A New Distal Radioulnar Joint Prosthesis

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J Wrist Surg 2013;2:359–362.

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Abstract

Pain and instability of the distal radioulnar joint (DRUJ) are common sequelae following a fracture of the distal radius. Many soft tissue procedures have been described, not all of which are successful. Ulnar head replacement prostheses are available but do not always provide stability. We designed a two-part, easy to implant, distal radioulnar prosthesis and implanted it in 19 patients. The first prototype was inserted in 2002 and is still in place. During the study, the design was changed twice, resulting in three groups with four patients in group A, five in group B, and ten in group C. Unfortunately all five prostheses in group B had to be removed because of loosening, while only two prostheses in group C had to be removed, for nonprosthetic reasons. For the 12 patients who retained their prosthesis, forearm function increased while grip strength increased significantly. Pain scores decreased and the Disabilities of the Arm, Shoulder, and Hand (DASH) score improved but remained high. We conclude that the prosthesis offers a new treatment option for ulnar instability following distal ulnar resection.

Keywords

- ▶ distal radioulnar joint
- ▶ instability
- ▶ prosthesis
- ▶ surgery
- ▶ wrist

Pain and instability of the distal radioulnar joint (DRUJ) are common sequelae following a fracture of the distal radius. Since the 1990s, DRUJ prostheses have been available in the form of total ulnar head, hemi-ulnar head, or total DRUJ replacements. A total ulnar head prosthesis is indicated in cases of posttraumatic osteoarthritis of the DRUJ, instability of the proximal stump after resection of the distal ulna, posttraumatic osteoarthritis of the DRUJ, or ulnar instability after resection of the distal ulna.

The purpose of this article is to present the evolution of the design and short-term functional outcomes of our DRUJ prosthesis. This total DRUJ prosthesis differs from others in that it consists of two parts and attains bony fixation by its hydroxyapatite coating. Adequate soft tissue and suitable bone stock are required for successful implantation of the total ulnar head prosthesis. If the DRUJ lacks soft tissue to stabilize the total ulnar head prosthesis (e.g., after multiple forearm surgeries), a total DRUJ prosthesis may be indicated.

Patients and Methods

We designed a two-component total DRUJ prosthesis with four degrees of movement: rotation around its own axis,

angulation, translation in volar to dorsal direction, and pistoning or longitudinal migration. To gain stability following implantation, the surface area of the ulnar component was enlarged with longitudinal grooves. For the radial component, a crucifix form was designed so as to increase the surface area as well as to prevent the chance of rotation prior to bony ingrowth, and initially the corners were rectangular. Furthermore, a spike was made at the radial end of the radial component, which would impale the radial cortex of the radius after implantation (→ Fig. 1a,b).

The ulnar part is made of standard chromium cobalt with a hydroxyapatite coating proximally (intramedullary portion) and a titanium niobium nitride (ceramic) coating distally. This coating is intended to reduce metal-on-polyethylene wear (ACCIS coating; Van Straten Medical, Netherlands).

The extramedullary part of the radial component has a polyethylene-lined inner ring. The radial component is made of standard chromium cobalt. Both components come together at the location of the former ulnar head.

The distal part of the ulnar component is placed through the ring on the protruding portion of the radial component. Prostheses used in the study were custom-made; given sizes are averages. The ulnar stem has a diameter of 3.6 mm

Fig. 1 Our total DRUJ prosthesis: (a) Design. (b) First implanted implant.

proximal to 4.9 mm distal and a length of 70 mm. The radial component has a length of 40 mm, and the ring has a diameter of 13 mm.

During this study the implant design evolved from prototype A, to B, to C (►Fig. 2). Prosthesis A was implanted in four patients. Because the importance of the pin was later doubted and the rectangular corners seemed too sharp, it was decided to adjust the prosthesis from A to B. Corners on the radial component were rounded, and the pin on the radial side was removed. All prototype B prostheses ($n = 5$) loosened over time and had to be removed. During production the polyethylene ring was unfortunately made too tight, and it swelled by taking up synovial fluid. Both factors caused too much friction, resulting in loosening of the radial component.

In prototype C, rectangular corners on the radial side of the radial component and the pin were reintroduced (the corners on the ulnar side remained rounded). The tolerance of the ring was also increased. In this group, no loosening was seen. This prosthesis was implanted in ten patients. The only difference between prototypes A and C is that the latter had rounded corners on the ulnar side.

For the ulnar component, an awl is used to open the medullary canal followed by a trial component. A thread is made in the distal part of the component, into which a screw can be inserted for easy removal. For the radial component, a jig is positioned at the level of the resected ulnar head. The jig is then fixed temporarily while holes are drilled through the jig in the shape of the radial component's crucifix form

(►Fig. 3a,b). The jig is then removed and a crucifix-shaped chisel used to open the ulnar-side cortex of the radius (►Fig. 3c). Once the cortex is opened, the radial component is inserted by gentle hammering (►Fig. 3d,e,f). If needed, the radial component can be removed by inserting a pin through the polyethylene ring using an instrument on the set.

Between January 2002 and November 2007, 19 patients received a DRUJ prosthesis—prosthesis A ($n = 4$), prosthesis B ($n = 5$), or prosthesis C ($n = 10$). Mean follow-up of successful placement of the prosthesis was 4 years and 1 month (range, 1–7 years). For those prostheses that failed, the mean time between placement and removal was 1 year (range, 4–21 months).

