Clin Orthop Relat Res (2017) 475:3082–3087
DOI 10.1007/s11999-017-5445-z

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

CLINICAL RESEARCH

High Survivorship and Few Complications With Cementless Total Wrist Arthroplasty at a Mean Followup of 9 Years

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Received: 11 April 2017 / Accepted: 7 July 2017 / Published online: 18 July 2017

Abstract

Background Total wrist arthroplasty (TWA) has been described as traditionally being performed with fixation in the radius and carpus with cement. The TWA implant used in our series has been associated with promising results in studies with up to 6 years followup; however, studies evaluating survivorship, pain, and function with this implant are limited.

Question/Purpose (1) To report ROM and pain scores after wrist reconstruction with cementless fourth-generation TWA at a mean followup of 9 years (range, 4.8–14.7 years). (2) To report complications of a cementless fourth-generation TWA and the cumulative probability of not undergoing a revision at a mean followup of 9 years.

Methods This is a retrospective case series of 69 patients who were treated for pancarpal wrist arthritis between 2002 and 2014. Of those, 31 had inflammatory arthritis (rheumatoid arthritis [n = 29], juvenile rheumatoid arthritis [n = 1], and psoriatic arthritis [n = 1]); all of these patients received TWA with the cementless implant studied in this investigation. Another 38 patients had osteoarthritis or posttraumatic arthritis; in this subgroup, 28 patients were 65 years or younger, and all underwent wrist fusion (none were offered TWA). Ten patients with osteoarthritis were older than 65 years and all were offered TWA; of those, eight underwent TWA, and two declined the procedure and instead preferred and underwent total wrist arthrodesis. The mean age of the 39 patients who had TWA was 56 ± 8.9 years (range, 31–78 years) at the time of surgery; 36 were women and three were men. The patients who underwent TWA were seen at a minimum of 4 years (mean, 9 years; range, 4–15 years), and all had been examined in 2016 as part of this study except for one patient who died 9 years after surgery. The dominant wrist was involved in 60% (25) of the patients. All patients were immobilized for 4 weeks postoperatively and then underwent hand therapy for 4 to 6 weeks. Pain and ROM were gathered before surgery as part of clinical care, and were measured again at latest

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Lifespan IRB approved the human protocol for this investigation, and each author certifies that all investigations were conducted in conformity with ethical principles of research.

This work was performed at the Department of Orthopaedics, Warren Alpert Medical School of Brown University, Rhode Island Hospital, Providence, RI, USA.

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followup; at latest followup, radiographs were analyzed (by the senior author) for evidence of loosening, defined as any implant migration compared with any previous radiograph with evidence of periimplant osteolysis and bone resorption. Subjective pain score was assessed by a verbal pain scale (0–10) and ROM was measured with a goniometer. Complications were determined by chart review and final examination. Kaplan Meier survival analysis was performed to estimate the cumulative probability of not undergoing a revision.

Results The mean preoperative active ROM was 34° ± 18° flexion and 36° ± 18° extension. Postoperatively, the mean active ROM was 37° ± 14° flexion and 29° ± 13° extension. The mean difference between the preoperative pain score (8.6 ± 1.2) and postoperative pain score (0.4 ± 0.8) was 8.1 ± 1.9 ($p < 0.001$). Implant loosening occurred in three (7.7%) patients. No other complications occurred in this series. Kaplan-Meier survivorship analysis estimated the cumulative probability of remaining free from revision as 78% (95% CI, 62%–91%) at 15 years.

Conclusion Cementless fourth-generation TWA improves pain while generally preserving the preoperative arc of motion. The cumulative probability of remaining free from revision at 14.7 years after the index procedure is 77.7% (95% CI, 62.0%–91.4%). Future studies should compare alternative approaches for patients with endstage wrist arthritis; such evaluations—which might compare TWA implants, or TWAs with arthrodesis—will almost certainly need to be multicenter, as the problem is relatively uncommon.

Level of Evidence Level IV, therapeutic study.

