Wrist Hemiarthroplasty Combined with Proximal Row Carpectomy

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Introduction

Although total wrist arthroplasty (TWA) has been used in select patients with advanced arthritis due to late Kienböck's disease, those with physically demanding lifestyles are infrequently considered appropriate due to a higher risk for implant loosening, particularly of the distal component. A wrist hemiarthroplasty may obviate the need for strict physical restrictions following TWA and thus provide another motion-preserving option for active patients with advanced wrist arthritis, especially those with distal radius or capitate articular degeneration. Wrist hemiarthroplasty combined with a proximal row carpectomy (PRC) has shown promising early clinical results in properly selected patients with arthritis for whom there are very limited options [1, 2].

In this chapter, a review of the concept of wrist hemiarthroplasty, including assessment in a cadaver study and the early clinical outcomes in a series of patients will be presented. Although hemiarthroplasty has shown promising early results, the procedure is relatively new and it is considered an "off-label" use of an implant system in the USA and some other countries.

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Surgical Technique

Concept

The standard technique described for the Universal 2 (UNI 2) or Freedom wrist arthroplasty implant system (Integra Life Sciences, Plainsboro, NJ) is used. A PRC is performed, but only the radial component is implanted.

Incision

In this technique, a dorsal longitudinal incision is made over the wrist in line with the third metacarpal, extending proximally from its midshaft to approximately 8 cm proximal to the wrist joint. The skin and subcutaneous tissue are elevated together off the extensor retinaculum, with care to protect the branches of the superficial radial nerve and the dorsal cutaneous ulnar nerve.

Extensor Tendons

The EDQ extensor compartment is opened and the entire retinaculum is elevated radially, to the septum between the first and second extensor compartments. Each septum is divided carefully to avoid creating rents in the retinaculum, especially at Lister's tubercle. An extensor tenosynovectomy is performed if needed, and the tendons

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are inspected. The ECRB must be intact or repairable (preferably the ECRL is also functional).

Dorsal Capsule

A quarter inch Penrose tubing is used to retract the extensor tendons, with the EDQ and EDC tendons pulled ulnarly and the EPL, ECRB, and ECRL pulled radially.

The dorsal wrist capsule is raised as a broad distally based rectangular flap to the level of the mid-capitate. The capsule is raised in continuity with the periosteum over the distal ½ cm of the radius to create a longer flap for closure. The radial side of the flap is made in the floor of the second extensor compartment and the ulnar side extends from the radius to triquetrum. The first extensor compartment is elevated subperiosteally from the distal 1 cm of the radial styloid. The remaining dorsal wrist capsule is elevated ulnarly from the triquetrum. The wrist is fully flexed to expose the joint. If necessary, a synovectomy is performed. If the distal ulna is to be resected, a separate capsulotomy is made proximal to the triangular fibocartilage complex (TFCC).

PRC

A proximal row carpectomy is performed with care to preserve the capitate head and volar wrist capsule. No further carpal preparation is required. The capitate head should not have any erosions or cysts that would lead to structural weakening. However, articular cartilage is not a requirement for a hemiarthroplasty.

Trials

Using the radial trials, apply their articular surface against the capitate head to determine the appropriate size. The capitate head must fit easily into the articular surface of the radial trial and allow volar-dorsal translation throughout all ranges of motion.

Implant

Although there is some difference in the radius preparation between the UNI 2 and Freedom implant systems, the UNI 2 technique is described here. Insert the radial intramedullary guide rod into radius, entering below Lister's tubercle and approximately 3 mm beneath the edge of the articular surface. Confirm the rod is entered in the radial canal using both PA and lateral fluoroscopic images. Apply the radial resection guide to the rod and adjust its position so as to remove on the dorsal rim of the radius; the cut need not remove the entire articular surface, particularly its volar portion. Secure the cutting guide with K wires, remove the guide rod, and then resect the radius without violating the sigmoid notch, triangular fibrocartilage or ulnar head. Reinsert the guide rod and sequentially broach to the planned implant size. Insert a trial radial component and perform a reduction to ensure the capitate head will easily fit and glide on the implant surface. Remove the trial and prepare three sets of paired holes along the dorsal rim of the distal radius and place three horizontal mattress sutures for later capsule closure. Insert the final implant using the impactor. Reduce the joint and close the capsule without imbrication. Repair the extensor retinaculum, leaving the radial wrist extensor tendons and extensor pollicis longus subcutaneous. Apply a dressing and plaster splint.

