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ORIGINAL STUDY

Results of a unicentric series of 15 wrist prosthesis implantations at a 5.2 year follow-up

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Our retrospective study aimed to evaluate functional and radiological results of a unicentric series of 17 total wrist prostheses implanted between 2001 and 2011. Nine women and seven men, mean age 59, underwent wrist joint arthroplasty, bilateral in one case. Universal Total Wrist and Remotion prostheses were used and followed-up at a mean of 5.2 years (1.1-10). Fifteen patients were reviewed. Four patients had postoperative complications, three of whom required arthrodesis. The rest obtained satisfactory pain relief. Grip strength nevertheless decreased compared to the contralateral side and mobility was reduced : flexion/extension = 33°, ulnar/radial deviation = 20°. The Quick DASH score was 29% and PRWE, 26%. Radiological assessment revealed carpal implant loosening in eight patients. Our series confirms the discordance generally observed between patients' subjective satisfaction and mediocre clinical and radiological results over the medium term.

Keywords : total wrist arthoplasty.

INTRODUCTION

The first wrist prosthesis was reported early in surgical history by Gluck in 1890. More modern procedures reappeared at the end of the 1960s, but were characterised by a high rate of complications and more or less long-term failure (Chantelot, 2006). Many implants were developed, then abandoned, in light of their poor results (Radmer *et al*, 2003 ; Kretschmer *et al*, 2007). Further to these observations, the design of prostheses evolved to better embrace wrist joint biomechanics and better respect bone capital. Nevertheless, their use today remains limited. The total wrist prosthesis has not yet reached the success rate of hip or knee implants (Reigstad *et al*, 2011 ; Krukhaug *et al*, 2011). Series published prior to 2000 report poor results, while more recent series often lack sufficient follow-up time. Our aim was thus to retrospectively evaluate functional and radiological results of a unicentric series of 15 total wrist prostheses implanted between 2001 and 2011.

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METHODS

From December, 2001, to May, 2011, nine women and seven men underwent wrist joint arthroplasty, bilateral in one case, for a total of 17 cases. Fourteen concerned the dominant side. Patients' mean age was 59 years (41-74). At time of surgery, eight patients still led professional lives. Among the 17, there were seven cases of inflammatory arthritis (six of whom had rheumatoid polyarthritis), eight cases of post-traumatic osteoarthritis (five scapholunate advanced collapse, SLAC ; one scaphoid nonunion advanced collapse, SNAC), one case of Kienböck's disease and one sequel of septic arthritis (Table 1).

Ten patients had already undergone wrist surgery, in five cases involving bones : three patients had four-corner bone arthrodesis (two SLAC wrists, one Kienböck's disease) ; one patient had undergone capitate resurfacing arthroplasty further to post-traumatic osteoarthritis (perilunar luxation) ; finally, one patient had been treated for rhizarthrosis by trapezectomy. One patient had undergone denervation for a SLAC wrist. Four patients with rheumatoid polyarthritis had been treated by extensor synovectomy. In all cases, the extent of joint impairment excluded the possibilities of partial arthrodesis, leaving as sole options total arthrodesis or arthroplasty. Patients' preferences guided prosthetic treatment : refusal of arthrodesis, bilateral pathology, contralateral arthrodesis or professional needs.

Two types of anatomical non-constrained implants were used : ten Universal Total Wrist first generation (UTW1) (KMI, San Diego, CA, USA) prostheses (2001 to 2007) and seven Remotion (SBI, Morrisville, PA, USA) (2007 to 2011). The design of the UTW1 prosthesis (KMI, San Diego, CA, USA) makes ulnar resection necessary using Darrach's procedure. Cementation of the radial and carpal implants was systematic. The Remotion (SBI, Morrisville, PA, USA) implant required no ulnar intervention. Cementing was necessary in one case for the carpal plate, and in a second, for the radial implant.

Assessment of this retrospective study was based on clinical and radiological data, along with two functional scores. Clinical examination began by questioning patients' satisfaction and their difficulties or discomfort in professional and everyday life, leisure activities and during sleep. A four-point scale was used specifying absence of, slight, moderate or severe discomfort. Pain was assessed according to the visual analogue scale (VAS) from zero to ten. Physical assessment included Jamar (Kinetec, Charleville Mézières, France) measurement of grip strength on both operated and contralateral wrists. We also measured amplitudes of flexion/extension, ulnar/radial deviation and pronation/supination.