Introduction

Despite the relatively dependable results of total wrist arthrodesis, the functional advantage of preserving motion with total wrist arthroplasty (TWA) has motivated efforts to refine implant design and investigate outcomes of TWA in the treatment of wrist arthritis [4, 5, 15, 24]. Unlike total wrist arthrodesis, which has been shown to make it difficult to complete certain activities of daily living, TWA allows for preservation of some wrist motion [15, 23]. A prior systematic review showed that complication rates of total wrist arthrodesis averaged 17% [7]. In a retrospective study of 22 patients who had been treated with wrist arthrodesis, 20 (91%) said they would have another procedure performed if it meant that they could move their wrist again, with patients reporting substantial dysfunction after arthrodesis [2]. A cost-utility study showed that TWA was as effective as arthrodesis with only a small incremental cost [8]. Despite there not being a prospective randomized controlled trial comparing TWA with total wrist arthrodesis, many patients prefer TWA over wrist arthrodesis [11, 18].

Total wrist implant designs and their insertion techniques have evolved during the past 30 years. As reported by Weiss et al. [24], the one-piece silicone elastomer implant design first popularized by Swanson in the 1970s, has evolved into third-generation implants consisting of separate radial and carpal base components with an interposed polyethylene component [7, 13, 14, 17, 22, 24, 25]. The fourth-generation TWA used in our series is part of a small group of implant designs redesigned to enhance articulation between the radial and polyethylene components while incorporating the carpal screw fixation and porous coated radial component elements of the third-generation designs, with promising results in two prior reports with mid-term followup [10, 25].

The aims of the current study were to: (1) report ROM and pain scores after wrist reconstruction with a cementless fourth-generation TWA at a mean followup of 9 years (range, 5–15 years); (2) report complications of the cementless fourth-generation TWA and the cumulative probability of not undergoing a revision at a mean followup of 9 years.

Patients and Methods

Between 2002 and 2014, one surgeon (APCW) treated 69 patients surgically for pancarpal wrist arthritis that inhibited them from completing activities of daily living owing to substantial pain (Fig. 1). Of those, 31 had inflammatory arthritis and 38 had degenerative or posttraumatic arthritis. All 31 patients with inflammatory arthritis were offered and received a TWA; there was no minimum age for a TWA in this subgroup. Among the group with degenerative or posttraumatic arthritis, 28 patients were 65 years or younger, and all underwent wrist fusion; this group of patients was not offered a TWA. Ten patients in the degenerative or posttraumatic arthritis group were older than 65 years; of those, eight underwent TWA and two declined TWA and underwent total wrist arthrodesis. The treatment rationale was to use TWA in only older and theoretically less-active patients with osteoarthritis or posttraumatic arthritis (with the arbitrary cutoff age set at 65 years) since TWA traditionally had not been used in this subgroup, therefore data regarding survival were sparse [6].

All patients who underwent TWA had adequate bone stock to accommodate a TWA. In all of these patients, an uncemented, press fit impaction technique was used. Although the use of TWA in the USA is approved for use with cement only, some surgeons (including our group) prefer to implant the prosthesis without cement because of

