Increasing Use of Total Wrist Arthroplasty—An Australian National Joint Registry Report

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Abstract

Background and Purpose There is limited literature reporting the long-term results and outcomes of total wrist arthroplasty (TWA). The aim of this study was to describe the incidence, usage, and survival of wrist arthroplasty using data from the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR).

Methods Data included all primary TWA procedures from 2006 to 2021. The primary outcome assessed was revision surgery. Utilization of TWA, etiology leading to TWA, patient demographics, and surgical factors were also assessed.

Results There were 439 primary TWA procedures performed across the 16-year reporting period. Four prostheses (Motec, Universal 2, Freedom, and ReMotion) have been used, with a recent increased usage toward the Motec, which accounted for 97.4% of prostheses implanted in 2021. There has also been an increase in the number of surgeons performing TWA over time. The most common underlying etiology was osteoarthritis (72.7%), followed by rheumatoid arthritis (15.9%). Implantation for inflammatory arthropathy remained relatively constant across time; however, TWA has been utilized with increasing frequency for the treatment of osteoarthritis and other indications more recently. The cumulative percent revision at 10 years was 18.3%. Loosening accounted for 25.6% of all revisions, followed by osteolysis (12.8%), pain

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(12.8%), and instability (7.7%). Attempted conversion to an arthrodesis occurred in 10.3% of all revisions.

Conclusion There has been an increase in both the volume of TWA performed and the number of surgeons undertaking this procedure in Australia over the past 16 years. The Motec system has become the prosthesis of choice. Medium-term revision rates are inferior when compared with Australian data for hip, knee, and shoulder arthroplasty.

Wrist replacement is thought to have been first performed in the late nineteenth century, utilizing ivory for articulating surfaces.[1] However, greater acceptance and innovation has only occurred in the last half century. Initial designs incorporated greater levels of constraint, with resultant abnormal stresses and high levels of failure and complications.[2] As a result, wrist arthroplasty was reserved for older, low demand patients.[3,4] More recent generations of implants have concentrated on uncemented designs with minimal constraint, with provision of alternate articulating surfaces aimed at diminishing wear and allowing greater motion.[5–7] This philosophy (and options to facilitate conversion to arthrodesis as a salvage procedure in certain designs) has resulted in an expansion of patient eligibility criteria. However, there is limited medium- to long-term data on the utilization and survivorship of these prostheses in the literature.

Although there are six national registries worldwide that record on the utilization of wrist arthroplasty, there is a paucity of literature describing the characteristics, trends, and outcomes of this procedure.[8] Indeed, to the best of our knowledge there is a single study reporting on the outcomes of total wrist arthroplasty (TWA), with Krukhaug et al extracting data from the Norwegian Arthroplasty Register.[9] Thus, the aim of this study was to utilize the Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR) to analyze the incidence, trends, and survivorship of TWA in Australia.

Methods

This study included all primary TWA procedures reported to the AOANJRR between January 1, 2006 and December 31, 2021. The AOANJRR commenced national data collection for TWA in 2006 and by 2021, 87% of wrist arthroplasty procedures had been reported to the registry (AOANJRR).[10] These data are externally validated against patient-level data provided by all Australian state and territory health departments. A sequential, multilevel matching process is used to identify any missing data which are subsequently obtained by follow-up with the relevant hospital. Each month, in addition to internal validation and data quality checks, all primary procedures are linked to any subsequent revision involving the same patient, joint, and side. Data are also matched biannually to the Australian National Death Index data to identify patients who have died. Emigration of patients is outside the scope of the registry but considered to have a minimal effect on revision rates.

Four different prostheses were implanted during the study period. The Universal 2 prosthesis (Integra, Plainsboro, NJ) incorporates an unconstrained design with porous coated cobalt-chrome radial and titanium carpal components, and an ultra-high-molecular-weight polyethylene (UHMWPE) interface. The Freedom (Integra) is a modification of the Universal 2, and similarly comprises a titanium carpal plate upon which a convex UHMWPE bearing is inserted to articulate with a concave radial component—however, cement is utilized to fix both the carpal and radial prostheses. The nonconstrained ReMotion TWA (Stryker, Kalamazoo, MI) consists of porous coated titanium radial and carpal components (which can be inserted in cemented or press-fit fashion), and a UHMWPE intercalated carpal ball which rotates 10 degrees relative to the carpal plate. The Motec (Swemac Orthopaedics, Linkoping, Sweden) is a modular, uncemented ball-and-socket arthroplasty with conical screw-shaped components which insert into the radius proximally and the capitate and third metacarpal distally. Alternate bearing surfaces are available (metal-on-metal or poly-ether-ether-ketone). This design can be converted to arthrodesis in the setting of failure.

