Survivorship of Revision Wrist Replacement

E. M. Pinder, BMedSci, BMBS¹ K. G. Chee, MBBS, MMed¹ M. Hayton, BSc, MBChB¹
S. R. Murali, MBBS, MA¹ S. C. Talwalkar, MBBS¹ I. A. Trail, MBChB, MD¹

¹Upper Limb Unit, Wrightington Hospital, Wigan, United Kingdom

J Wrist Surg 2018;7:18–23.

Address for correspondence E. M. Pinder, BMedSci, BMBS, c/o Prof. Trail's Secretary, Upper Limb Unit, Wrightington Hospital, Hall Lane, Appley Bridge, Wigan WN6 9EP, United Kingdom (e-mail: elizabeth.pinder@ipswichhospital.nhs.uk).

Abstract

Purpose This study aims to report the 5-year survivorship of revision wrist arthroplasties and to report midterm clinical and radiological results.

Materials and Methods All patients receiving a revision wrist arthroplasty in our unit between January 1, 1997 and October 31, 2010 were identified, and clinical notes retrospectively analyzed for Quick Disabilities of the Arm, Shoulder and Hand (quick-DASH), Patient Evaluation Method (PEM), Patient-Rated Wrist Evaluation (PRWE), the range of movement, and visual analog score (VAS). In cases where patient review had not occurred within the past year, they were invited for assessment, and this data was included in the analysis. Plain radiographs were analyzed for loosening of each component. The 5-year survival was plotted using Kaplan–Meier analysis.

Results Of the 19 patients identified, 1 was lost to follow-up and therefore excluded from all analyses. Mean age at revision wrist arthroplasty was 55.8 years and the mean time from primary to revision wrist arthroplasty was 6.7 years. At revision arthroplasty, 7 patients received the Biaxial implant (DePuy, Inc., Warsaw, IN) and 11 received the Universal II implant (Integra, Inc., Plainsboro, NJ). The 5-year implant revision survivorship was 83%. Depending on the variable of interest, clinical data were available for either three, four or five patients. At final follow-up (mean: 10.4 years), mean visual analog score was 2.9, mean quickDASH 57, mean PEM 49, mean PRWE 61, and mean arc of flexion/extension was 26 degrees. Radiological data were available for 12 patients, with evidence of gross loosening present in around 60% of the carpal components and 50% of the radial components at mean 6.7 years.

Conclusion Revision wrist replacement implant survival is acceptable, but the majority of the surviving implants are radiologically loose. It is not clear at this time whether they are better or worse than a fusion after a failed primary wrist arthroplasty.

Clinical Relevance It is reasonable to offer revision wrist arthroplasty in selective cases, but regular clinical and radiological follow-up is recommended.

Keywords

- clinical outcome
- radiological outcome
- revision wrist arthroplasty
- revision wrist replacement
- wrist replacement survival

A total wrist fusion is often considered the surgical treatment of choice for pancarpal arthritis. Although successful outcomes are reported, the loss of movement interferes with several activities of daily living as most require 30 degrees of extension, 5 degrees flexion, 10 degrees radial deviation, and 15 degrees ulnar deviation.¹ Retaining some wrist movement

with a total wrist arthroplasty (TWA) is an appealing alternative, although many designs fail to achieve the functional range of motion described by Palmer et al.^{1,2} Indeed, other authors suggest that an even greater range of movement is required for most day to day tasks.³ Ideal candidates are low demand, do not require walking aids and have good bone

received
October 26, 2016
accepted after revision
April 17, 2017
published online
May 15, 2017

Copyright © 2018 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA.
Tel: +1(212) 584-4662.