Radiological assessment included six images : three anterior views (neutral, maximum ulnar deviation, radial deviation) and three lateral views (neutral, maximum palmar flexion, dorsal extension). Sinking of the carpal plate was assessed by the ratio of capitate height relative to height of the third metacarpal. Specifically, this meant measuring, on an anterior view, the remaining height of the capitate from the lower edge of the carpal plate to the capito-metacarpal interline and from the third metacarpal of the capito-metacarpal interline to the metacarpo-phalangeal interline. The measurement was taken immediately following surgery and during follow-up or prior to arthrodesis. Quick Disabilities of arm, shoulder and hand (QuickDASH) and patient-related wrist evaluation (PRWE) scores completed the assessment.

Results are shown as means (with minima/maxima). Prosthesis survival was analysed by the Kaplan-Meier curve. An unpaired Student's *t*-test was used ($p = 0.05$) to compare means for quantitative variables.

RESULTS

Complete follow-up was possible for 14 out of 16 patients, totalling 15 prostheses out of 17. The two patients who died before final assessment had experienced no postoperative complications. At the time of death, one had had a wrist prosthesis for 3 years, the other for 9. The last consultation for each patient showed satisfactory clinical outcome (no pain and joint mobility preserved), although radiography revealed carpal plate loosening in one case.

The mean follow-up period for the 15 wrists was 5.2 years, ranging from 13 months to 10 years. Precisely, the mean follow-up was respectively 3 years and 6.5 years for the Remotion (SBI, Morrisville, PA, USA) and for the UTW1 (KMI, San Diego, CA, USA). Postoperative complications occurred in four patients who required revision surgery. In three of these cases, symptomatic loosening of the carpal implant made it necessary to remove the prosthesis and perform radiocarpal arthrodesis.

The first of these patients experienced clicking in pronosupination, corresponding to a conflict between the distal diaphyseal root of the ulna and the distal radial metaphysis. Darrach's procedure performed three months postoperatively corrected the

Table I. — Presentation of the series

Case	Age Sex	Dominant side	Pre-prosthetic history	Indication	Type of implant	Follow-up (months)	Postoperative complication	Status at final follow-up
1	63 Male	Yes	Synovectomy	Inflammatory arthritis (RP)	UTW	102	No	Deceased Prosthesis
2	54 Male	Yes	Four-corner arthrodesis	Post-traumatic osteoarthritis (SLAC)	UTW	100	Clicking in pronosupination	Arthrodesis
3	51 Female	Yes	Synovectomy	Inflammatory arthritis (RP)	UTW	120	No	Prosthesis
4	71 Male	Yes	Denervation	Post-traumatic osteoarthritis (SLAC)	UTW	24	Palmar luxation Extensor rupture	Arthrodesis
5	43 Male	No	Four-corner arthrodesis	Inflammatory arthritis (RP)	UTW	44	Flexor rupture	Arthrodesis
6	54 Male	Yes	Trapezectomy	Post-traumatic osteoarthritis (SLAC)	UTW	106	No	Prosthesis
7	53 Female	Yes	Cement spacer	Inflammatory arthritis	UTW	95	No	Prosthesis
8	52 Female	Yes	–	Septic arthritis	UTW	80	No	Prosthesis
9	59 Male	Yes	–	Inflammatory arthritis (RP)	UTW	42	No	Deceased Prosthesis
10	63 Female	Yes	–	Post-traumatic osteoarthritis (SLAC)	UTW	62	No	Prosthesis
11	73 Male	Yes	–	Post-traumatic osteoarthritis (SLAC)	Remotion	60	Postoperative haematoma	Prosthesis
12	72 Female	Yes	–	Post-traumatic osteoarthritis (SNAC)	Remotion	55	No	Prosthesis
13	74 Female	Yes	–	Post-traumatic osteoarthritis	Remotion	43	No	Prosthesis
14	54 Male	No	Capitate resurfacting arthroplasty	Post-traumatic osteoarthritis (perilunar luxation)	Remotion	32	No	Prosthesis
15	59 Female	No	Synovectomy	Inflammatory arthritis (RP)	Remotion	30	No	Prosthesis
16	63 Female	Yes	–	Inflammatory arthritis (RP)	Remotion	19	No	Prosthesis
17	41 Female	Yes	Four-corner arthrodesis	Kienböck's disease	Remotion	13	No	Prosthesis