Rehabilitation

Begin gentle range of motion exercises within a few days but do not allow excessive flexion until 4 weeks to protect the dorsal capsule repair. Advance to full available active motion and routine activities at 6 weeks. Long term restrictions include avoidance of impact loading such as using a hammer and forced wrist extension such as a push-up.

Cadaver Study

A feasibility study focusing on joint alignment was undertaken in a cadaver study to determine if the concept of wrist hemiarthroplasty combined

with a PRC should be considered for patients with wrist arthritis. The primary goal was to determine if wrist alignment remained similar to the natural wrist throughout a functional arc of motion. Because the articular shape of the radial component of the UNI 2 is designed to restore the natural loading axis of the wrist, which passes through the long axis of the third metacarpal, capitate, and lunate fossa, the expectation was that longitudinal alignment of the wrist would be maintained but some shortening of the wrist would occur due to the PRC. However, because only minimal resection of the radius is necessary, and there is some thickness of the radial component, the overall shortening of the wrist is minimal.

In this study, eight fresh-frozen specimens from eight donors, with an age range of 43–82 years, were amputated through the proximal forearm. Radiographs showed no preexisting arthritis or deformity. A radial component of the Universal 2 implant system was inserted using the standard described technique for this system.

Radiographic markers were placed in the base of the third metacarpal, in the capitate (near center of rotation) and in the distal radius to track changes in position of the capitate with respect to the radius. Fluoroscopic images were obtained for each specimen before component implantation and after the PRC with hemiarthroplasty (Fig. 27.1). These included; posterior-anterior (PA) images with the wrist in neutral, radial and ulnar deviation; and lateral images in neutral, 45° flexion and 45° extension.

The images were imported into AutoCAD 2002® (Autodesk, Inc, San Rafael, CA) and a pixilated two-dimensional Cartesian coordinate system was then constructed on each image. Projection error was calculated to range from 0.04 to 1.43 mm.

Changes in radial-ulnar alignment of the capitate ranged from 0.21 to 2.21 mm on the PA images and from 0.21 to 4.69 mm on lateral images. These were not significant. As expected, there was significant shortening due to the PRC, which was 4.36–5.43 mm on the lateral images and 5.72–6.10 mm on the PA images ($p < 0.01$ in all wrist positions).

The results of these static measurements in this model demonstrated good wrist alignment in both the coronal and sagittal planes in all wrist positions following combined hemiarthroplasty with PRC (Figs. 27.2 and 27.3). Furthermore, although joint stability was not quantitatively assessed, none of the specimens were unstable during manipulation after the procedure.

