Four-Year Outcomes of Midcarpal Hemiarthroplasty for Wrist Arthritis

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Purpose The purpose of this study was to review the average 4-year outcomes of a cohort of patients with wrist arthritis, treated by a single surgeon with a novel prosthetic hemiarthroplasty of the midcarpal joint. We hypothesized that midcarpal hemiarthroplasty would improve range of motion and grip strength of patients with wrist arthritis, with a complication profile comparable with that of alternative solutions for wrist arthritis.

Methods We reviewed a series of 20 patients treated with a midcarpal hemiarthroplasty at an average of 4 years following surgery. Patients were evaluated objectively with grip strength, wrist range of motion, serial radiographs, and subjectively surveyed with Disabilities of the Arm, Shoulder, and Hand (DASH) and Mayo scores.

Results Range of motion increased by a mean 33° in flexion-extension and 10° in radial-ulnar deviation compared with preoperative range of motion. Mean grip strength improved to 20.8 kg from 14.1 kg, and Mayo and DASH scores also significantly improved. Three patients had a manipulation under anesthesia for stiffness. One patient required open reduction internal fixation of an unstable fourth carpometacarpal joint after falling. Two patients were revised to a total wrist arthroplasty and 1 to a wrist fusion.

Conclusions Midcarpal hemiarthroplasty provides improved wrist range of motion, grip strength, and patient-reported outcome scores compared with preoperative values, with a complication profile comparable with that of other surgical options for patients with wrist arthritis. Advantages of midcarpal arthroplasty include retention of the native distal carpal row, preservation of midcarpal motion, as well as the option for conversion to a total wrist arthroplasty should revision be required. (J Hand Surg Am. 2017;42(11):894–903. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)

Type of study/level of evidence Therapeutic IV.

Key words Arthritis, SLAC, wrist arthroplasty, midcarpal joint, wrist.
Partial or complete wrist arthrodesis brings predictable improvement in pain, but it does not increase mobility compared with the preoperative state. Proximal row carpectomy (PRC) is a viable option when the lunate facet is preserved, but it may be associated with progressive degenerative arthritis. Both partial arthrodesis and PRC demonstrate deterioration of both wrist kinematics and performance compared with normal wrists. Total wrist arthroplasty provides pain relief but not improved ROM and has a risk of distal component failure and osteolysis.

Failure of total wrist arthroplasty may be partly related to incomplete understanding of wrist kinematics. Clinical and basic research over the past decade has identified the importance of “coupled” or composite motions of wrist flexion-extension and radioulnar deviation, best exemplified by the “dart-throwers motion” of the wrist. This motion, from radial-extension to ulnar-flexion, occurs almost exclusively at the midcarpal joint. It plays an important role in many high-demand activities of daily living.

Studies of upper and lower extremity arthroplasty have demonstrated that prosthetic loosening is associated with failure to replicate normal joint kinematics. In conventional total wrist arthroplasty, the midcarpal joint has been essentially eliminated, focusing instead on replacing the radiocarpal articular surface with a biaxial or ellipsoid shape. Electrogoniometric analysis of wrist motion following total wrist arthroplasty demonstrates a marked reduction of the circumduction arc and an alteration in the major axis of motion to a predominantly flexion-extension plane rather than the oblique dart-throwers plane of normal wrists. Removal of the midcarpal joint may increase demands on the prosthetic articulation and bone-prosthetic interface during daily and occupational activities. A proximal shift of the prosthetic wrist’s center of rotation increases the moment arm on the distal component and may contribute to distal component failure. We reasoned that preservation of the midcarpal joint in wrist arthroplasty would simultaneously increase coupled wrist motion and decrease component stress.

The growing evidence on wrist kinematics provided the impetus to design a midcarpal arthroplasty that would preserve the wrist’s center of rotation, carpal height, the midcarpal joint, and the important dart-thrower’s motion. The KinematX midcarpal hemiarthroplasty (Extremity Medical, LLC, Parsippany, NJ) (Fig. 1) replaces the proximal carpal row and removes the arthritic radiocarpal joint while preserving the native distal carpal row and midcarpal joint. Initial outcomes of the first 9 cases showed promising results. The purpose of this study is to report the average 4-year outcomes of the first 20 patients with wrist arthritis treated with a midcarpal hemiarthroplasty. We hypothesized that midcarpal hemiarthroplasty would improve ROM, grip strength, and outcome scores of patients with wrist arthritis, with a complication profile comparable with those of alternative solutions for wrist arthritis.