M : male, F : female, RP : rheumatoid polyarthritis, SNAC : Scaphoid Nonunion Advanced Collapse, SLAC : Scapholunate Advanced Collapse, UTW (KMI, San Diego, CA, USA), Remotion (SBI, Morrisville, PA, USA).

impairment. The second patient experienced several episodes of palmar luxation, one of which occurred a few days postoperatively and required open reduction. Four months following initial arthroplasty, the same patient suffered a rupture of the extensors of the fifth finger and the common extensor of the fourth finger, requiring reoperation. The third patient, 8 months after the initial surgery, had a rupture of the flexor digitorum profundus of the fourth and fifth fingers caused by both rheumatoid inflammation and mechanics (contact with the anterior edge of the metal base of the carpal plate).

The fourth postoperative complication was a case of cutaneous necrosis along the incision site linked to postoperative haematoma. This haematoma was developed despite drainage. The patient was a non-insulin dependent diabetic well controlled by oral medication also treated by anticoagulants for hypertrophic cardiomyopathy. Surgical evacuation of the haematoma was done three days postoperatively, and was followed by the appearance of a necrotic zone. Given the risk of exposing the implant, the necrosis was debrided at day 14 and immediately covered with a posterior interosseuous skin flap. No problems occurred during recovery.

For the remaining patients, where the wrist implant remained in place, subjective assessment showed 58% to be very satisfied, 25% satisfied and 75% wishing to repeat the same procedure. Eighty-three percent reported no discomfort while sleeping, 76% none or slight discomfort in everyday life and leisure activities. Only 42%, however, felt that they "forgot" about their wrist, and a mere 25% of those patients still working at the time of implant were able to return to their same job without accommodation (Table 2).

Clinical assessment showed quasi-systematic pain relief : a VAS mean score of 2/10 (0-7). Grip strength on the operated wrist averaged 66% of the contralateral side and measured 17.3 kg (8-27) compared to 29.5 kg (10-68). Mobility was, in most patients, quite maintained and was clearly less than the contralateral side, except for pronosupination. Mean range of motion (ROM) for flexion/extension was 33° (18°-57°) and 20° (6°-42°) for ulnar/radial deviation. Ninety-four percent of patients enjoyed full pronosupination, with only one experiencing a total lack of supination and 40° pronation. Radiological analysis of this patient revealed voluminous ulnocarpal ossification. Functional assessment resulted in a mean QuickDASH score of 29% (2.3%-65.9%) and a PRWE of 26% (2%-55.3%).

Radiological assessment brought to light two cases of poor anchoring of the radial implant : one loosening of the UTW1 (KMI, San Diego, CA, USA) and one of the Remotion (SBI, Morrisville, PA, USA) on the only cemented prosthesis for this model. However, poor anchoring of the carpal plate was observed in 47% of patients, with 40% carpal plate migration. This phenomenon showed up as a resorbed zone around the central stem and a sinking of the plate with progressive destruction of the second row of carpal bones (Fig. 1). In most cases, this sinking was asymmetrical and occurred preferentially in ulnar or radial deviation. The phenomenon was found in 60% of the UTW1 (KMI, San Diego, CA, USA) prostheses and 14% of the Remotion (SBI, Morrisville, PA, USA) implants.

Patients whose implant was removed had, prior to arthrodesis, a mean decrease in the ratio of capitate height to height of the third metacarpal corresponding to 9% of postoperative value. In patients retaining the implant, but with asymptomatic poor carpal anchoring, the mean decrease in the ratio was only 2%. The difference between the two was statistically significant ($p = 0.01$).

Since the problems encountered in implant fixation at the time of study had no major functional or pain-causing impact, no arthrodeses were programmed on the short term. In one patient with a UTW1 (KMI, San Diego, CA, USA) prosthesis, the central stem of the metal base carpal plate ruptured, but with no resulting discomfort. There was no traumatic, septic or any other type of explanation of this phenomenon.

