removed the Kirschner wires later in smokers. Perhaps this approach is also helpful in promoting union.

We had 2 patients who had evidence of silicone synovitis. We included them as it would take a rather massive amount of silicone in all the tissues (bones, synovium, and ligaments) to have progressive joint destruction after silicone removal, and neither of these 2 patients demonstrated those findings. Previous surgeries such as arthrotomy, scaphotrapezialtrapezoid (STT) fusion, and bone grafting of the scaphoid for a scaphoid nonunion were intended to prevent the development of SLAC wrist and should not have a significant effect on the outcome of surgery. This holds true for carpal tunnel release as well.

Our average QuickDASH score was 7.8 with only 1 score above 16. The one higher DASH score of 32.5 may be related to the presence of particulate synovitis from prior placement of a silastic scaphoid implant that was subsequently

removed.² Studies related to PRC have reported DASH scores that have been consistent over time, but the average scores are generally higher than the scores we found in this study. Dacho noted an average DASH score of 25 in 30 patients.⁹ Kremer noted an average DASH score of 26 in 45 patients.¹⁵ Richou et al¹⁹ reported a final DASH score of 31 in 24 patients.¹⁹ The longest average follow-up in these reports was 116 months.

In this study, wrist flexion and extension was about 50% of normal. This is consistent with other reported studies despite differences in technique to achieve fusion, such as the spider plate or headless screws.^{14,18} This remains above the minimal motion necessary for a functional arc of motion which was described by Ryu et al²⁰ as being 60° of extension, 54° of flexion, 40° of ulnar deviation, and 17° of radial deviation of the wrist.

The most significant limitations of this study are due to its retrospective nature and the small number of patients we were able to fully evaluate. The demographics of the population that was treated with a 4CF are such that despite an exhaustive effort to evaluate their wrists at long term, we only managed to bring back 2.5% for evaluation. This not only supplied us with a small cohort of patients to evaluate but also may have caused a selection bias in that only satisfied patients were willing to come in for follow-up. Compared with the existing literature, our average follow-up period was longer.^{5,9} This may in part explain our difficulty in obtaining patients for follow-up examination.

Furthermore, preoperative AROM was not documented in all charts for comparison with postoperative results. Comparisons of preoperative radiographs were not done

because records were not available, so we cannot determine how much progression took place. Also, functional evaluation was limited to the QuickDASH.

In summary, this long-term review of 4CF showed stable functional results over an average of 18 years. Especially for the young active patient, this procedure remains reliable and seems not to deteriorate clinically with time. Functionality persisted despite radiographic changes.

Ethical Approval

The research protocol was approved by the appropriate ethical committee in line with the Declaration of Helsinki 1975, revised, Hong Kong 1989.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Statement of Informed Consent

Informed consent was obtained from all patients for being included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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