DOI <https://doi.org/10.1055/s-0037-1603320>.
ISSN 2163-3916.

stock with little wrist or hand deformity. Indications for TWA have expanded to include pathologies other than rheumatoid arthritis, including posttraumatic arthritis, Kienbock's disease, and other inflammatory arthropathies.⁴⁻⁶

For primary TWA, survivorship mostly ranges between 75 and 100% for studies with at least 5 years mean follow-up.² Results from our unit compare favorably for the Universal II implant (Integra, Inc., Plainsboro, NJ), with 91% survival at 7.8 years mean follow-up.⁷ The Biaxial implant (DePuy, Inc., Warsaw, IN), which is no longer available, has demonstrated a survivorship of 83% at 8 years mean follow-up.⁸

When primary implants fail, they will often require intervention; a challenging task, especially when there is a significant bone loss. Options include conversion to fusion with bone grafting, excision arthroplasty, interposition arthroplasty, or revision to a further TWA. The decision is guided by the patients' symptoms, goals, general medical health, deformity, and the amount of bone loss.

Few studies report the survival of revision TWA. Those which do are limited to small patient series and involve earlier implants.⁹⁻¹² The purpose of this study was to report the 5-year survival of revision TWAs performed at our institution and to report midterm clinical and radiological results. Our primary outcome measure was the absence of implant removal at 5 years. Secondary outcome measures were patient-reported outcomes measures, the range of motion, and radiological loosening.

Materials and Methods

Patients undergoing revision wrist replacement in our unit from January 1, 1997 to October 31, 2010 were identified from theater registers and a computerized database. Patient notes were analyzed and the following recorded: demographic data, date of initial surgery, type of implant, date of revision surgery, type of revision implant, indication for revision, microbiology results, complications, and further surgery. Computerized records were accessed to identify if the patient had died.

Survivorship Analysis

The 5-year survivorship was determined using Kaplan-Meier analysis with implant failure as the end point. This was defined as removal of one or both components during further revision surgery. Implants still in situ at 5 years according to the medical records were treated as censored data at 5 years. Patients who died within 5 years of their revision wrist arthroplasty were also included as censored data, but at the time point defined by the number of years from revision arthroplasty to death. This method allows patients who did not complete the study (e.g., died) to be included in the survivorship curve.

Clinical Outcome Analysis

Clinical outcome data was gathered during September and October 2015. Patient notes were retrospectively analyzed for: Quick Disability of the Arm, Shoulder and Hand Outcome

Measure (quickDASH), Patient Evaluation Method (PEM), Patient-Rated Wrist Evaluation (PRWE), range of movement, and visual analog score (VAS).¹³⁻¹⁵ VAS was measured on a 10 cm unmarked scale labeled "no pain" and "severe pain" at the extremes in response to the question: "what is your usual level of pain?" The length from the start of the scale to the marked point was measured to obtain a numerical value from 0 to 10. The outcomes above were not usually available at 5 years following revision arthroplasty. Therefore, data obtained at the most recent follow-up appointment was collected. Patients without a review in the last 12 months were contacted by telephone to invite them for routine clinical follow-up, and these measurements and scores were included as part of the assessment. E.M.P. or K.G.C. reviewed the patients. Wrist flexion and extension were measured using a goniometer using the dorsal border of the third metacarpal and the radial shaft as landmarks. Patients who declined outpatient clinical review were given the option to complete a quickDASH outcome score by telephone.

Radiological Assessment

The latest available posteroanterior and lateral plain radiographs were retrieved and assessed for loosening on October 12, 2015. Some patients had received further revision surgery. Therefore, the last plain radiograph before the revision procedure was assessed. The carpal and radial components were separately divided into zones for the Universal II and Biaxial prostheses (see ►Fig. 1).⁸ Gross loosening was defined as radiolucency in all zones of a component.

Statistical analysis was performed with $p < 0.05$ used to define statistical significance. Fisher's exact test was used to compare survival of the two types of revision implant used. The study was authorized by our institution's audit and research department.

Results

Overall, 19 patients underwent revision wrist arthroplasty between January 1, 1997 and October 31, 2010. One patient was lost to follow-up and was excluded from the analysis. For the remaining 18 patients, age, sex distribution, indication for primary arthroplasty, the number of years from revision arthroplasty until October 2015, and the implants used in primary, and revision surgery are shown in ►Table 1. All patients with rheumatoid arthritis were under the care of a consultant rheumatologist. Mean age at revision wrist arthroplasty was 55.8 years (range: 28–83 years). The mean time from primary to revision procedure was 6.7 years (range: 4 months–20.5 years). Indications for revision surgery are presented in ►Table 2. The indication for the patient who received revision surgery at 4 months was stiffness. It was felt that insufficient bone had been resected at index surgery and the radial component was revised accordingly. A further two patients experienced stiffness following their primary arthroplasty and were also treated with radial component revision involving additional radial bone