We found no significant difference between the type of implant used and VAS, grip strength, mobility, QuickDASH and PRWE. The rate of carpal plate loosening was, however, significantly higher in patients with UTW1 (KMI, San Diego, CA, USA) prostheses ($p = 0.01$). Taking implant removal as the criterion for survival, the 5-year rate was 93%, dropping to 58% after 10 years. With loosening of the carpal plate as the key criterion, the 5-year

Table II. — Results

Case	Satisfaction, Would repeat procedure	Difficulty: sleep	Difficulty: daily life	Difficulty: leisure activities	Range of motion flexion/ extension (in degrees)	Range of motion radial/ulnar deviation (in degrees)	VAS (out of 10)	Carpal plate loosening	Radial implant loosening	DASH (in%)	PWRE (in%)
1	–	–	–	–	–	–	–	No	No	–	–
2	–	–	–	–	–	–	–	Yes	No	–	–
3	VS Yes	N	S	N	25	12	0	Yes	No	27.3	36
4	–	–	–	–	–	–	–	Yes	Yes	–	–
5	–	–	–	–	–	–	–	Yes	No	–	–
6	VS Yes	N	N	S	38	31	1	Yes	No	2.3	7
7	PS No	M	M	M	18	6	6	No	No	54	83
8	VS Yes	N	N	N	39	15	0	Yes	No	7	3
9	–	–	_	–	–	–	–	No	No	–	–
10	VS Yes	N	S	S	43	20	2	No	No	25	21
11	S Yes	N	S	S	22	8	0	No	No	31.8	59
12	S Yes	N	M	M	19	20	2	No	No	23.3	36
13	VS Yes	N	S	S	40	42	0	No	No	15.9	31
14	VS Yes	N	S	S	40	20	4	Yes	Yes	45.4	45
15	S Yes	N	S	N	25	13	2	No	No	29.5	40
16	VS Yes	N	S	S	57	28	1	No	No	27.3	26
17	MS No	S	M	M	32	20	7	No	No	65.9	81

VS : very satisfied, S : satisfied, MS : moderately satisfied, PS : Poorly satisfied, N : None, S : slight, M : moderate.

survival rate was 70% and 33% after 10 years (Fig. 2).

Comparing the implants themselves, the mean follow-up period for the UTW1 (KMI, San Diego, CA, USA) prostheses was 6.5 years, and 3 years for the Remotion (SBI, Morrisville, PA, USA). The survival rate for the former was 90% at 5 years and 50% at 10. The 5-year rate for loosening of the carpal plate was again 90%, but progressively fell off with a statistical probability of carpal plate loosening estimated at 100% after 10 years. The Remotion (SBI, Morrisville, PA, USA) prosthesis maintained a survival rate of 100% after 6 years, with removal as the key criterion, but was estimated at 75% after 6 years considering loosening of the carpal plate as key indicator.