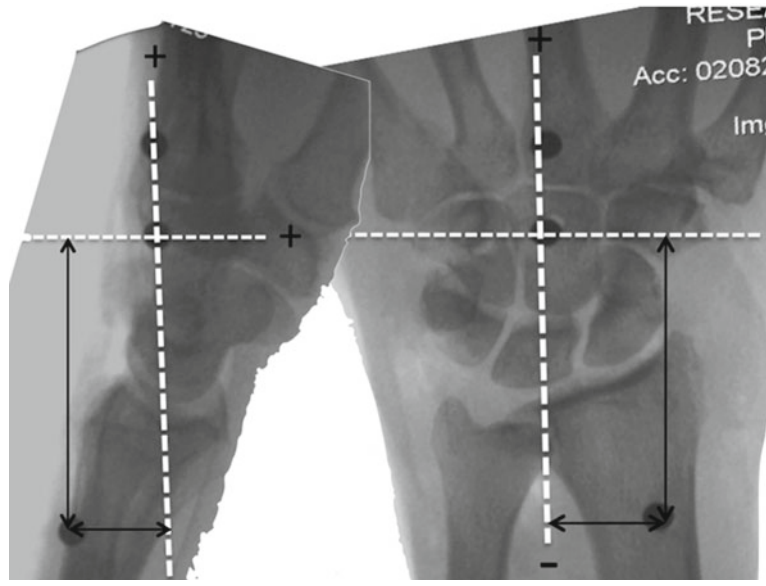

Fig. 27.1 Cadaveric hemiarthroplasty study. Lateral and AP fluoroscopic images demonstrating the coordinate system used to perform measurements

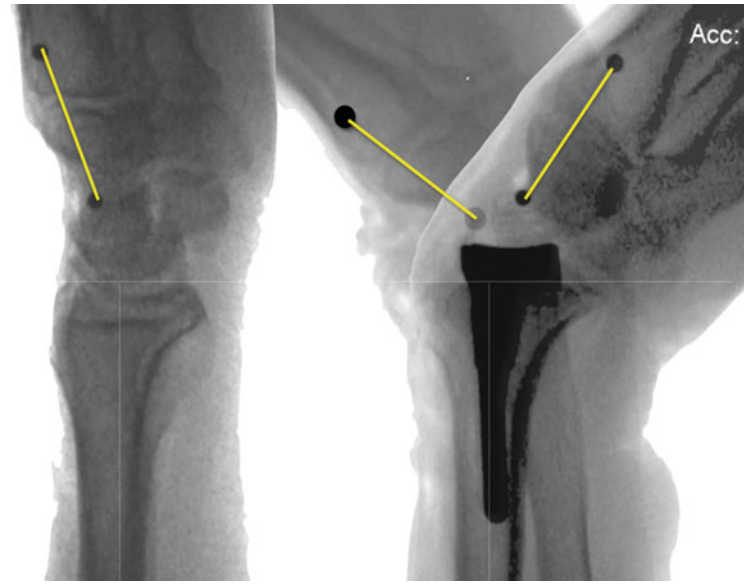

Fig. 27.2 Lateral fluoroscopic image of the wrist. (*Left*) With markers in situ. (*Right*) Composite image following PRC and insertion of hemiarthroplasty (Universal 2, Integra Life Sciences, Plainsboro, NJ). Note the alignment throughout the flexion and extension range of motion

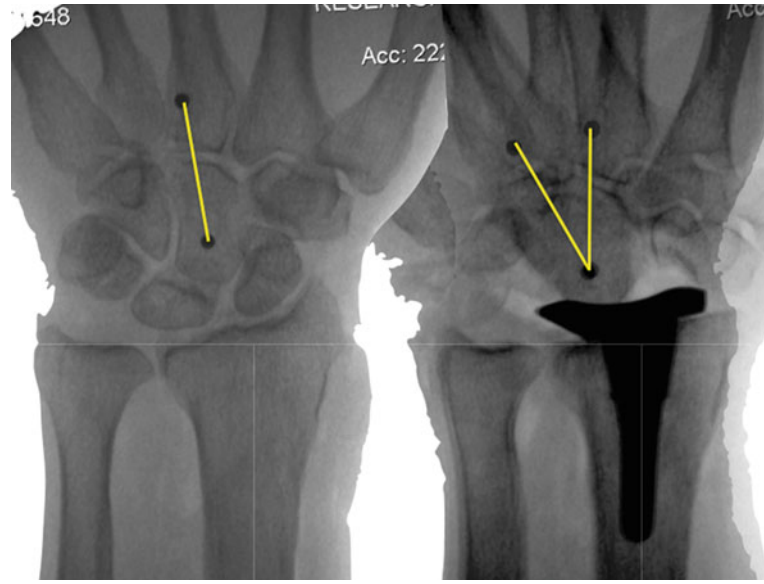

Fig. 27.3 AP fluoroscopic image of the wrist. (*Left*) With markers in situ. (*Right*) Composite image following PRC and hemiarthroplasty (Universal 2, Integra Life Sciences, Plainsboro, NJ). Note the alignment throughout the range of radial and ulnar deviation