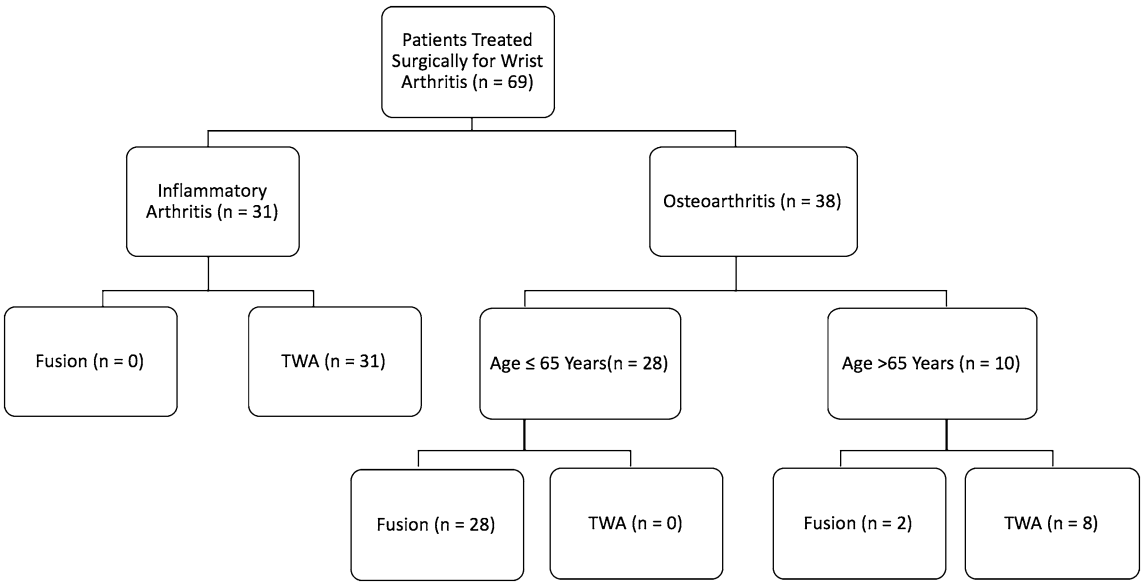

Fig. 1 Between 2002 and 2014, 69 patients were surgically treated for wrist arthritis that inhibited them from completing activities of daily living. All 69 patients were last examined in 2016 except for one patient who died 9.1 years after surgery. This patient was seen for the 9-year followup. TWA = total wrist arthroplasty.

the advantage of stability achieved through osseous integration, maintenance of bone stock, and theoretical longevity [1, 16]. The 39 patients who underwent TWA were seen at a minimum of 4 years (mean, 9 years; range, 5–15 years), and all patients were seen in 2016 as part of this study except for one patient who died 9 years after surgery and 2 months after a routine followup. After obtaining approval from our institutional review board, the charts of all patients who underwent TWA with an uncemented TWA implant were retrospectively evaluated.

Pain and ROM were gathered before surgery as part of clinical care, and were measured again at latest followup for this study by the senior author (A-PCW). Subjective pain was assessed by a verbal pain scale (0–10) and ROM was measured with a goniometer by the senior author (A-PCW). Complications were determined by chart review and final followup. Kaplan Meier survival analysis was performed with SPSS Version 24.0 (IBM Corporation, Armonk, NY, USA) to estimate the cumulative probability of not undergoing a revision. Age, hand dominance, ROM, and indication for TWA were recorded. Radiographs were analyzed by the senior author (A-PCW); radiographic loosening was defined as any implant migration compared with any previous radiograph with evidence of periimplant osteolysis and bone resorption.

The TWA implant used in this series was a Universal2™ (Integra LifeSciences Corporation, Plainsboro, NJ, USA), which is a fourth-generation design with an ellipsoid articulation [21]. The redesign of its predecessor to the ellipsoid design was based on a finite element model analysis which indicated greater contact area, lower peak contact pressures, and greater stability [13]. The implant has a central carpal stem and areas for two-screw fixation to the carpus and a radial component that is porous coated to promote osseous integration.

Surgical Technique

A surgical technique similar to that originally described by Menon [19] was used for all 39 patients. Thirty-six patients had a Darrach procedure [12] completed first, and then the radius was broached and a trial radial implant was placed before the carpus was addressed. After excising the lunate, a drill hole was made through the capitate, using the third metacarpal as a guide, and the carpal cutting jig was placed. After carpal cuts were made, a trial carpal component and polyethylene were placed. The wrist then was tested for stability during passive flexion and extension with polyethylene carpal inserts of differing sizes until appropriate stability was achieved. Because of the importance of attaining carpal fusion to aid carpal component fixation, additional bone graft from the excised carpal bones was placed in the cartilage denuded intercarpal joints (specifically the remaining distal scaphoid-capitate, hamate-capitate and hamate-distal triquetral joints) before final placement of the carpal component. Carpal and radial components were placed in a press fit fashion without cement use. All patients wore a short arm splint for 1 week, followed by a short arm cast for 3 weeks, and then

underwent 4 to 6 weeks of hand therapy. Patients were allowed full use at 6 weeks, however they were instructed to avoid lifting greater than 10 pounds with the implanted extremity, on a long-term basis.

