

# Wrist arthroplasty – a systematic review

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## ABSTRACT

**INTRODUCTION:** Severely painful or dysfunctional destroyed wrists can be reconstructed by fusion, interposition of soft-tissue or by arthroplasty using artificial materials. Total and partial wrist arthroplasty (T/PWA) has been used on a regular basis since the 1960's. The objective of this study was to review the literature on second, third and fourth generation implants.

**METHODS:** The review was conducted according to the PRISMA – guidelines. A search was made using a protocolled strategy and well-defined criteria in PubMed, in the Cochrane Library and by screening reference lists.

**RESULTS:** 37 publications describing a total of 18 implants were selected for analysis. 16 of the publications were useful for the evaluation of implant longevity. Despite methodological shortcomings in many of the source documents, a summary estimate was possible.

**CONCLUSION:** It seems that T/PWA has a good potential to improve function through pain reduction and preservation of mobility. The risk of severe complications – deep infection and instability problems – is small with the available implants. Implant survival of 90-100% at five years are reported in most series – if not all – using newer second generation and third generation implants, but declines from five to eight years. Periprosthetic osteolysis/radiolucency is frequently reported. Its causes and consequences are not clarified.

Painful, dysfunctionally destroyed wrists can be reconstructed by fusion, interposition of soft-tissue or arthroplasty using artificial materials. Total or partial wrist arthroplasty (T/PWA) was attempted in the beginning of the twentieth century and has been used on a more regular basis since the 1960s. Several generations of implants exist, the first being interposition of single-component silicone implants, a procedure that is hardly ever used today [1].

The second generation of implants was multi-component implants [2-6]. There is no consensus on the definition of second generation. Herein, we define it as an implant consisting of a radial component and a carpal component, fixated in one or more of the metacarpal bones. Some of these systems have been developed after the introduction of the third generation [7].

The third generation of implants is characterised by minimal bone resection to avoid fixation in the metacarpal bones, with the exception of an optional and re-

stricted fixation in the second metacarpal. These implants attempt to mimic the natural anatomy and biomechanics of the wrist and the implants are largely unconstrained [8-10]. Pyrocarbon was recently introduced as a single-component interposition arthroplasty [11] or hemiarthroplasty [12]. We define these as “fourth generation” implants.

The objective of this study was to review the literature concerning T/PWA using second, third and fourth generation implants. The questions to be answered were: What is the present knowledge on clinical results, complications and implant longevity. An effort was made to draw general conclusions rather than to describe the results obtained in individual series.

## METHODS

The review was conducted according to the PRISMA guidelines [13].

### Search strategy

We made a primary search through PubMed with the Mesh terms “Wrist Arthroplasty” and “Wrist Replacement”. We restricted the search to the 1994-2013-period, considering earlier material to have historical value only. We made a second search in the Cochrane Library and a continuous supplementary search by scanning the reference lists of the papers first included.

The inclusion criteria were: papers with primary clinical data on second, third and fourth generation implants. Excluded were: cadaveric studies; biomechanical studies; studies not accessible in journals, books or online; reviews without primary data. Double publications and articles with overlap of cases were relative exclusion criteria. Articles not written in English, Danish, Swedish, Norwegian, French, Dutch or German were evaluated on the basis of an English abstract, if available.

### Quality assessment and handling of data

We focused on the number of cases, the methodology and the observation period. Papers with less than ten cases were considered to be less useful and are therefore only mentioned very briefly. Implant longevity was primarily evaluated on the basis of papers with a cumulated implant survival of at least five years; secondarily, papers with a follow-up of a minimum of two years in each case. Function was evaluated by well-validated and relevant outcome measurement tools like the Disabil-