The primary outcome assessed was revision surgery, which is an unambiguous measure of the need for further intervention.[10] Trends in incidence of TWA, etiology leading to TWA, patient demographics, and surgical factors were also assessed.

Kaplan–Meier survival analysis was used to report time to revision, with censoring at the time of death and closure of the data set in December 2021. The cumulative percent revision (CPR), with 95% confidence intervals (CIs), was calculated using unadjusted pointwise Greenwood estimates. Statistical analysis was performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC).

Ethics

The AOANJRR is approved by the Commonwealth of Australia as a Federal Quality Assurance Activity (F2022L00986) Part VC of the Health Insurance Act 1973 (HIA) and Part 10 of the Health Insurance Regulations 2018. All AOANJRR studies are conducted in accordance with ethical principles of research (the Helsinki Declaration II).

Results

Demographics

There were 439 primary TWA procedures reported during the 16-year period (2006–2021) of which 39 procedures

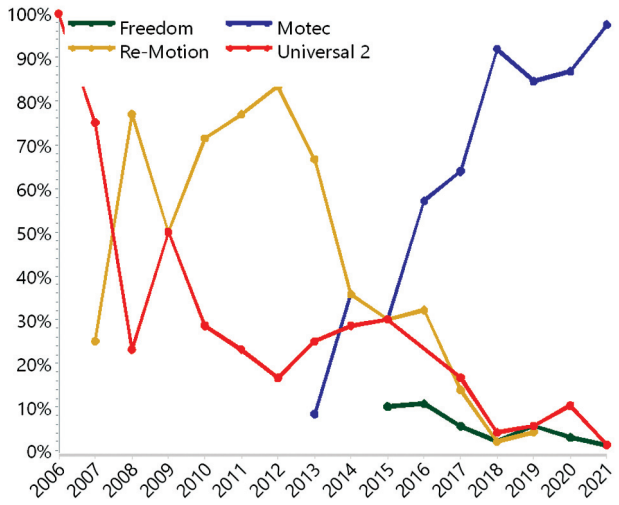

Fig. 1 Procedure year of primary total wrist replacement by carpal component.

were revised (►**Table 1**). Patients undergoing primary TWA had a mean age of 63.9 years (±12 years) and there 227 male and 212 female patients. The American Society of Anesthesiology (ASA) score was available for 364 patients, with the majority (90.6%) recording an ASA score of 2 or 3. Body mass index (BMI) data were available for 319 patients, with 43.9% of these recording a BMI of ≥ 30 kg/m^2. The maximum follow-up was 14.4 years and the mean follow-up was 3.9 years (±3.5 years).

Prostheses

The first Motec prosthesis worldwide was implanted in 2006, with 2013 marking the first utilization in Australia. In 2013, the Motec prosthesis accounted for 8.3% of all TWA performed that year, while in 2021, there were 76 Motec prostheses implanted, comprising 97.4% of all prostheses implanted (►**Fig. 1**). As usage of the Motec prosthesis has increased, there has been a decrease in the use of alternative prostheses.

Etiology and Surgical

A total of 69 different surgeons performed TWA during the period of interest. There was an increase in the number of surgeons performing TWA per year throughout the study period, peaking with 31 surgeons in 2019 and 2020 (►**Table 2**). The most common etiological diagnosis was osteoarthritis (319 patients; 72.7%), followed by rheumatoid arthritis (70 patients; 15.9%) (►**Table 3**). Although fracture-dislocation only accounted for 3.2% of cases (14 patients), 71% were performed since 2016. Osteonecrosis and instability accounted for 2.5% each.

Revision of Primary Wrist Arthroplasty

Of the 439 primary TWA procedures, 39 procedures required revision. The CPR for any reason at 1 year was 2.6% (95% CI 1.4, 4.8), 5 years was 11.3% (95% CI 8.0, 16.0), and 10 years was 18.3% (95% CI 12.6, 26.1) (►**Table 4**, ►**Fig. 2**).