Results

Active flexion and extension mean was 37° flexion (SD, ± 14°) and 29° extension (SD, ± 13°). The mean difference between the preoperative pain score (8.6 ± 1.2) and postoperative pain score (0.4 ± 0.8) was 8.1 ± 1.9 ($p < 0.001$). Complications included osteolysis with implant loosening in three (7.7%) patients, with two undergoing surgical revision with an uncemented carpal component and one with revision of the carpal and radial components (Fig. 1). There were no other complications (such as infection, fractures, or excessive stiffness) in this series. Kaplan-Meier survivorship analysis estimated that the cumulative probability of remaining free from revision was 78% (95% CI, 62%–91%) at 15 years (Fig. 2).

Discussion

Total wrist implant designs and surgical techniques have evolved during the past 30 years [15, 26]. Previous studies have shown the outcomes and survivorship of the cementless fourth-generation TWA used in the current series up to a mean of 6 years of followup [3, 9, 20]. Results of these studies appeared similar to ours regarding motion (Table 1). Our study, with a mean 9-year followup of a cementless fourth-generation implant, found that TWA improves pain while generally preserving the preoperative arc of motion. The cumulative probability of remaining free from revision at 14.8 years followup is 77.7% (95% CI, 62.0%–91.4%).

This study has numerous limitations. First, the generalizability of the results is limited owing to it being a single-surgeon series performed in an academic medical center; we have described the indications and the patient population, but caution the reader that other settings using other indications may achieve different results. As a retrospective case series, the study is susceptible to selection bias, particularly with the younger subset (younger than 65 years) of patients who all underwent primary total wrist arthrodesis. In contrast, all patients with inflammatory arthritis underwent a TWA. Therefore, when interpreting the results, it is critical to recognize that they are most relevant to patients with inflammatory arthritis or in patients with degenerative or posttraumatic osteoarthritis who are older than 65 years. Our study is limited given that we did not use any validated patient-reported outcome instruments. Moreover, the outcomes were assessed by the surgeon (APCW) who was directly involved in the care; assessment bias (the lack of validated patient-reported outcomes measurements) and assessor bias (an individual assessing patients whose care he or she was involved in) have a tendency to inflate apparent benefits of treatment in clinical research. Another limitation is that while some of the patients included in the series had more than 10 years followup, others had as little as 4 years; longer surveillance will be important for patients in this group as in any reconstructive series, as loosening may yet occur in some of these patients.

Our cumulative probability of remaining free from revision at 15 years is 78% (95% CI, 62%–91%), and we

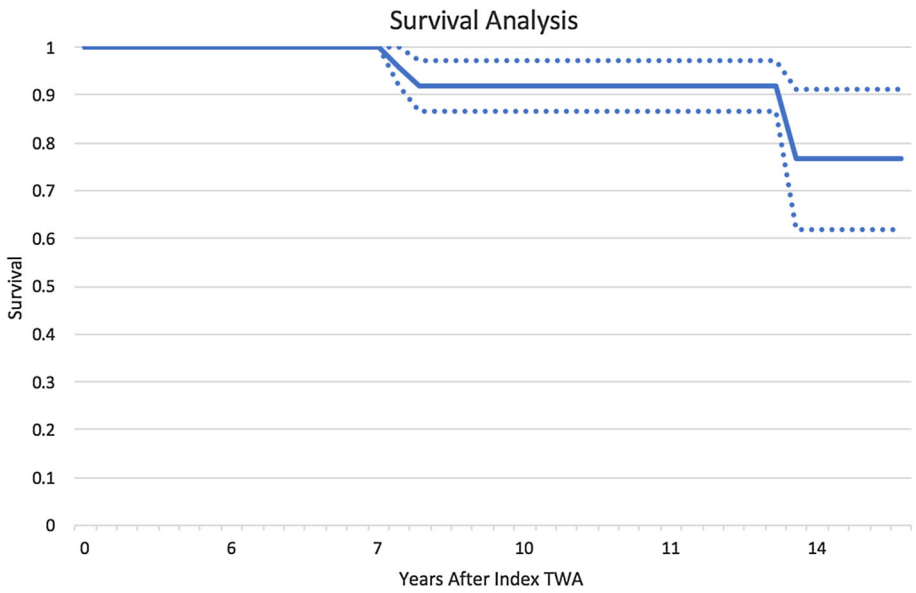

Fig. 2 The Kaplan Meier survival estimate for the 39 patients included in the examined cohort is shown. TWA = total wrist arthroplasty.