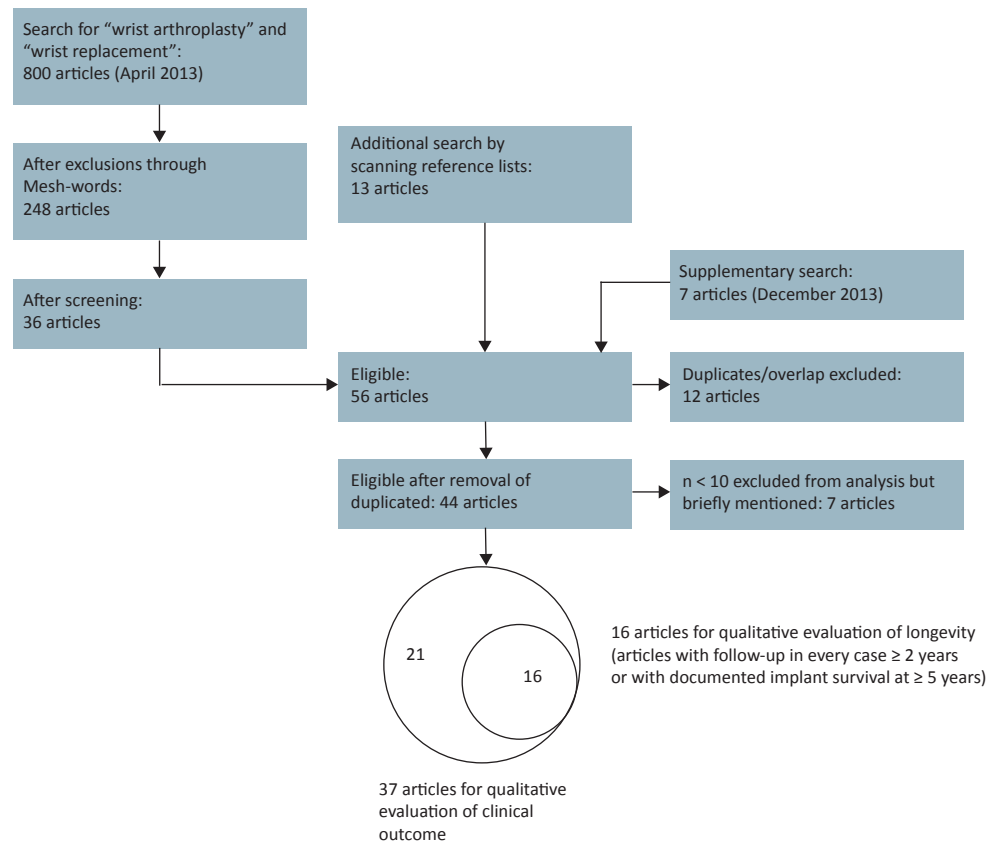
## SYSTEMATIC REVIEW

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 FIGURE 1

Flow diagram of search strategy.



ities of Arm, Shoulder and Hand (DASH/QuickDASH), the Patient-Rated Wrist Evaluation (PRWE) or the Michigan Hand Questionnaire (MHQ). Series with clinical data collected before operation and similarly at follow-up were defined as prospective, even if there had been no mention of a preoperative protocol. We made an effort to clarify whether the authors were involved as inventors, developers, or producers.

## RESULTS

### Selected publications

A total of 56 papers were eligible (Figure 1). Screening for double publication or overlap of data led to the exclusion of 12 papers [3, 7, 9-10, 14-21]. One paper [22] was a retrospective review of TWA using three implants, with a large overlap concerning the Biaxial implant with two other included papers [4, 23], and there were data on eight cases only concerning the second implant, the Universal 2. Thus, only data concerning the Remotion were used despite important methodological limitations in this paper. Seven publications comprised less than ten cases, which left 37 articles for final analysis of which 16 fulfilled the criteria for analysis of longevity. The eligible

studies represent a maximum of 1,127 cases, but the precise number is probably somewhat smaller due to a possible minor overlap between some of the series. 71% were rheumatoid, 6% scapholunate advanced collapse (SLAC) wrists, 4% scapho-nonunion advanced collapse (SNAC) wrists, 4% other posttraumatic causes, 4% other degenerative causes, 2% Kienboeck's disease, and 9% other or not well specified causes.