KinematX Midcarpal Hemiarthroplasty is Conformité Européene-approved in Europe. Wrist hemiarthroplasty is not currently U.S. Food and Drug Administration–approved.

**MATERIALS AND METHODS**

After institutional review board approval by the Hospital’s Medical Advisory Committee and the National Institute, 20 patients were recruited into a prospective, single-surgeon trial of midcarpal hemiarthroplasty between October 2011 and May 2013. Eleven patients were men and 9 patients were women (Table 1). The mean age was 51 years (range, 23–74

**FIGURE 1:** The KinematX midcarpal hemiarthroplasty.
years). Thirteen of the 20 patients had the surgery on their dominant wrist.

The diagnoses were scapholunate advanced collapse (SLAC) wrist (9 wrists), noninflammatory osteoarthritis (OA; 5), scaphoid nonunion advanced collapse (SNAC) wrist (2), psoriatic arthritis (2), rheumatoid arthritis (1), and Kienböck disease (1). All patients had failed nonsurgical treatment including orthosis wear, hand therapy, and steroid injection prior to surgery. All had pain, limited ROM, and substantial impairment of functional activities as demonstrated by a mean Mayo score of 34.1 and mean Disabilities of the Arm, Shoulder, and Hand (DASH) score of 50.3 (Table 2). All patients underwent wrist arthroscopy prior to surgery and were excluded if there was exposed bone on the articular surface of the capitate. Absolute contraindications to the procedure included recent or remote infection, previous surgical fusion, or lack of active wrist extension.

### Surgical technique

The procedure is performed with the patient supine with the operative limb on an arm board and with tourniquet control. A dorsal 4- to 5-cm longitudinal incision is made just ulnar to Lister’s tubercle, in line with the fourth extensor compartment. Full-thickness skin flaps are raised, elevating sensory nerve branches within the flaps. The extensor retinaculum is divided and the fourth compartment tendons are retracted ulnarly. The capsule is opened through a proximally based rectangular dorsal flap, which allows preservation of the posterior interosseous nerve (PIN) if desired. The longitudinal arms of the proximally based flap underlie the second and fifth dorsal compartments, and the transverse arm is
aligned with the carpometacarpal joint. Every effort is made to preserve the important dorsal intercarpal and radiocarpal ligaments on the triquetrum by reflecting a dorsal wafer of the triquetrum in continuity with the flap. Proximal reflection of the flap provides complete exposure of the proximal and distal carpal rows while preserving the dorsal capsuloligamentous anatomy and the PIN.

The proximal carpal row is excised using joysticks and sharp curved elevators. The radial articular surface is exposed by palmar dislocation of the distal carpal row and maintained with a Bennett retractor. Care is taken to preserve the cartilage of the capitate.

The radius is prepared using a custom elliptical power rasp to remove cartilage, flatten the interfacet ridge, and shape the subchondral plate to precisely match the base of the implant. The origins of the extrinsic volar and dorsal wrist ligaments as well as the radial subchondral plate are preserved.

A 2.5-mm guidewire is inserted into the medullary canal of the radius under fluoroscopic control. The entry point is between the middle and the dorsal thirds of the radial articular surface at the ulnar border of Lister’s tubercle. A box chisel is used to create a window in the subchondral bone. The osteotomized bone is impacted into the medullary canal during

<table>
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<tr>
<th>TABLE 2. Preoperative and Postoperative (Latest Follow-Up in Parenthesis) Range of Motion and Functional Scores</th>
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Mean, All Patients | 63 (96)§ | 22.7 (32.4)§ | 14.1 (20.8)§ | 34.1 (62.3)§ | 50.3 (24.6)§ | 49 |

Mean, Inflammatory Patients | 52.0 (69.7) | 16.3 (22.7) | 3.3 (9.5) | 23.3 (31.7) | 68.2 (56.6) | 51.7 |

Mean, Noninflammatory Patients | 64.9 (100.6)§ | 23.8 (34.1)§ | 16 (24.8)§ | 36 (67.7)§ | 47.1 (18.9)§ | 47.9 |

*Inflammatory arthritis.
†Underwent manipulation under anesthesia.
‡Converted to total arthroplasty.
§Died from unrelated causes.
‖Converted to wrist fusion.
§ Reached statistical significance when before surgery was compared with after surgery (P < .05).
sequential broaching. Maintaining appropriate coronal, sagittal, and rotational alignment is important for the subchondral bone to be able to support the implant on all sides.