Two men and 17 women with a mean age of 45 years (range, 22–62 years) were included. Eighteen patients were right-handed, and one patient was left-handed. The prosthesis was placed in 8 dominant and 11 nondominant limbs. Decreased grip, decreased range of motion (ROM), and pain and instability due to ulnar impingement syndrome were the main indications for the placement of the prostheses.

Ten patients previously had a Darrach procedure, and 7 had a Sauvé-Kapandji procedure, with unsatisfying results. The prosthesis was placed as salvage of the previous procedures. All 17 had an unstable distal ulna. Of the remaining two patients, one joint was destroyed by trauma and the other by progressive synovitis.

Results

Follow-up measurements were performed at 3, 6, and 12 months after surgery, and thereafter at yearly intervals. A paired *t*-test was performed to assess the significance of difference between preoperative and postoperative measurements. Statistical significance was based on $p < 0.05$.

Prosthesis A had no failures. Prosthesis B was removed in all five patients because of loosening. After signs of loosening, three of the five prostheses were revised and cemented. However, this could not prevent further loosening and removal. Prosthesis C was removed in two of 10 patients, one because of continuing pain during movement and one at the request of the patient, who was dissatisfied with her treatment and requested removal, although there were no complaints of pain or reduction of function. After removal of the prosthesis, the patients returned to their preoperative

Fig. 2 Line drawings of prostheses A, B, and C. Arrows indicate the increase in tolerance; the pins in prostheses A and C are colored red for clarification.

Fig. 3 (a) Cruciform drill holes in radius. (b) Jig for drill holes in radius. (c) Radial chisel in radius. (d) Insertion of ulnar component. (e) Radial component insertion. (f) Both components inserted.

functional states. This study ended in 2009, but as of August 2012 no more prostheses have been removed or revised. There were no postoperative infections and no cases of complex regional pain syndrome.

For the 12 patients who retained their prostheses, there were significant increases in ROM for some wrist and forearm movements and trends toward significant increases in others (► **Table 1**). The largest increase in forearm movement was seen in pronation, from an average of 79° (SD, 8.8°) to 88° (SD, 4.0°; paired *t*-test, *p* = 0.01). Grip strength increased significantly (► **Table 2**) from an average of 10 kg (SD, 3.7 kg) to an average of 16 kg (SD, 7.7 kg; *p* = 0.01). Pain scores improved, and disability scores showed a trend toward improvement in

11 of the 12 patients (► **Table 3**). The Disabilities of the Arm, Shoulder, and Hand (DASH) score decreased from a mean of 39 (SD, 10.5) to a mean of 31 (SD, 18.3; *p* = 0.07). The Visual Analog Scale (VAS) score for pain decreased from a mean of 5.3 (SD, 2.8) to a mean of 3.5 (SD, 3.1; *p* = 0.02).

Discussion

Our high failure rate is a cause for concern; however, five of the seven removed prostheses were implanted in the same year, using prosthesis B, all before increasing the tolerance of the polyethylene ring (prosthesis C). We think that the five removals were caused by the high amount of friction when the ulnar

Table 1 ROM and average increase/decrease

	Dorsal flexion	Palmar flexion	Radial deviation	Ulnar deviation	Pronation	Supination
Preoperative	48 (SD 18.3)	39 (SD 16.1)	12 (SD 7.5)	19 (SD 10.9)	79 (SD 8.8)	70 (SD 15.1)
Postoperative	59 (SD 19.5)	46 (SD 20.3)	14 (SD 10.4)	24 (SD 12.5)	88 (SD 4.0)	72 (SD 18.6)
Difference	≈23%	≈18%	≈11%	≈26%	≈11%	≈3%
<i>p</i> Value	0.01	0.29	0.66	0.26	0.01	0.7

Table 2 Grip and pinch strength and average increase/decrease

	Grip	Tip	Lateral
Preoperative	10 Kg (SD 3.7 Kg)	1.9 Kg (SD 1.2 Kg)	3.0 Kg (SD 1.5 Kg)
Postoperative	16 Kg (SD 7.7 Kg)	2.3 Kg (SD 1.3 Kg)	3.4 Kg (SD 1.6 Kg)
Difference	≈56%	≈21%	≈13%
p Value	0.01	0.26	0.37

Table 3 DASH and VAS scores and average increase/decreases

	DASH	VAS
Preoperative	39 (SD 10.5)	5.3 (SD 2.8)
Postoperative	31 (SD 18.3)	3.5 (SD 3.1)
Difference	≈21%	≈33%
p Value	0.07	0.02

part glided through the polyethylene ring. This friction resulted in loosening of the prosthesis. After we increased the tolerance, only two of the ten prostheses had to be removed in the following 4 years, one because of continuing pain and the other at the request of the patient. We also think that the reintroduction of rectangular corners and the small pin on the radial side of the radial component increased fixation. Based on the early results, the prosthesis in its current state (prosthesis C) has a much lower failure rate than before (prosthesis B). Unfortunately, the average DASH score decreased only slightly, from an average of 40 to an average of 31, and this decrease did not reach statistical significance.

The study's limitations should be noted: Because of the small patient cohort, the study lacks the power to find differences in outcome measurements. Furthermore, there was no comparison group. Still, the current prototype of our prosthesis gave an average increase in all forearm movements and grip strength and an average decrease in forearm disability and pain. The DRUJs remained clinically stable. The early results show clinical improvement after placement of the prosthesis. Based on these results, we conclude that the prosthesis offers a new treatment option for ulnar instability after distal ulnar resection.

Conflict of Interest

None