### Implants

A total of 18 different implants were reported, including certain modifications (Table 1). Of these, seven are no longer available: the APH [19], Biaxial [4], CFV [24], Desdot [25], Meuli [3], Trispherical [26], Volz [27] and the Rozing wrist system (RWS) [5]. Three have been redesigned: The Guepar [28], now marketed as Horus, the Aphis [29] and Universal 1 [8]. The following are currently available: Amandys [11], Maestro [30], Motec [7], Pech [31], RCPI [32], Remotion [9], Total Modular [6] and Universal 2 [33]. The Amandys is an interposition pyrocarbon implant, and the RCPI a pyrocarbon hemiarthroplasty. All of the remaining devices have a carpal and a radial component. The radial component of the



TABLE 1

Implants, number of cases and methodology in 37 publications.

Reference	Implant	Generation	Cases (rheumatoid cases), n	Preoperative data permitting comparison	Validated outcome measures instrument	Change in scores
<i>Pierrart et al</i> , 2012 [68]	Amandys	IV	11 (0)	Not reported	QDASH PRWE	–
<i>Bellemère et al</i> , 2012 <sup>a</sup> [11]	Amandys	IV	25 (1)	Reported	QDASH PRWE	Improved 27 and 29 points (p < 0.05)
<i>Radmer et al</i> , 2003 [41]	APH	II	40 (40)	Not reported	–	–
<i>Isselin</i> , 2003 <sup>a</sup> [29]	APHIS	III	13 (0)	Reported	–	–
<i>Lirette &amp; Kinnard</i> , 1995 [42]	Biaxial	II	15 (15)	Not reported	–	–
<i>Cobb &amp; Beckenbaugh</i> , 1996 <sup>a</sup> [4]	Biaxial	II	57 (57)	Reported	–	–
<i>Cobb &amp; Beckenbaugh</i> , 1996 <sup>a</sup> [67]	Biaxial (long stem)	II	10 (10)	Not reported	–	–
<i>Courtman et al</i> , 1999 [44]	Biaxial	II	26 (26)	Not reported <sup>c</sup>	–	–
<i>Takwale et al</i> , 2002 [47]	Biaxial	II	66 (66)	Not reported	–	–
<i>Rizzo &amp; Beckenbaugh</i> , 2003 <sup>a</sup> [23]	Biaxial (long stem)	II	17 (approx. 15)	Reported	–	–
<i>Stegeman et al</i> , 2005 [43]	Biaxial	II	16 (16)	Not reported	–	–
<i>Kretschmer &amp; Fansa</i> , 2007 [46]	Biaxial	II	42 (3)	Reported	–	–
<i>Van Harlingen et al</i> , 2011 [45]	Biaxial	II	32 (32)	Reported	–	–
<i>Ferlic &amp; Clayton</i> , 1995 <sup>a</sup> [24]	CFV	II	15 (13)	Not reported	–	–
<i>Levadoux &amp; Legré</i> , 2003 <sup>a</sup> [25]	Destot	II	27 (0)	Not reported	–	–
<i>Fourastier et al</i> , 1996 <sup>a</sup> [28]	Guepar	II	72 (72)	Not reported	–	–
<i>Nydick et al</i> , 2012 [30]	Maestro	III	23 (5)	Reported	DASH	Not recorded preoperatively
<i>Meuli</i> , 2000 [52]	Meuli	II	54 (approx. 45)	Not reported	–	–
<i>Vögelin &amp; Nagy</i> , 2003 [66]	Meuli	II	16 (13)	Not reported	–	–
<i>Strunk &amp; Bracker</i> , 2009 [48]	Meuli, Biaxial, Universal 2	II, II, III	41 (38)	Not reported	DASH	–
<i>Reigstad et al</i> , 2012 <sup>a</sup> [36]	Motec	(II)	30 (0)	Reported	DASH	Improved 26 points (p < 0.05)
<i>Pech et al</i> , 2008 <sup>a</sup> [31]	Pech	II	32 (32)	– <sup>e</sup>	–	–
<i>Marcuzzi et al</i> , 2013 [32]	RCPI	IV	35 (0)	Reported	DASH	Improved 45 points (p < 0.05)
<i>Cooney et al</i> , 2012 <sup>a</sup> [22]	Remotion	III	22 (?)	Reported	DASH	–
<i>Herzberg et al</i> , 2012 [38]	Remotion	III	112 (75)	Reported	QDASH	Improved 21 points (NS)
<i>Bidwai et al</i> , 2013 [51]	Remotion	III	10 (10)	Reported	–	–
<i>Rahimtoola &amp; Rozing</i> , 2003 <sup>a</sup> [5]	RWS	II	29 (approx. 27)	Reported	–	–
<i>Rahimtoola &amp; Hubach</i> , 2004 <sup>a</sup> [6]	Total Modular	II	32 (29)	Reported	–	–
<i>Kraay &amp; Figgie</i> , 1995 <sup>b</sup> [26]	Trispherical	II	35 (35)	Not reported <sup>d</sup>	(HSS)	(Improved, significance not reported)
<i>Menon</i> , 1998 <sup>a</sup> [8]	Universal 1	III	31 (23)	Reported	–	–
<i>Van Winterswijk &amp; Bakx</i> , 2010 [40]	Universal 2	III	17 (16)	Reported	DASH	Improved 24 points (significance not reported)
<i>Ferreres et al</i> , 2011 [50]	Universal 1/2	III	21 (15)	Not reported	PRWE	–
<i>Ward et al</i> , 2011 <sup>a</sup> [39]	Universal 1	III	24 (24)	Reported	DASH	Improved 22 points (significance not reported)
<i>Morapudi et al</i> , 2012 [37]	Universal 2	III	21 (19)	Reported	DASH PRWE	Improved 10 and 46 points (p < 0.05)
<i>Adams</i> , 2013 <sup>a</sup> [33]	Universal 2 (hemiarthroplasty using radial component)	(III)	26 (3)	Not reported	–	–
<i>Bosco et al</i> , 1994 [27]	Volz	II	18 (14)	Not reported	–	–
<i>Gellman et al</i> , 1997 [49]	Volz	II	14 (14)	Not reported	–	–
<b>Total</b>			<b>1,127 (approx. 803 ≈ 71%)</b>			