Table 1 Summary of primary wrist replacement (all diagnoses)

Variable	Primary total wrist ($n = 439$)
Follow-up years	
Mean ± SD	3.9 ± 3.5
Median (IQR)	2.6 (1.2, 5.5)
Minimum	0
Maximum	14.4
Age	
Mean ± SD	63.9 ± 12
Median (IQR)	65 (56, 73)
Gender	
Male	227 (51.7%)
Female	212 (48.3%)
ASA score[a]	
1	24 (6.6%)
2	185 (50.8%)
3	145 (39.8%)
4	10 (2.7%)
BMI[b]	
Underweight (< 18.50)	4 (1.3%)
Normal (18.50–24.99)	60 (18.8%)
Pre-obese (25.00–29.99)	115 (36.1%)
Obese class 1 (30.00–34.99)	92 (28.8%)
Obese class 2 (35.00–39.99)	34 (10.7%)
Obese class 3 (≥ 40.00)	14 (4.4%)
Total	439

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (kg/m^2); IQR, interquartile range; SD, standard deviation.
[a]Excludes 74 procedures with unknown ASA score.
[b]Excludes 120 procedures with unknown BMI category.

Loosening accounted for 25.6% of all revisions, followed by osteolysis (12.8%), pain (12.8%), and instability (7.7%) (►**Table 5** and ►**Fig. 3**). The most common revision procedure was revision of the carpel component and carpal head or radial cup (17.9%), followed by minor components, reoperation future, and ulna component (10.3%). Attempted conversion to an arthrodesis comprised 10.3% of all revisions.

Discussion

There is an increase in utilization of TWA due to a greater acceptance, increased innovation, and widening of eligibility criteria. However, reports of medium- and long-term outcomes remain limited.[9] This study finds an increase in both the volume of TWA being performed, and the number of surgeons performing these procedures, through the 16-year period of interest. Of particular note is the sharp increase in utilization over the last 5 years with 68.7% of all TWA being

Table 2 Revised number of number of revisions of primary total wrist replacement by wrist class and procedure year (all diagnoses)

Procedure year	*N* (revised)	*N* (total)	Number of known surgeons
2006	0	1	1
2007	0	4	
2008	4	13	8
2009	2	12	6
2010	0	14	8
2011	0	13	7
2012	1	6	3
2013	3	12	6
2014	2	14	8
2015	2	20	12
2016	4	28	12
2017	5	36	18
2018	8	49	22
2019	4	71	31
2020	3	68	31
2021	1	78	25
Total	39	439	69

performed in that time. The Motec system has become the prosthesis of choice since its introduction. Despite advances, overall revision rates remain higher than other large joint arthroplasty, with a CPR of 11.3% at 5 years and 18.3% at 10 years. This compares poorly to that of reverse shoulder arthroplasty (6.2% for all diagnoses), hip arthroplasty (4.4% for osteoarthritis), and knee arthroplasty (4.8% for osteoarthritis) at 10 years.[11]

The increase in TWA volume noted in this study is in contrast to prior literature. Krukhaug et al reported an unchanged utilization of wrist arthroplasty in a Norwegian registry report of 189 patients assessing the period between 1994 and 2009.[9] Elbuluk et al described a drop in TWA implantation in the United States between 2001 and 2013, with a peak of 128 procedures in 2007 declining to 65 procedures in 2013.[12] It is worth noting that the Motec implant is not currently available in the United States.

The most frequent etiological diagnosis in the current study was osteoarthritis, with a small but constant proportion of patients undergoing TWA for inflammatory arthropathy. Krukhaug et al demonstrated a significant decline in the rate of patients requiring TWA due to inflammatory arthritis, with a coincidental increase in noninflammatory arthritis.[9] This may be reflective of the differences in periods studied—Krukhaug et al reviewed a 15-year span between 1994 and 2009, which corresponded to advances in the medical management of rheumatoid arthritis which may have resulted in decreased disease burden.[9,13] Smaller proportions of the cohort in the current study underwent TWA for instability, osteonecrosis, and fracture or dislocation, with the majority of these indications being recorded post-2016. This may be reflective of an expansion of clinical indications for TWA due to greater experience and comfort with prostheses, or of improved reporting practices and familiarity with registry data forms. A potential gap remains as implantation by nonorthopaedic hand surgeons is not captured.