Table 1. Reported outcomes and survivorship using the cementless fourth-generation TWA implant used in the current study

Study	Methods	Indications	Mean followup	Mean flexion-extension arc	Pain (VAS)	Kaplan-Meier survivorship (removal of components as endpoint)
Cooney et al. [9]	Retrospective review of 46 TWAs (either third- or fourth-generation TWA system)	36 for rheumatoid arthritis, 10 for posttraumatic arthritis	6 years	68°	Preoperative, 7 Postoperative, 2.3	Not performed
Morapudi et al. [20]	Retrospective review of 21 TWAs (same implant used in our series)	19 for rheumatoid arthritis, 2 for posttraumatic arthritis	3.1 years	53°	VAS not collected	Not performed
Badge et al. [3]	Retrospective review of 95 TWAs (same implant used in our series)	95 for rheumatoid arthritis	4.4 years	50°	Preoperative, 8.1 Postoperative, 5.4	91% at 7.8 years
Ferreres et al. [10]	Retrospective review of 21 TWAs (same implant used in our series)	14 for rheumatoid arthritis, 2 for Kienbocks, 1 for posttraumatic arthritis, 1 for chondrocalcinosis	5.5 years	68°	VAS not collected	Not performed

observed few complications. Yeoh and Tourret [27] performed a systematic review to examine the outcomes of TWAs performed from 2009 to 2014. Implant survival for TWA in their study, using the same system used in our series, was 100% at 3 to 5 years followup. Two series that used the implant we evaluated [10, 20] seemed to have a higher proportion of patients reporting complications than we observed (nine of 21 and three of 21, respectively). The complications they reported included pain, stiffness (arc of ROM $< 15°$), infections, and one dislocation. The only complication we observed was loosening, which occurred in 7.7% (n = 3) of patients. Our results seemed comparable to those of Badge et al. [3] who documented survivorship free from revision at intermediate term; they reported that the probability of survival at 7.8 years was 91% (95% CI, 84%–91%). The confidence intervals they reported overlapped broadly with those in our study, which tends to validate our finding on survivorship. Badge et al. [3] retrospectively examined the clinical and radiologic outcomes of 95 TWAs performed with the same system we used. Their mean followup was 4.4 years (range, 2–10 years), and their reported probability of survival at 7.8 years was 91% (95% CI, 84%–91%). Reported adverse effects of their patients included persistent pain (n = 9), joint stiffness (arc $< 15^{o}$, n = 9), wound infection (n = 2), and dislocation (n = 1). In contrast to the studies by Badge et al. [3] and Yeoh and Tourret [27], our only complication was loosening, which occurred in 7.7% (n = 3) of patients.

A cementless TWA improves pain while generally preserving the preoperative arc of motion. The cumulative probability of remaining free from revision at 15 years is 78% (95% CI, 62%–91%). The results of our study, and those of previous investigations that assessed the same system we used [3, 10], suggest that the fourth-generation implant may be more durable, and the TWA has shifted from a surgical option that is controversial to one that is more predictable and reliable for patients with rheumatoid arthritis and posttraumatic osteoarthritis. Our experience and data from the current study have caused us to broaden our current indications in patients with osteoarthritis and posttraumatic arthritis who are younger than 65 years. Future studies are needed to see whether this results in measurable improvements in patient-reported outcomes. In addition, future studies should compare alternative approaches for patients with endstage wrist arthritis; such evaluations—which might compare TWA implants, or TWAs with arthrodesis—will need to be multicenter, as the problem is relatively uncommon.

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