APH = anatomic-physiologic; APHIS = Arthroplastie Physiologique Isselin; CFV = Clayton Ferlic Volz; DASH = Disabilities of Arm, Shoulder and Hand; HSS = hospital for special surgery; PRWE = Patient-Rated Wrist Evaluation; QDASH = QuickDASH; RCPI = Resurfacing Capitate Pyrocarbon Implant; RWS = Rozing Wrist System.

a) Some of the authors may be involved in the development or production of the implant; b) No clear available information on the authors' affiliation to the production; c) Only sum flexion – extension and of radial-ulnar reported, but without mention of statistical significance; d) HSS-score reported – this scoring system was not eligible according to the protocol due to its restricted use and validation; e) Full text in Czech, only abstract available in English.

 TABLE 2

Motion at follow-up in publications on currently available implants.

Implant	Post-operative flexion-extension			Post-operative radial-ulnar flexion			Total range of motion		
	post-operatively, degrees	change compared to preoperatively, degrees	p-value	post-operatively, degrees	change compared to preoperatively, degrees	p-value	post-operatively, degrees	change compared to preoperatively, degrees	p-value
Amandys									
<i>Bellemere et al, 2012 [11]</i>	68	1	NS	36	0	NS	–	–	–
<i>Pierrart et al, 2012 [68]</i>	71	–	–	36	–	–	–	–	–
Maestro									
<i>Nydick et al, 2012 [30]</i>	90	5	NS	43	8	< 0.05	–	–	–
Motec									
<i>Reigstad et al, 2012 [36]</i>							120	16	NS
Pech									
<i>Pech et al, 2008 [31]</i>	–	–	–	–	–	–	–	–	–
RCPI									
<i>Marcuzzi et al, 2013 [32]</i>	67	17	< 0.05	24	17	< 0.05	–	–	–
Remotion									
<i>Herzberg et al, 2012 [38]</i>	66	–4	NS	33	2	< 0.05 for radial flexion	–	–	–
<i>Cooney et al, 2012 [22]</i>	67	–6	–	27	7	–	–	–	–
<i>Bidwai et al, 2013 [51]</i>	61	38	< 0.05	22	–	–	–	–	–
Total Modular									
<i>Rahimtoola &amp; Hubach, 2004 [6]</i>	63	17	< 0.05	24	7	< 0.05 for ulnar flexion	–	–	–
Universal 2									
<i>Morapudi et al, 2012 [37]</i>	53	15	< 0.05	–	–	–	–	–	–

NS = non-significant; RCPI = Resurfacing Capitate Pyrocarbon Implant.