Fig. 1 Zones of loosening for (A) Biaxial and (B) Universal II implant.

resection. An intraoperative observation of loosening was made in seven cases: distal only (5) proximal only (0), both (2). An organism was grown from one intraoperative specimen in one patient (Neisseria species in one of three specimens). Bone graft was not required for 10 patients, impaction bone graft was used in 6, iliac crest graft reconstructed an ulna defect in 1, and the requirement of bone graft was unknown for 2. Supplementary cement was not used.

Table 1 Demographics

	Number	Percentage
Gender		
Male	3	17
Female	15	83
Age at revision TWA		
< 40	4	22
40–59	6	33
60–79	7	39
80+	1	6
Indication for surgery		
Rheumatoid arthritis	16	89
Osteoarthritis	1	6
Psoriatic arthritis	1	6
Number of years since revision TWA (on October 31, 2015)		
5–10	10	56
10–15	5	28
15–20	3	17

Abbreviation: TWA, total weight arthroplasty.

The cumulative 5-year implant revision survival was 83%, and the survival curve is shown in **Fig. 2** ($n = 18$). Of the three revision implants which failed, one was revised to a further revision TWA (radial component only) at 10 months due to stiffness, one was converted to an Amandys interposition arthroplasty at 23 months for painful loosening and one converted to a total wrist arthrodesis at 4 years (indication unknown as performed during temporary residency abroad). The Amandys interposition arthroplasty (Tornier SAS-Bioprofile, Grenoble, France) is a pyrocarbon implant designed to provide a salvage option following failed wrist surgery, including failed wrist arthroplasty.¹⁶ **Table 3** shows similar survival for the Biaxial and Universal II implants ($p = 1.00$). Other surgical procedures were performed in three further patients: soft tissue release and manipulation under anesthetic,¹ flexor tenolysis,¹ and centralization of extensor tendons.¹

Clinical outcome data were available for five patients at a mean follow-up of 10.4 years (range: 5.5–18.2 years) and is presented in **Table 4**. Four patients were assessed at the routine clinical review, and one completed the QuickDASH

Table 2 Implant type for primary and revision surgery

	Number	Percentage
Primary implant		
Swansons	5	28
Biaxial	8	44
Universal II	5	28
Revision implant		
Biaxial	7	39
Universal II	11	61

Fig. 2 Five-year survival for revision wrist arthroplasty. Confidence intervals shown as dotted lines.

assessment by telephone. Eleven patients could not be invited for routine review as they had either died (5), received further revision surgery within 5 years of follow-up (3), or received further revision surgery beyond 5 years of follow-up (3). Two patients declined routine follow-up.

The follow-up interval was greater for plain radiograph analysis because images were assessed during October 2015 rather than at 5 years postrevision. Further revision surgery had been performed on a total of six patients. Plain radiographs were available and included in the analysis for 12 patients (Biaxial: 4 and Universal II: 8) at a mean follow-up of 6.7 years after revision surgery (range: 0.6–18 years). Standard and long stem options were available for the Biaxial implant. During revision surgery, the standard length implant was used for three patients, and the long stem option was chosen for one. Of the 12 patients in whom radiographs were available, 3 had received further revision surgery for loosening or subsidence at 2, 6, and 9 years, respectively, and preoperative plain radiographs were selected. The revision procedure was the Amandys interposition arthroplasty (Tornier) for two cases and fusion in the remaining case. Four had received a Biaxial

Table 3 Comparison of revision implant survival at 5 years for the Biaxial and Universal II implants

Final status of RTWA	Biaxial	Universal II	p-Value (Fisher's exact test)
Implant survival	6	9	$p = 1.00$
Implant failure	1	2	

Abbreviation: RTWA, revision total weight arthroplasty.

implant, and the remaining eight had the Universal II. All 12 patients who had radiographs available for analysis had some degree of carpal component loosening, and all but two had additional loosening of the radial component. The mean number of zones displaying loosening was 5.2 (range: 2–6) for the carpal component and 3.6 for the radial component (range: 0–5). Seven of the carpal components (60%) and six of the radial components (50%) displayed evidence of gross loosening. Loosening according to implant type is shown in ▶Table 5. ▶Fig. 3 illustrates preoperative and postoperative plain radiographs of a patient who had loosening of both components and breakage of the distal component.