Four different TWA prostheses were utilized in Australia during the reporting period. The Motec wrist arthroplasty system was first implanted in Australia in 2013, but has shown rapid uptake since, accounting for 97.4% of all implants in the final year of reporting. Potential reasons for this widespread acceptance include ease of implantation, an alternative design resulting in superior postoperative range of motion, and the ability to convert to an arthrodesis in the event of failure. Prior studies suggest that greater than two-thirds of patients with a Motec TWA can expect an arc of wrist motion of approximately 120 degrees, which compares favorably with previous designs.[14,15] Long-term survivorship of the Motec prosthesis in nonrheumatoid patients (including those who returned to manual labor postimplantation) has been reported at 86% at 10 years, similar to the current cohort's CPR of 16.7% at 9 years.[14] Other prostheses share relatively similar survivorship, with studies reporting between 90 and 94% survivorship at approximately 10 years postimplantation.[16,17] The survivorship of the Universal 2 has been reported at 91% at 7.8 years, although this figure was achieved in a cohort of lower demand patients suffering from rheumatoid arthritis.[18]

The most frequent reason for revision in the current study was loosening, accounting for a quarter of all revision procedures. This figure is lower than the 50% of revisions attributed to loosening reported by Reigstad et al (4 of 8

Table 3 Procedure year of primary total wrist replacement by primary diagnosis (all diagnoses)

	Fracture/ Dislocation		Instability		Osteoarthritis		Osteonecrosis		Rheumatoid arthritis		Other		Other inflammatory arthritis		Total	
Procedure year	*N*	Col%	*N*	Col%	*N*	Col%	*N*	Col%	*N*	Col%	*N*	Col%	*N*	Col%	*N*	Col%
2006	.	.	.	.	1	0.3	.	.	.	.	.	.	.	.	1	0.2
2007	.	.	.	.	2	0.6	.	.	2	2.9	.	.	.	.	4	0.9
2008	1	7.1	.	.	6	1.9	.	.	5	7.1	.	.	1	11.1	13	3.0
2009	2	14.3	.	.	4	1.3	.	.	5	7.1	.	.	1	11.1	12	2.7
2010	.	.	.	.	8	2.5	1	9.1	5	7.1	.	.	.	.	14	3.2
2011	.	.	.	.	8	2.5	.	.	4	5.7	.	.	1	11.1	13	3.0
2012	1	7.1	.	.	5	1.6	.	.	.	.	.	.	.	.	6	1.4
2013	.	.	.	.	6	1.9	.	.	6	8.6	.	.	.	.	12	2.7
2014	.	.	.	.	10	3.1	.	.	3	4.3	1	20.0	.	.	14	3.2
2015	.	.	.	.	11	3.4	.	.	8	11.4	1	20.0	.	.	20	4.6
2016	1	7.1	.	.	20	6.3	1	9.1	6	8.6	.	.	.	.	28	6.4
2017	1	7.1	.	.	27	8.5	1	9.1	6	8.6	.	.	1	11.1	36	8.2
2018	2	14.3	.	.	38	11.9	2	18.2	4	5.7	1	20.0	2	22.2	49	11.2
2019	2	14.3	2	18.2	62	19.4	1	9.1	4	5.7	.	.	.	.	71	16.2
2020	2	14.3	5	45.5	53	16.6	2	18.2	6	8.6	.	.	.	.	68	15.5
2021	2	14.3	4	36.4	58	18.2	3	27.3	6	8.6	2	40.0	3	33.3	78	17.8
Total	14	100.0	11	100.0	319	100.0	11	100.0	70	100.0	5	100.0	9	100.0	439	100.0

Table 4 Yearly cumulative percent revision of primary total wrist replacement (all diagnoses)

CPR	1 y	2 y	3 y		4 y
Primary total wrist	2.6 (1.4, 4.8)	5.7 (3.7, 8.7)	8.4 (5.8, 12.1)		10.0 (7.0, 14.1)
CPR	**6 y**	**7 y**	**8 y**	**9 y**	**10 y**
Primary total wrist	13.0 (9.1, 18.2)	14.0 (9.9, 19.8)	15.3 (10.7, 21.7)	16.7 (11.6, 23.6)	18.3 (12.6, 26.1)

Abbreviation: CPR, cumulative percent revision.