Clinical Series

Twenty-six hemiarthroplasties combined with PRC were performed by the author in 23 patients who had a distribution of arthritic changes in the wrist that precluded the use of other motion preserving procedures. Only the UNI 2 implant system was used in this series, however the author converted to the use of the Freedom system when it became available. The surgical technique described above for the cadaver study was used in all patients. Indications initially included rheumatoid disease, osteoarthritis, post-traumatic arthritis and Kienböck's disease, however because some patients with active rheumatoid disease showed evidence of rapid carpal erosion the procedure was discontinued for these rheumatoid patients.

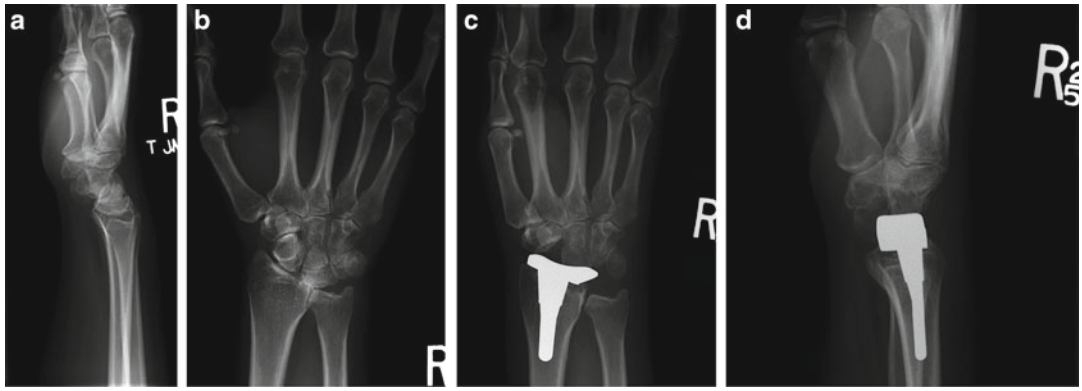

Fig. 27.4 Preoperative posteroanterior and lateral views (**a**, **b**) of a patient with radiocarpal arthritis showing ulnar translocation of the carpus. Postoperative posteroanterior and lateral views (**c**, **d**) following treatment by hemiarthroplasty (Universal 2, Integra Life Sciences, Plainsboro, NJ) combined with PRC showing correction of ulnar translocation and reestablishment of the normal longitudinal loading axis across the wrist

Radiographic alignment measurements equivalent to those performed in the laboratory study were made in the first 15 wrists in 14 patients, at a range of follow-up of 1–2 years, to confirm the procedure was performing similarly in patients with arthritis who had some wrist deformity. The results showed maintenance of wrist alignment or realignment into a more normal position along the *x*-axis by improving preexisting ulnar translocation of the carpus; with the average change in the *x*-axis of 3.9 mm. Wrist shortening as measured on the *y*-axis averaged 4.8 mm, which occurred primarily due to the PRC.

Clinical and radiographic follow-up at a range of 3–6 years was performed for all 26 arthroplasties (Figs. 27.4 and 27.5). The average recorded results were: flexion 34° (range 22–53), extension 24° (18–44), radial deviation 12°, and ulnar deviation 21°. Change over time in wrist motion was assessed for the first 15 wrists in 14 patients who had measurements made at 1–2 years post-operative and again at 4–6 years post-operative. The average decrease in motion was flexion 11°, extension 9°, radial deviation 4°, and ulnar deviation 6°. This average loss of motion, however, was substantially influenced by three patients who lost considerably more motion than the other patients, retaining an average of only 11° of flexion and 9° of extension. These three patients had rheumatoid disease and showed obvious carpal erosion, and eventually went on to a complete arthrodesis. Following recognition of these impending failures, patients with rheumatoid disease were no longer treated by this procedure. The amount of capitate erosion that was measured in the non rheumatoid patients ($n = 20$) at follow up of 2–6 years, ranged from 1 to 5 mm, with the exception of one patient who had osteoarthritis and bilateral procedures showed 7 mm of erosion at 4 years in both wrists. This patient also had evidence of substantial preoperative capitate cystic changes and very active osteoarthritis involving multiple joints in other extremities. Based on this adverse outcome, caution should be exercised when considering this procedure in osteoarthritic patients who have substantial synovitis and cystic or erosive changes in the carpus, which likely indicates more advanced disease or compromised bone quality.