Discussion

Our results indicate suboptimal results of revision TWA with a survivorship (lack of implant removal) of 83% at 5 years. Radiological evidence of gross loosening was present in 60% of carpal components and 50% of radial components. At final follow-up, VASs were low for all but one patient who was offered conversion to fusion. Availability of clinical outcome scores was low therefore it is difficult to draw meaningful conclusions regarding functional outcome.

The majority of studies reporting outcomes of revision wrist arthroplasty involve the Biaxial implant which has been withdrawn from the market due to an unacceptably high failure rate. Mean follow-up times varied from

Table 4 VAS/ROM/QuickDASH scores

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Number of years since RTWA	18	10	8	5	7
Revision Implant	Biaxial	Biaxial	Universal II	Universal II	Universal II
Grip (% of contralateral)	50	67	10	100	
VAS	0.5	9	1.25	0.75	
Wrist dorsiflexion (degrees)	10	–	14	11	
Wrist palmar flexion (degrees)	25	–	8	9	
Arc of wrist flexion/extension (degrees)	35	–	22	20	
Quick DASH	75	88.6	56.8	9.1	55
PEM score	44	71	55	26	
PRWE score	55.7	90	84.5	13.5	

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand; PEM, Patient Evaluation Method; PRWE, Patient-Rated Wrist Evaluation; ROM, range of motion; RTWA, revision total weight arthroplasty; VAS, visual analog score.

Table 5 Loosening according to implant

	Biaxial Median number of zones show- ing loosening (range)	Universal II Median number of zones show- ing loosening (range)
Radial component	3.5 (0–5)	5 (4–5)
Carpal component	6 (2–6)	5.5 (4–6)

28 months to 3.8 years with reported survival rates of 77 to 80%.^{9–11} Our study revealed a slightly better survival rate (86%) for our Biaxial subgroup despite a longer follow-up. For primary Biaxial prostheses, our unit has identified a survival rate of 83% at mean 8 years which is similar to the current study's results despite its use as a revision implant.⁸

Little data are available for other implant designs. Lorei et al reported their outcomes of revision wrist arthroplasty using the trispherical implant in three patients.¹⁷ None had been revised at 1, 1, and 9 years. The implant has been since removed from the market. Vogelien and Nagy report the results of 16 failed Meuli TWA.¹² Ten were revised, but it is unclear which revision implants were used for some patients. Implant survival was 50% at a mean of 3.2 years follow-up which is inferior to our cohort.

Fig. 3 Preoperative (top) and postoperative (bottom) plain radiographs of a patient who had revision total wrist replacement for a loosening of both components. Intraoperatively the distal component was found to be broken.

The Universal II implant was used as the revision prosthesis for 11 of our 18 patients. It is difficult to compare the 82% 5-year survival rate with previous studies as published data are limited to two case reports.^{18,19}

The previous reporting of clinical outcomes is variable. Two studies identified that the Biaxial implant achieves 19 degrees of mean flexion and 31 and 36 degrees of mean extension when used as a revision prosthesis.^{10,11} Range of movement was documented for three of our patients (Universal II implants: two and Biaxial implant: one), and they had inferior movement, but the length of follow-up was longer. VAS was additionally reported by one of these studies and mean score was very similar to our cohort (3 and 2.9, respectively). Functional outcome reporting of earlier studies has been restricted to descriptive terminology rather than modern scoring systems. Rettig et al identified that 7 of their 10 patients were “much better” following surgery while Cobb et al reported that all 8 of their patients were “better” or “much better.”^{9,10} We included the quickDASH, PEM, and PRWE scores, all of which identified variable results. Some of these scores suggest suboptimal outcomes. However, one must remember that these patients had rheumatoid arthritis and consequently have poor hand and upper limb function. Wrist replacements will only demonstrate a limited improvement in function. Patient numbers were too small to make meaningful statistical comparisons between the Biaxial and Universal II implants.