The trial component is inserted, the carpus reduced, and ROM and stability are assessed. A degree of laxity is preferred over tension in the volar and dorsal ligaments. When satisfied with the position and stability, the trial is removed and the corresponding press-fit prosthesis is gently impacted into the subchondral bed. Cement was not utilized in this series. The carpus is reduced and the capsule repaired anatomically with a single running suture. The retinaculum and skin is closed in layers and the wrist immobilized in a volar plaster orthosis in neutral position. Active digital, elbow, and shoulder motion is begun immediately, and active wrist motion is begun in a supervised therapy program after suture removal on day 10. Weight-bearing began 4 to 6 weeks after surgery and full activity was permitted at 8 weeks with no activity restrictions.

**Outcome assessment**

All patients were evaluated before and after surgery by a hand therapist who measured wrist ROM and grip strength and was independent of the study. The DASH and Mayo wrist scores were completed at each visit. Radiographs were evaluated for loosening, osteolysis of the capitate, or component migration at each follow-up visit (Fig. 2). Data were analyzed using the Kolmogorov-Smirnov and the Shapiro-Wilk test of normality. A paired-samples t test was used to determine statistically significant mean difference between pre- and postoperative results using an alpha value of .05.

**RESULTS**

The mean surgical time was 54 minutes (range, 45–66 minutes). The mean clinical and radiographic assessment for all 20 patients was 4.1 years (range, 2.3–5.3 years). Mean postoperative flexion-extension arc was 96°, and mean radioulnar deviation arc was 32.4°. Mean ROM significantly improved in both flexion-extension (33° improvement; SD. 26) and radial-ulnar deviation (10° improvement; SD. 9) with respect to the preoperative values (Figs. 3, 4). An example of the smooth wrist circumduction and coupled motion that resulted from midcarpal preservation is provided in Video A (available on the Journal’s Web site at www.jhandsurg.org). Mean grip strength improved significantly from 14.1 kg to 20.8 kg, an increase of 6.7 kg (SD, 9) (Fig. 5). The mean postoperative ROM compared with the contralateral side was 68%, 58%, and 74% for flexion-extension, radial-ulnar deviation, and grip strength, respectively. The DASH score significantly improved from 50.3 to 24.6 (Fig. 6), and mean Mayo scores...
significantly improved from 34.1 before surgery to 62.3 after (Fig. 7 and Table 2).

Compared with the noninflammatory patients, the 3 patients with inflammatory arthritis showed less improvement in all objective and patient-derived outcome parameters, although the small number of inflammatory patients precluded a valid statistical comparison. No patients with inflammatory disease required a revision.

**Complications**

Three patients (patient 4 [SNAC], patient 8 [psoriatic arthritis], and patient 13 [OA]) underwent closed manipulation under anesthesia for wrist stiffness at an average of 3.2 months (range, 3–5 months) after surgery. Patient 4 gained 50° in flexion-extension, patient 8 gained 29°, and patient 13 did not benefit from manipulation. Patient 11 fell and fractured his fourth carpometacarpal joint and underwent successful plate stabilization. There were no cases of superficial or deep infection.

**Failures**

Patient 4 was the only patient who demonstrated radiographic evidence of component loosening and underwent successful conversion to total wrist arthroplasty for aseptic loosening at 1 year after surgery. Patient 15 (OA) was diagnosed with complex regional pain syndrome prior to hemiarthroplasty surgery. This
ROM of 100 total wrist arthroplasties that showed no pre- to postoperative improvement in ROM.20 A review of the published outcomes for partial arthrodesis or PRC did not identify another surgical alternative for SLAC arthritis that improved pre- to post-operative ROM.8–10,13,14,18,20–23,47–50

The conversion rate to total wrist arthroplasty or fusion was 3 of 20. Other series of patients treated with prostheses have documented revision rates ranging from 0% to 39%; but given the small sample sizes in these series, the true revision rate is difficult to assess.20,42,51,52 Three patients underwent manipulation under anesthesia within 5 months of surgery with limited or no improvement in ROM. Based on this and the demonstrated early stability of the prosthesis, we changed our postoperative protocol to begin active ROM on day 7 following patient 13, and have performed no further manipulations.