Review of Literature

Boyer and Adams first described the procedure of combining a PRC with a distal radius hemiarthroplasty in a case study of two patients in 2010 [1]. The first patient was a 42-year-old rheumatoid patient who had bilateral wrist arthritis and the typical associated deformity and the second patient was a 52-year-old male with osteoarthritis of the right wrist and previous partial left fusion. The initial results were good in both patients but

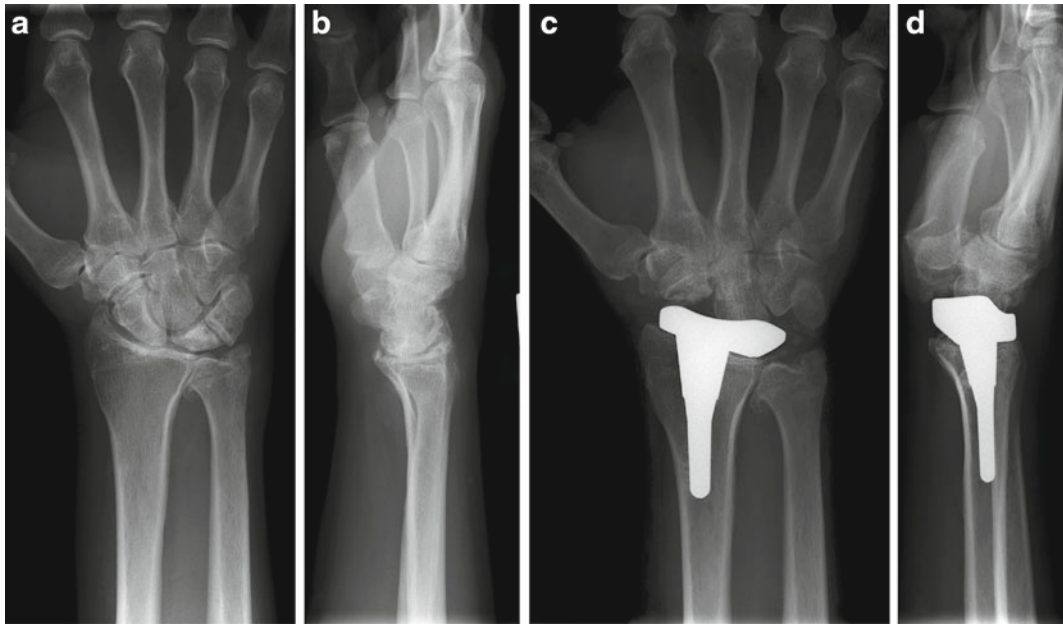

Fig. 27.5 Preoperative posteroanterior and lateral views (**a**, **b**) of a wrist showing findings of Lichtman Stage 4 Kienböck's disease. Note that the capitate articular surface is preserved (Bain grade 3), making it a good indication for the hemiarthroplasty (Universal 2, Integra Life Sciences, Plainsboro, NJ). Postoperative posteroanterior and lateral views (**c**, **d**) after distal radius hemiarthroplasty combined with a PRC

the first patient developed the progressive carpal erosion described above while the second patient continues to have a good result at 6 years.