Universal, the Remotion and the Maestro have been used as hemiarthroplasties [33-35]. The APH and the Motec are metal-on-metal prostheses; all others are metal-on-polyethylene. Only the Trispherical is fully constrained. For further details concerning all these implants, we refer to the primary publications.

### Clinical results

Six papers provided preoperative as well as post-operative data on function, all reporting improvement (Table 1): four reported statistical significance [11, 32, 36, 37], one a statistically non-significant improvement [38] and two papers did not report significance [39, 40]. In two of the papers, a t-test was used to assess significance, which is debatable since the scoring systems are based on ordinal scales [36, 37].

The mean or median range of flexion-extension at follow-up was reported in 32 papers and ranged from 15 to 89 degrees. The mean or median range of radial-ulnar deviation was reported in 27 papers and ranged from seven to 48 degrees (Table 2).

In all, 13 of 36 papers reported grip strength at follow-up, but only ten compared grip strength with preoperative values, eight showing increased and two decreased values.

A total of 12 papers evaluated pain on a visual analogue scale, 14 on a verbal Likert scale and one used the pain section of the PRWE. Thirteen of these 26 papers demonstrated improvement of mean values and nine reported statistical significance. The other 14 had no preoperative values for comparison. Clear information concerning pain was missing in ten papers.

### Complications

Besides the important issue of prosthetic loosening, we selected two major complications because we expected these to be most consistently defined and reported. Deep infection (early or late) was reported in a total of 16 cases (1.4%). The infection rate ranged from 0% (in 23 series) to 13% [24]. Instability problems were related to certain implants. Radmer reported 32 cases of “loosening with subsequent dislocation” out of 40 cases using the APH prosthesis [41], the main reason for abandoning the use of this implant. A total of 22 of 278 (8%) Biax implants in seven series were reported to have dislocated [4, 42-48], and four out of 32 (13%) Volz prostheses were reported to have subluxed or dislocated in two series [27, 49]. Menon [8] reported dislocation of five out of 37 (14%) cases, and Ward [39] reported one persistent instability and one dislocation out of 24 Universal 1



TABLE 3

Cumulated survival rate and/or revision rate of implants in 16 publications.

Reference	Implant	Diagnosis	Survival			Revision rate, n	Follow-up, mean (range), yrs
			at 5 yrs	at 8 yrs	at 10 yrs		
Radmer <i>et al</i> , 2003 [41]	APH	RA (PSA, OA) <sup>b</sup>	–	–	–	36/37	4.3 (2-6.1)
Courtman <i>et al</i> , 1999 [44]	Biaxial	RA/PSA	1.0	–	–	–	2.8 (2-5.2)
Van Harlingen <i>et al</i> , 2011 [45]	Biaxial	RA	0.90 <sup>c</sup>	0.81	–	–	6.0 (5-8)
Cobb & Beckenbaugh, 1996 <sup>a</sup> [4]	Biaxial	RA	–	–	0.83	–	6.5 (5-9.9)
Takwale <i>et al</i> , 2002 [47]	Biaxial	RA	0.90 <sup>c</sup>	0.83	–	–	4.3 (1-8.3)
Cobb & Beckenbaugh, 1996 <sup>a</sup> [67]	Biaxial (used for revision)	RA	–	–	–	2/10	3.8 (3-4.8)
Rizzo & Beckenbaugh, 2003 <sup>a</sup> [23]	Biaxial (long stem)	RA (OA) <sup>b</sup>	1.0	1.0	–	–	6.2 (4.1-8.6)
Meuli, 2000 <sup>a</sup> [52]	Meuli	RA/PT	0.92	0.77	–	–	–(0.5-13)
Reigstad <i>et al</i> , 2012 [36]	Motec	SLAC/SNAC	0.93	–	–	–	3.2 (1.1-6.1)
Herzberg <i>et al</i> , 2012 [38]	Remotion	RA/PT/OA	0.92	0.92	–	–	4.0 (2-8)
Rahimtoola & Rozing, 2003 <sup>a</sup> [5]	RWS	RA (PSA, OA) <sup>b</sup>	–	–	–	1/29	4.0 (2-8)
Menon, 1998 <sup>a</sup> [8]	Uni 1	RA/OA	–	–	–	4/37	6.7 (4-10)
Ward <i>et al</i> , 2011 <sup>a</sup> [39]	Uni 1	RA	0.75	0.62 <sup>c</sup>	0.40 <sup>c</sup>	–	7.3 (5-10.8)
Ferreres <i>et al</i> , 2011 [50]	Uni 1 and 2	RA (PSA, OA, misc.) <sup>b</sup>	1.0	1.0	–	–	5.5 (3.2-8.8)
Gellman <i>et al</i> , 1997 [49]	Volz	RA	–	–	–	1/14	6.5 (3.5-11.5)
Bosco <i>et al</i> , 1994 [27]	Volz	RA (PT) <sup>b</sup>	–	–	–	1/18	8.6 (3.5-12.5)