It is surprising that our Biaxial and Universal II survival rate was similar, as this is not the case in the primary situation. Patient numbers were low which raises the possibility of a type 2 error obscuring a true difference. Another potential explanation is that the biaxial implant has a longer stem option for the carpal components which the Universal II does not. However, only one patient in the Biaxial group had a longer stem as assessed by plain radiographs, although the number could be higher as data were not available for three of the seven patients in that group.

Previous studies of revision wrist arthroplasty have identified loosening and/or subsidence in 31% at 31 months and 50% at 3.8 years.^{9,10} Our cohort had a higher rate, but follow-up was longer. Of the RTWAs which received further revision surgery, the indication was loosening or subsidence in two-thirds. Of the remaining patients for whom plain radiographs were available, all had radiological evidence of loosening. We acknowledge that there was heterogeneity within our cohort and indeed the aforementioned studies in terms of implant used, stem length and cementation which limits objective comparison of loosening rates.

Strengths of our study include the length of follow-up and the inclusion of all but one patient in the survival analysis (due to loss to follow-up). Clinical, radiological, and survival outcomes were considered. There are some limitations. The design was retrospective, and preoperative objective outcome data were not available for comparison. Three different primary prostheses were revised: Swanson's, Biaxial, and Universal II. This variability may be a source of bias, particularly as the mechanical function of the Swanson's implant

is very different to articulating designs of nonfirst-generation arthroplasties. Nevertheless, we felt that these groups could be combined as revision following failure presents similar challenges for all types of implant. Two different implants were used for revision surgery, but a subgroup analysis of each revealed similar survival rates, so these groups were combined. In some cases, only the proximal or distal component was revised. We did not view this heterogeneity as a significant limitation, and it did not appear to be related to outcome. It is well established that one component, in particular, the distal one, may loosen in isolation and if the other is well fixed and correctly positioned, revision of both is not indicated. A further limitation is the missing data for clinical outcomes. All patients with rheumatoid arthritis were under the care of a rheumatologist, but the degree of disease control is unknown. While it is possible that uncontrolled disease may be a contributory factor to arthroplasty failure, this is outside the remit of our article. Finally, we did not include a comparison group. Therefore, the inferiority/superiority compared with other revision procedures such as fusion is unknown. Historical studies have reported the outcome of patients who underwent fusion with a Steinman pin or similar device following failed wrist arthroplasty.^{20–22} Fusion rates varied between 58 and 83%, but not all pseudarthroses were symptomatic. More concerning is the complication rate which totaled 17 in 9 patients in one study and included pin migration (6), pseudarthrosis (5), ilium fracture (3), wound infection (1), wound dehiscence (1), and groin pain (1).²⁰ We plan to investigate patient outcomes following total wrist fusion for a failed primary arthroplasty. It is possible that fusion with a plate may give equally good results as revision arthroplasty but this is currently unknown and outside the remit of this article.

In our practice, we base our decision to offer further surgery on clinical findings, particularly pain. The specific procedure (further replacement vs. fusion) depends on whether the bone stock is sufficient to support another implant. If there is a little loss, one can consider impaction bone grafting, but larger defects require fusion with structural bone grafting as there would be insufficient support for a revision arthroplasty. The Biaxial implant is no longer available, but we continue to use the Universal II as well as the updated model, the Integra Freedom wrist replacement.

In conclusion, we report 83% implant survival for revision wrist replacements at 5 years. All patients in whom radiographs were available had some evidence of loosening at a mean follow-up of 10.7 years. Results were similar for the Universal II and Biaxial implant. The results are concerning for the reasons set out. It is not clear at this time however as to whether they are better or worse for total wrist fusion following wrist arthroplasty.

Conflict of Interest
None.