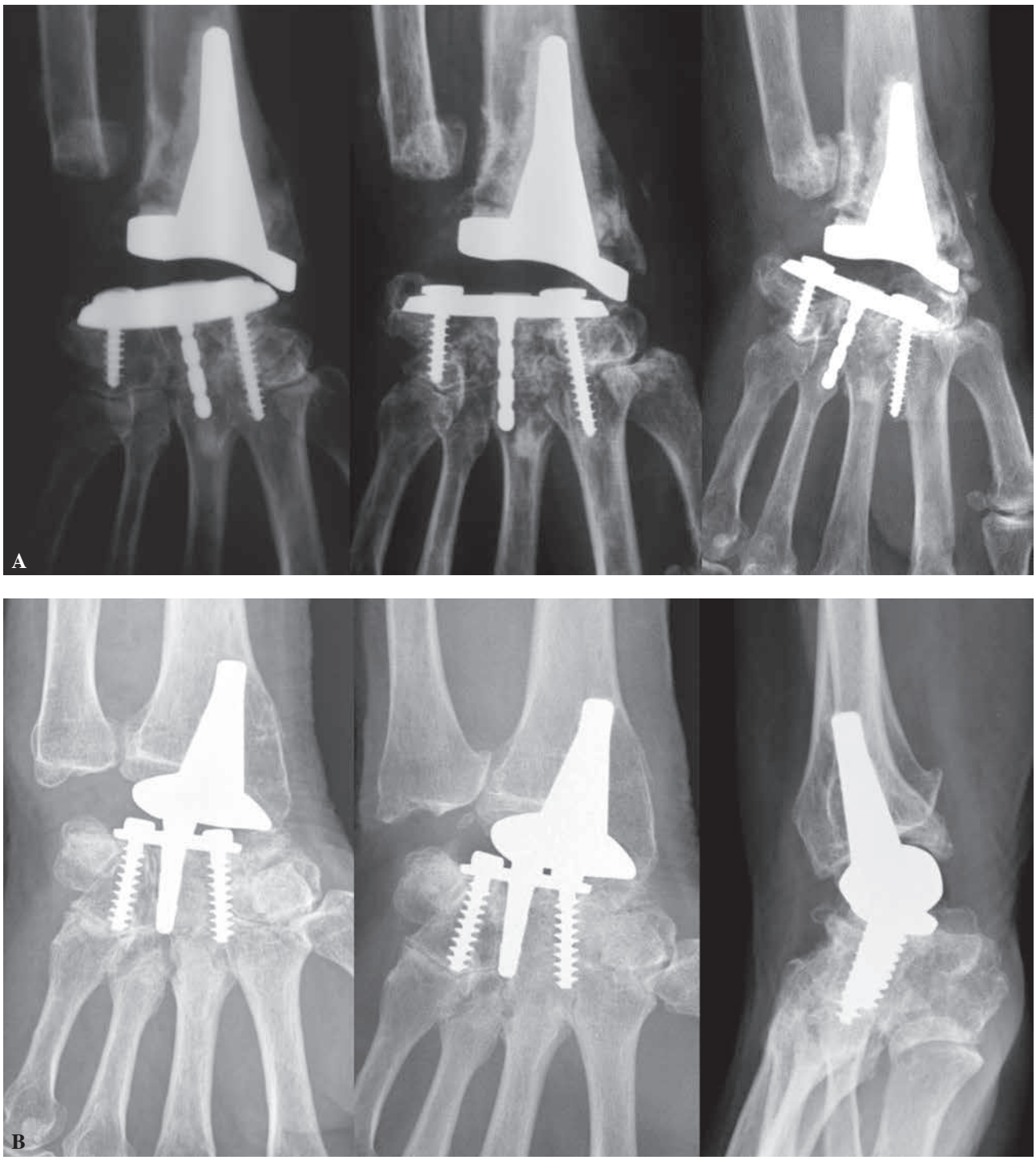

Fig. 1. — Clinical case. A. Case n° 1 : Female, 51 years old. Indication in a context of rheumatoid polyarthritis, UTW (KMI, SanDiego, CA, USA) prosthesis. Post operative follow-up and evolution at 3 years and 10 years. Observation of a progressive radial sinking of the carpal plate. Pain-free patient with implant remaining in place. B. Case n° 2 : Female, 72 years old. Indication in a context of post-traumatic osteoarthritis, Remotion (SBI, Morrisville, PA, USA). Post operative follow-up and evolution at 5 years. No modification in the carpal plate position.

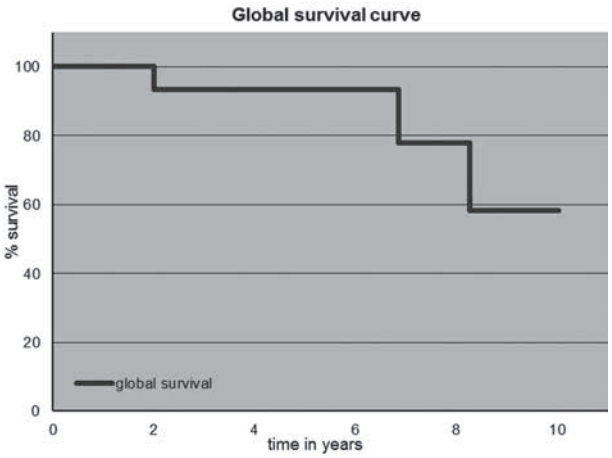

Fig. 2. — Cumulative survival curve ; survival criterion = implant removal.

DISCUSSION

Radiocarpal arthrodesis is currently the "gold standard" for a wrist where the extent of radiocarpal joint impairment precludes conservative treatment. Consequently, results of total wrist arthroplasty must be compared to the functional outcome of arthrodeses, keeping in mind the key indications for prosthesis : pain relief and joint function. For the wrist, this means restoring joint mobility and grip strength. Furthermore, the complication rate should be considered. Cavaliere and Chung (2008), in a meta-analysis of wrist arthroplasty and wrist arthrodesis in patients with rheumatoid arthritis, demonstrated an overall complication rate of 30% for wrist arthroplasty and 17% for wrist arthrodesis. However, this article was based both on new and old generation implants.