APH = anatomic-physiologic; OA = degenerative osteoarthritis; PSA = psoriatic arthritis; PT = posttraumatic arthritis; RA = rheumatoid arthritis; SLAC = scapholunate advanced collapse; SNAC = scaphoid non-union advanced collapse.

a) Some of the authors may be involved in the development or production of the implant.

b) Diagnosis in bracket because of small percentage.

c) Evaluated on an illustration showing the cumulated implant survival curve in the publication.

cases (8%). Van Winterswijk [40] reported dislocation in one out of 17 Universal cases. This instability problem seems to have been solved with the modified version, the Universal 2 [37, 50].

Dislocation has been only a very small problem with the Remotion: one in 144 reported cases (< 1%) [22, 38, 51]. In the two Amandys series, problems were seen in seven out of 36 cases (19%). One recurrent subluxation was reported out of 13 Isselin [29] implants, and one instability problem out 23 Maestro implants [30]. No dislocations or other instability problems worth mentioning have been reported following the Destot, GUEPAR, Meuli, Motec, Pech, RWS, Trispherical or RCPI [5, 25, 26, 28, 31, 32, 36, 51].

### Radiology

Osteolysis or radiolucency at follow-up, with or without loosening of the prosthetic components, was assessed in varying ways. In 13 of the 37 series, no useful information could be retrieved, whereas 20 papers reported osteolysis, ten of these mentioning radiolucency without frank loosening of the implant components [5, 23, 36, 38, 39, 42, 45, 49-51].

In a consecutive series of Biaxial TWA with a follow-up time of 5-9 years, there was progressive radiolucency at the carpal component in 12 out of 46 wrists, seven of which were revised. Subsidence of the carpal component was present in seven cases after one year and in 20 cases at final follow-up [4].

### Implant survival

Ten papers provided data that permitted an evaluation of the cumulated survival at five years or more (Table 3). Eight reported a cumulated five-year survival of 90% or more and one a cumulated five-year survival of 75%. The last paper reported 0.83 at ten years.

### Small series

Seven papers included less than ten cases. Boyer & Adams used the radial component of a Universal 2 total wrist arthroplasty system in two rheumatoid cases as a hemiarthroplasty in combination with a proximal row carpectomy [34]. Roux developed a hemiarthroplasty for usage primarily in comminuted distal radius fractures with irreparable joint surfaces [53]. Lorei *et al* used a custom Trispherical implant for the revision of three failed TWAs [54]. O'Flynn reported on a single case of failure of the hinge mechanism in a Trispherical TWA [55]. Talwalkar *et al* reported on five revision Biaxial replacements [56]. Lundborg *et al* published five cases using a titanium/polyethylene ball-and-socket articulation fixated with osseointegrated Titanium screws [18] and with a further follow-up [57]. Daruwalla presented a series of six Amandys pyrocarbon implants [58].