References

- Palmer AK, Werner FW, Murphy D, Glisson R. Functional wrist motion: a biomechanical study. *J Hand Surg Am* 1985;10(01):39–46
- Yeoh D, Turrett L. Total wrist arthroplasty: a systematic review of the evidence from the last 5 years. *J Hand Surg Eur Vol* 2015;40(05):458–468
- Ryu JY, Cooney WP III, Askew LJ, An KN, Chao EY. Functional ranges of motion of the wrist joint. *J Hand Surg Am* 1991;16(03):409–419
- Nydic JA, Greenberg SM, Stone JD, Williams B, Polikandriotis JA, Hess AV. Clinical outcomes of total wrist arthroplasty. *J Hand Surg Am* 2012;37(08):1580–1584
- Nydic JA, Watt JF, Garcia MJ, Williams BD, Hess AV. Clinical outcomes of arthrodesis and arthroplasty for the treatment of posttraumatic wrist arthritis. *J Hand Surg Am* 2013;38(05):899–903
- Ferreres A, Lluch A, Del Valle M. Universal total wrist arthroplasty: midterm follow-up study. *J Hand Surg Am* 2011;36(06):967–973
- Badge R, Kailash K, Dickson DR, et al. Medium-term outcomes of the Universal-2 total wrist arthroplasty in patients with rheumatoid arthritis. *Bone Joint J* 2016;98-B(12):1642–1647
- Takwale VJ, Nuttall D, Trail IA, Stanley JK. Biaxial total wrist replacement in patients with rheumatoid arthritis. Clinical review, survivorship and radiological analysis. *J Bone Joint Surg Br* 2002;84(05):692–699
- Cobb TK, Beckenbaugh RD. Biaxial long-stemmed multipronged distal components for revision/bone deficit total-wrist arthroplasty. *J Hand Surg Am* 1996;21(05):764–770
- Rettig ME, Beckenbaugh RD. Revision total wrist arthroplasty. *J Hand Surg Am* 1993;18(05):798–804
- Talwalkar SC, Hayton MJ, Trail IA, Stanley JK. Management of the failed biaxial wrist replacement. *J Hand Surg [Br]* 2005;30(03):248–251
- Vogelin E, Nagy L. Fate of failed Meuli total wrist arthroplasty. *J Hand Surg [Br]* 2003;28(01):61–68
- Beaton DE, Wright JG, Katz JN; Upper Extremity Collaborative Group. Development of the QuickDASH: comparison of three item-reduction approaches. *J Bone Joint Surg Am* 2005;87(05):1038–1046
- Dias JJ, Bhowal B, Wildin CJ, Thompson JR. Assessing the outcome of disorders of the hand. Is the patient evaluation measure reliable, valid, responsive and without bias? *J Bone Joint Surg Br* 2001;83(02):235–240
- MacDermid JC, Turgeon T, Richards RS, Beadle M, Roth JH. Patient rating of wrist pain and disability: a reliable and valid measurement tool. *J Orthop Trauma* 1998;12(08):577–586
- Bellemère P, Maes-Clavier C, Loubersac T, Gaisne E, Kerjean Y, Collon S. Pyrocarbon interposition wrist arthroplasty in the treatment of failed wrist procedures. *J Wrist Surg* 2012;1(01):31–38
- Lorei MP, Figgie MP, Ranawat CS, Inglis AE. Failed total wrist arthroplasty. Analysis of failures and results of operative management. *Clin Orthop Relat Res* 1997;(342):84–93
- Khan Y, Konan S, Sorene E. Revision of a failed Swanson arthroplasty to a total wrist replacement restores wrist function and movements. *J Plast Surg Hand Surg* 2014;48(02):136–138
- Khan Y, Sorene E. Salvage Universal 2 total wrist replacement for a failed Swanson prosthesis. *Inj Extra* 2010;41:74–75
- Beer TA, Turner RH. Wrist arthrodesis for failed wrist implant arthroplasty. *J Hand Surg Am* 1997;22(04):685–693
- Ferlic DC, Jolly SN, Clayton ML. Salvage for failed implant arthroplasty of the wrist. *J Hand Surg Am* 1992;17(05):917–923
- Carlson JR, Simmons BP. Wrist arthrodesis after failed wrist implant arthroplasty. *J Hand Surg Am* 1998;23(05):893–898