Although we report only a small cohort of patients at 4 years after surgery, our results compare favorably with radiocarpal hemiarthroplasty, which articulates the radial component of a total wrist arthroplasty system with the native distal carpal row. Culp et al51 presented a series of combined PRC and radiocarpal hemiarthroplasty in 10 patients using the radial polyethylene component of the Maestro Wrist Reconstructive System (BioMet, Warsaw, IN) or ReMotion Total Wrist Implant (Stryker, Kalamazoo, MI). After 19 months, mean ROM had decreased and 9 of 10 patients had complications of which 7 required reoperation (aseptic loosening requiring revision, 2; tenosynovitis, 2; contracture, 2; tendon adhesions, 2; ulnar nerve compression, 1; painful clicking, 1; and asymptomatic osteolysis, 1). Two patients were revised to a different prosthesis. The authors discontinued the use of this prosthesis for hemiarthroplasty.

In 2013, Adams52 reported 3-year follow-up of 26 cases of PRC combined with radiocarpal hemiarthroplasty using the Universal 2 Wrist Arthroplasty System (Integra Life Sciences, Plainsboro, NJ). They reported satisfactory pain relief, but mean ROM, grip strength, or outcome scores were not reported. In 22 of 26 wrists, the procedure generated a minimum of 60° of flexion-extension, but preoperative ROM was not reported. One patient showed radiographic erosion of the capitate and 1 was converted to total wrist fusion.

Total joint arthroplasty is considered the gold standard for treatment of severe arthrosis of most joints in the body. Total wrist arthroplasty has been an option since Alfred Swanson developed a silicone prosthesis in 1967,53 and many designs and materials have followed, each with inherent complication risks. In recent years, the outcomes of total wrist replacement have improved, but the procedure continues to have persisted following surgery, and despite conversion to a total wrist arthroplasty, his pain persisted. There was no sign of prosthetic loosening or capitate osteolysis on radiographs and the capitate cartilage was intact at reoperation. Patient 12 (SLAC) went on to have a wrist fusion by another surgeon to treat ulnar-sided pain. One patient (patient 9) died of unrelated causes, but her results at 31 months were good and there were no known issues with her implant.

From the 13 patients who were employed at the time of surgery, 10 had returned to work at latest follow-up (Table 3). Four patients that could not participate in sporting activities before surgery because of pain resumed recreational activities including golf and shooting after surgery (patients 1, 3, 5 and 20; Video A; available on the Journal’s Web site at www.jhandsurg.org). Excluding the patient who died, 16 of the initial 19 prostheses (84%) were in situ at the most recent follow-up (Fig. 8) with an average flexion-extension ROM of 100°, radioulnar deviation arc of 32°, grip strength 22.5 kg, Mayo score of 61.9, and an average DASH score of 25.4. Figure 8 shows the survival analysis in a Kaplan-Meier plot. The patient who died is censored and the failures were taken out at time for conversion.

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DISCUSSION

We report significant improvement in ROM, grip strength, and patient-reported outcomes in our initial cohort of 20 patients following midcarpal hemiarthroplasty at average 4-year follow-up. This compares favorably with a recent multicenter analysis of 215 total wrist arthroplasties that showed no pre- to postoperative improvement in ROM.20 A review of the published outcomes for partial arthrodesis or PRC did not identify another surgical alternative for SLAC arthritis that improved pre- to post-operative ROM.8–10,13,14,18,20–23,47–50

TABLE 3. Return to Work at Latest Follow-Up
problems of distal component failure and periprosthetic osteolysis. The ROM following total wrist arthroplasty is predicted by preoperative wrist ROM.