Culp et al. reported their results with this procedure using two different implants [2]. Their over all experience with the procedure included the use of the Maestro (Biomet, Warsaw, IN) radial implant that has polyethylene on its articular surface in the first 17 patients and the ReMotion (Small Bone Innovations, Morrisville, PA) that is made entirely of cobalt-chrome-molybdenum in the next 19 patients. They abandoned the use of the Maestro due to early osteolysis and reactive tenosynovitis from polyethylene wear of its articular surface. They had also stopped using the procedure in patients with inflammatory arthritis due to an apparent higher incidence of carpal erosion. Ten patients who did not have inflammatory arthritis and had proper medical records were reviewed in more detail at a follow up of 14–29 months. Post-operative wrist flexion and extension averaged 22° and 30°, respectively. Pain relief was often incomplete but improved following the procedure if there were no complications. They concluded the procedure provides a functional arc of motion and adequate grip strength in select patients but implant design likely plays a role an important role in outcome.

Discussion

Active individuals with advanced Kienböck's disease often desire to maintain wrist motion so as to better perform tasks and activities that are important to their life style. However, due to the physical restrictions that are recommended following total wrist arthroplasty, those with physically demanding life styles are infrequently considered for total wrist replacement because of the risk for implant loosening, particularly of the distal component. A distal radius hemiarthroplasty may obviate the need for strict physical restrictions because of the durability typically found with radial component fixation.

Several criteria need to be satisfied before distal radius implant hemiarthroplasty is considered for routine use, including joint alignment and

stability. The articular shape of the radial component of the UNI 2 and its successor, Freedom wrist system, conform well to the head of the capitate for optimum stability, but the shape also allows the necessary flexion–extension arc of motion as well as the important freedom of anterior-posterior and radial-ulnar translation to better replicate physiologic motion. Both the UNI 2 and Freedom systems are designed to restore the natural loading axis of the wrist, which passes through the long axis of the third metacarpal, capitate, and lunate fossa. In both the cadaver study and the clinical series, the UNI 2 design recreated the natural longitudinal loading axis in both the coronal and sagittal planes. Its successor, the Freedom system, maintains this important loading axis concept while providing a broader and shallower lunate fossa to allow increased capitate translation and increased wrist motion.

Despite the procedure including a PRC, which could potentially destabilize the joint, stability was not problematic in either the cadaver study or the clinical series. However, the UNI 2 and Freedom implant designs do not necessarily reflect the performance that will occur with other available radial implant designs. Furthermore, since none of the specimens and only a few of the wrists in the clinical series had severe deformity, the surgeon will need to exercise good judgment and proper caution when considering treatment in patients severe wrist deformity.

In clinical application, erosion of the carpus due to contact with the cobalt chrome surface is likely, but the rate of erosion will be difficult to predict. Erosion will probably depend on several factors including the initial condition of the carpus surface, bone density, and activity of the patient. In this series, some patients with rheumatoid arthritis showed rapid carpal erosion, which lead the author to discontinue this procedure in these patients. Additionally, patients who have substantial synovitis and cystic changes associated with active osteoarthritis are likely not good candidates. In the other patients, carpal erosion appeared to be acceptable and did not impact clinical results. Although pain relief will vary among patients due to variation in the response of the normal or arthritic joint surface against cobalt chrome. The results for up to 6.5 years indicate most patients can achieve good clinical and radiographic outcomes.

Conclusion

Despite the potential disadvantages of hemiarthroplasty, it is an alternative for active patients with advanced wrist arthritis. This includes patients with Stage 4 Kienböck's disease who are not candidates for traditional motion preserving procedures due to distal radius or capitate articular degeneration. Our cadaver and clinical results indicate this technique has potential for a satisfactory clinical outcome in properly selected patients. However, the patient should fully understand the risks, including possibilities of incomplete pain relief, deterioration of outcome, and need for revision surgery.

References

1. Boyer JS, Adams BD. Distal radius hemiarthroplasty combined with proximal row carpectomy: case report. Iowa Orthop J. 2010;30:168–73.
2. Culp RW, Bachoura A, Gelman SE, Jacoby SM. Proximal row carpectomy combined with wrist hemiarthroplasty. J Wrist Surg. 2012;1(1):39–46.