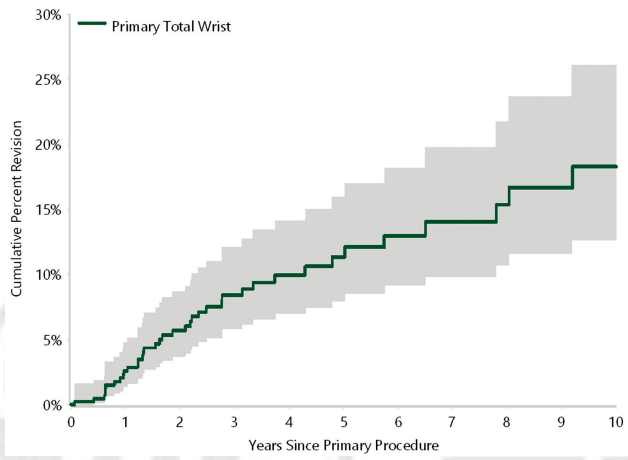

Fig. 2 Cumulative percent revision of primary total wrist replacement (all diagnoses).

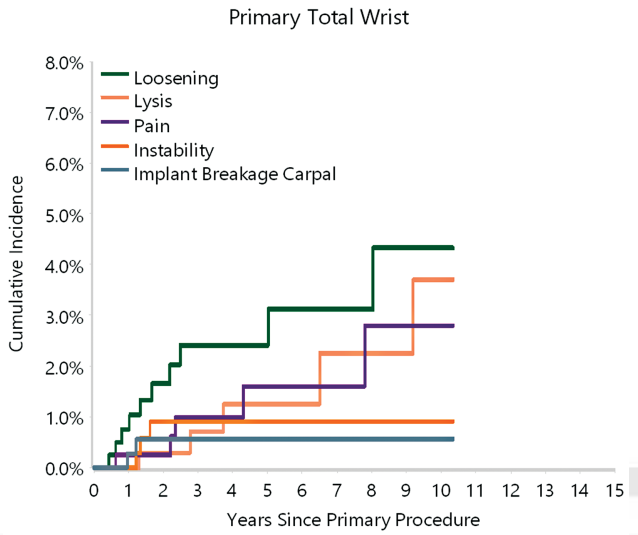

Fig. 3 Cumulative incidence revision diagnosis of primary wrist replacement by wrist class (all diagnoses).

revisions from a cohort of 56 patients).[14] The discrepancy may be related to variations in data input, with subcategories such as lysis or pain potentially occurring concurrent to, or as a result of loosening.

This study has several limitations. The AOANJRR does not allow for recording of functional or patient-reported outcomes for the wrist. Further, while ASA and BMI are now

Table 5 Revision diagnosis of primary wrist replacement

	Primary total wrist		
Revision diagnosis	**Number**	**% Primaries revised**	**% Revisions**
Loosening	10	2.3	25.6
Lysis	5	1.1	12.8
Pain	5	1.1	12.8
Instability	3	0.7	7.7
Implant breakage carpal	2	0.5	5.1
Incorrect sizing	2	0.5	5.1
Infection	2	0.5	5.1
Metal-related pathology	2	0.5	5.1
Progression of disease	2	0.5	5.1
Arthrofibrosis	1	0.2	2.6
Flexion deformity	1	0.2	2.6
Implant breakage wrist plate	1	0.2	2.6
Other	3	0.7	7.7
N, revision	39	8.9	100.0
N, primary	439		

recorded, patient factors that may influence prosthesis survivorship, including comorbidities, previous wrist surgery, and return to manual labor, are also not available for analysis. Nuanced analysis is not possible, as the registry does not incorporate subcategories (for example, identifying loosening to involve the proximal, distal, or both components). Registry data are inherently dependent on the quality of data input and may lead to selection or measurement bias.

However, this study reveals that there has been a steady increase in the volume of TWA being performed, and the number of surgeons undertaking the procedure, in Australia over the past 16 years. Of particular note is the sharp increase in utilization over the last 5 years. The Motec system has become the prosthesis of choice since its introduction. Revision rates, while higher than other large joint arthroplasty, are comparable to other reports.[14] Further in-depth analysis, assessing different rates of survivorship between prostheses, patient and technical factors contributing to failure, and functional and patient-reported outcome measures would be useful.

Conflict of Interest
None declared.

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