Total wrist arthroplasty converts the obliquely inclined axis of normal wrist circumduction into a nearly vertical axis of flexion-extension, with marked restriction of circumduction and radioulnar deviation. A 2015 systematic review of 405 total wrist arthroplasties from 7 manufacturers demonstrated that only 1 prosthesis achieved the functional ROM defined by Palmer et al in 1985.

Midcarpal hemiarthroplasty must also be evaluated in the light of nonprosthetic surgical options for wrist arthritis. Denervation is simpler than reconstructive procedures. Because it involves dividing the PIN, there may be theoretical concerns with loss of proprioceptive control of the wrist. Braga-Silva et al evaluated 49 patients at 6 years following wrist denervation. They found that average pain improvement (visual analog score) was 79% but they reported no significant improvement in ROM in any plane.

Ablative surgery removes the pain-generating degenerative portions of the carpus. The most common are PRC, radial styloidectomy, and distal scaphoidectomy (as treatment for SNAC wrist). Ablative procedures are motion-sparing and are often successful in reducing pain, although progressive articular degeneration is often seen. Degeneration is, however, poorly correlated to symptoms or failure. Didonna et al published their 10-year follow-up on 22 patients treated with PRC. Four procedures failed (18%) and results were analyzed for the 15 patients available at follow-up. Flexion-extension averaged 72°, grip strength averaged 91% of that of the contralateral side, and the DASH score averaged 9. Preoperative DASH was not reported. All but 3 patients showed signs of radiographic degeneration of the radiocapitate space. At 20 years follow-up on the same series, 2 additional wrists were fused and 1 was unsatisfied with the result, yielding a failure rate of 35%. Like partial arthrodesis, PRC has been demonstrated to reduce motion, wrist coupling, and functional performance compared with normal wrists.

Partial arthrodesis involves fusion of a portion of the carpus, thereby gaining pain relief while preserving some motion. Scaphoid excision with 4-corner fusion is the most commonly performed. The procedure considerably alters the biomechanics and function of the wrist, has a 39% rate of moderate-severe radiolunate arthritis at 7 years, and is associated with a rate of nonunion ranging from 5% to 55%. Radioscaphoid-lunate fusion and distal scaphoid excision spare the midcarpal joint and preserve carpal height, thus simulating midcarpal hemiarthroplasty. Garcia-Elias et al reported an average flexion-extension arc of 67° (64° before surgery) and 33° (27° before surgery) of radial-ulnar deviation in 16 patients at an average 3-year follow-up. Mulford et al reported a high rate of satisfaction following 4-corner fusion, and Cha et al reported statistical improvements in patient-reported outcomes at 5 years after this procedure. Both PRC and partial arthrodesis avoid the inherent risks of prosthetic arthroplasty, including loosening, component failure, particulate wear, or periprosthetic fracture.

Total arthrodesis is a reliable procedure that offers pain relief and restores strength, but at the expense of all wrist motion. Adey et al reported an average of

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Figure 8: Kaplan-Meier survival plot.
79% grip strength of the uninvolved side in 22 patients. Twenty of the 22 would elect to have a surgery to make their wrist move again, if this was available. Wrist arthrodesis is generally considered a salvage procedure, but it may be indicated as a primary treatment in those with heavy manual requirements.1,6,73

The data presented in this retrospective study support our hypothesis that midcarpal hemiarthroplasty provides significant improvement in ROM, grip strength, and patient-reported outcome measures, with a complication profile comparable with those of alternative solutions for wrist arthritis. The preservation of the midcarpal joint geometry and extrinsic wrist ligaments may help explain this cohort’s pre-operative improvements in wrist ROM, despite the sacrifice of the radiocarpal joint.19,39 These data cannot be directly compared with procedures that eliminate the midcarpal joint, but their 4-year complication and failure rates are comparable with all current solutions for wrist arthritis. Arthroplasty of the midcarpal joint should be considered a motion-improving option for SLAC arthritis that relieves pain, requires little post-operative immobilization, eliminates the risk of nonunion as seen in partial arthrodesis and the risk of osteolysis or distal component failure that may affect total wrist arthroplasty.44,52,54 The procedure is relatively straightforward and preserves carpal bone stock and carpal height, should revision to total wrist arthroplasty be required.

ACKNOWLEDGMENTS

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