### DISCUSSION

Although this review used systematic search criteria and protocol inclusion and exclusion criteria, it was limited by the quality of the source reports. After exclusion of

one paper for language reasons and one paper reporting data as a part of a less commonly used scoring system, no more than 17 publications were prospective, even when using a broad definition: data collected preoperatively as well as post-operatively. Of these 17 papers, eight used a validated and widely used outcome measurement system. This weakness of methodology applies mainly to second generation implants. In at least 16 of the 37 papers, one or several authors were involved as or close to the inventors, developers or producers, but this seemed not to have had an impact on the reported clinical or longevity results. Finally, due to the lack of more detailed information, our analyses were limited to calculation of mean or median values, whereas calculation of statistically significant differences was impossible. Despite these weaknesses, we find that some summary estimate of the results after T/PWA and some general conclusions are possible.

The majority of the data are based on rheumatoid cases, although other diagnoses are increasingly represented in recent publications. The general opinion has generally been that better longevity must be expected in low-demand patients, typically rheumatoid patients. It is not possible throughout the different series to compare results in rheumatoid and non-rheumatoid patients, but the series of Herzberg [38], which consists of 75 rheumatoid and 37 non-rheumatoid cases, draws on prospective data and concludes that there are no clinically or statistically significant differences. This is consistent with an emerging consensus that non-rheumatoid patients may do better because of a better bone stock, provided that their level of activity is restricted [33].

In terms of complications, it appears that the risk of deep infection is small. Likewise, it seems that the instability problems of earlier designs have been solved, except for the Amandys implant. Time must show if this requires modification of the implant or if the issue can be solved by modified surgical techniques.

In general, mean values for motion at follow-up are similar for most implants and within the functional

range defined by Palmer et al [59], although somewhat smaller than the more rigorous range defined by Ryu & Cooney [60] (Table 2). An exception may be the Maestro that showed better motion in the single series with this implant [30]. On the other hand, there is less consistency concerning the change in motion from before operation to follow-up. This may be attributed to different case selections, different post-operative protocols or factors related to the implant itself, but it is impossible to clarify this on basis of the published data. The general tendency is that the mean level of function, as evaluated with patient-rated outcome measures, increases, and that pain is reduced. However, a general summary of the extent of the pain reduction through the different reports is impossible.

The main advantage of T/PWA over total wrist fusion (TWF) is claimed to be a higher degree of functionality. Although many patients with bilateral procedures – TWA on one side and TWF on the other – would have preferred arthroplasty on both sides, this is not always the case [47]. The present work did not aim to make a comparison between these two solutions, but the question is important. Murphy et al made a comparison between TWA (24 rheumatoid wrists) and TWF (27 rheumatoid wrists) in a retrospective design [20]. Treatment groups were well matched by patient characteristics and radiographic staging. There were no statistically significant differences between arthroplasty and arthrodesis in either DASH or PRWE scores.

Cavaliere & Chung compared TWA with TWF in a systematic review of the literature [61]. They identified 18 total wrist arthroplasty studies representing 503 procedures and 20 TWF studies representing 860 procedures in rheumatoid patients. They concluded that the outcomes for TWF were comparable and possibly better than those for TWA. One major limitation in that study was that the methodology in the source publications was often very weak.

In a subsequent study [62], TWA was associated with the highest expected gain in quality-adjusted life-years (QALY). This finding reflects the attitude of medical specialists, but is, of course, not evidence of the superiority of TWA. In a third study, the authors compared costs per QALY [63]. TWA turned out to have only a small incremental cost over the traditional TWF procedure. However, this study is limited by the uncertainty associated with utility values, life span and complication rates. Especially, we question the assumption in the model, that prostheses are durable enough to last the duration of the patient's life.

Nydick et al compared TWA (seven wrists) and TWF (15 wrists) [10] in posttraumatic arthritis. The PRWE scores were significantly better in the arthroplasty group, but there were no differences in DASH scores.



#### FACT BOX

Several generations of total wrist arthroplasty have been used on a regular basis since the 1960s and hemiarthroplasty has been introduced in recent years.

Many designs have been utilised and quite a few abandoned or modified. Currently, ten different implants are available.

Wrist arthroplasty has a good potential for improvement of function through pain reduction and preservation of mobility, but its superiority above total wrist fusion has not been proven in controlled randomised trials.

The five-year implant survival is higher than 90% in most series using late second generation and third generation implants. Implant survival seems to decline from five to eight years.



Besides its retrospective design, the weakness of this study was the very small number of TWA and the fact that all cases had been treated at the same clinic, implying that there had been a preoperative decision to prefer TWA in some patients and TWF in others.

In our study, a reasonable appreciation of the longevity of the implants was possible in 16 papers, although only ten provided information on cumulated implant survival. The most widely accepted and commonly used definition of failure in implant survival analysis is "removal of implants", but the decision to remove an implant depends on the attitude of the surgeons: Some might advise not to remove an implant, even in the presence of some (tolerable) pain; some might advise removal of an implant with periprosthetic osteolysis, even if the implant seems to be stable and in the absence of pain. Thus, it is argued that other definitions should be considered, but until another consensus is reached, removal of implants remains the definition of choice.

Generally, the five-year implant survival rate was higher than 90% (Table 3), but declining at eight years. One exception is the low survival reported by Ward et al [39]. This series contains exclusively rheumatoid cases, but there were no statistically significant differences between the ten revised and ten non-revised wrists in terms of age, Simmen classification, dominance or preoperative DASH score. Another notable result concerns the metal-on-metal APH prosthesis. Solitary loosening of the carpal component was predominant. The authors believed that the main cause of loosening was bone resorption induced by titanium debris, and they abandoned the use of this implant [41]. Krughaug et al reported on the survival of 189 TWA in the Norwegian Arthroplasty Register [64]: The cumulated survival of the Biax was 85% at five years and approximately 78% at eight years, which is somewhat lower than in the series we have analysed. The survival of the Gibbon/Motec was obviously lower than that published by Reigstad et al [36], which can possibly be attributed to underreporting to the register [65].

Six papers merely permitted a calculation of the revision rate, which is much weaker information. Indeed, a given revision rate in series with a long observation period has a quite different value than the same revision rate in a series with a short observation period. Failed TWA can successfully be revised by fusion [8, 15, 22, 36, 39, 41, 66], by total or partial replacement of the components [8, 15, 22, 39, 66, 67] or by total or partial removal of the components with or without soft-tissue interposition, typically fascia lata [4, 39].

Although reported in 20 articles, periprosthetic osteolysis/radiolucency, with or without gross loosening, has been systematically investigated in two series only [4, 47]. The remaining studies report on the phenom-



X-ray of the Remotion total wrist arthroplasty.

enon but use no standardised definitions or methods. Osteolysis occurred frequently around both the radial and carpal components, whereas frank loosening of the component was more frequent on the carpal side. Radiostereographic studies have not been published.

The cause of periprosthetic osteolysis is not clear, but has been attributed to a local osteolytic reaction to metallic or polyethylene debris. In this review, we can confirm that it occurs in metal-on-polyethylene [4-6, 23, 27, 28, 39, 43-47, 49-51] as well as in metal-on-metal prostheses [36, 41], but we are unable to clarify its causes or consequences. To our knowledge, no systematic analyses of metallic ion levels in blood have been published [36, 41].

## CONCLUSION

Despite the methodological shortcomings in a considerable proportion of the published papers, some general conclusions are possible. It seems that T/PWA has a strong potential for improvement of function through pain reduction and preservation of mobility. The risk of severe complications – deep infection and instability problems – is small with the available implants. An implant survival of 90-100% at five years is reported in most series – if not all – using newer second generation and third generation implants, but implant survival declines from five to eight years.

There is a need of continuous research with a focus on indications (rheumatoid versus non rheumatoid, age-groups, level of activity etc.) and on long-term results achieved through large prospective multicentre studies, national registries or even with post-market surveillance registries of implants that are no longer available. Furthermore, the question as to which extent and on what indications TWA is superior to TWF still needs to be answered definitely.

Finally, the possible causes and consequences of the frequently reported periprosthetic loosening must be exposed by radiostereographical methods, histo-

logical examinations, bone mineral content measurements, metallic ion levels in blood, etc.

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