Our study focused on two prostheses, the UTW1 (KMI, San Diego, CA, USA) implant, whose design precluded conservation of the distal radioulnar joint obliging ulnar resection using Darrach's procedure, and the Remotion (SBI, Morrisville, PA, USA) implant, where such conservation was possible, and where no peri- or postoperative complications involving this joint were encountered. Switching from one prosthesis to the other was simply due to the fact of the former no longer being commercialised. The UTW1 (KMI, San Diego, CA, USA) implant was systematically cemented. While the Remotion (SBI, Morrisville, PA, USA) implant has a coated surface, poor anchoring made cementing necessary in two cases for a carpal base plate and for a radial implant, the latter of which later loosened. In this two cases, there was not enough cancellous bone peroperatively to maintain the implant.

In one patient, we implanted a wrist prosthesis in a context of septic arthritis sequela. This patient was a woman of 50 years old who refused a total wrist arthrodesis. She was clearly informed of the risk of such a surgical procedure but she asked for an arthroplasty. We have no septic complications after surgery. However, we do not suggest this therapeutic approach.

We reported a serious postoperative skin complication. In this particular situation, we needed to use a posterior interosseous flap to salvage this wrist. It is an uncommon complication infrequently reported in the literature. Nevertheless, this procedure did not affect the clinical and radiological medium-term outcome in this patient.

Postoperative complications have been observed in other series for this same type of implant, as well as for others, and our rate of revision surgery is comparable to that of other authors (Ward *et al*, 2011 ; Nydick *et al*, 2012) (Table 3). At a mean follow-up of more than 5 years, more than 15% of patients had already undergone implant removal and arthrodesis. It is also difficult to compare to other series of wrist implantations, given the lack of homogeneity in the literature. Our result appears to be lower than the arthrodesis rate for first generation prostheses, but higher than that reported in recent publications. Only Ward *et al* (2001) noted a higher rate of complications than our series, 45%. Several series have been published with preliminary, favourable, results at 2 or 3 years follow-up (Herzberg, 2011 ; Morapudi, 2012), but this length of time is probably insufficient. The rare recent series covering more than 5 years often report mediocre survival for these implants. Ward *et al* (2011), for example, at 7.3 years distance for a series of UTW1 (KMI, San Diego, CA, USA) prostheses, observed a survival rate of 60%, comparable to our findings. Menon (1998) noted in a series with UTW1 (KMI, San Diego, CA, USA) 26% of revision surgery and 8% of wrist arthrodesis at

Table III. — Review of the literature

Series	Type of study	Number of cases Sex Age	Type of implant	Follow-up (years)	Indication	VAS	PRWE	DASH	Amplitude (in degrees)	Complications requiring revision surgery (%)	Survival rate (%)	Arthrodesis rate (%)	Loosening (%)
Our series	UC	17 9F/7M 59	UTW and Remotion	5.2	RP = 7 OE = 10	2	26	29	FE = 33 URD = 20	23	93 (5 years) 58 (10 years)	17	L = 29 LWM = 12 T = 41
			UTW = 10	6.5	RP = 5 OE = 5	1.8	20	23	FE = 33 URD = 17	30	90 (5 years) 53 (10 years)	30	L = 50 LWM =10 T = 60
			Remotion = 7	3	RP = 2 OE = 5	2.2	30	34	FE = 34 URD = 22	10	100 (5 years)	0	L = 0 LWM = 14 T = 14
Boeckstyns *et al* (2013)	MC	65 48F/17M 58	Remotion	6.5	RP = 50 OE = 15	2.9 2.3	– –	41* 50*	FE = 53 URD = 26 FE = 87 URD = 35	8	90	5	L =11 LWM = 21 T = 32
Morapudi *et al* (2012)	UC	21 14F/5M 62	UTW 2	3.1	RP = 19 OE = 2	–	35	44	FE = 53 –	10	100	0	L = 0 LWM = 0 T = 0
Herzberg *et al* (2012)	MC	129 98F/31M 63	Remotion	4	RP	–	–	–	FE = 58 URD = 30	5	96	3	L = 4 LWM = 8 T = 12
		86 57F/29M 63	Remotion	4	OE	–	–	–	FE = 63 URD = 38	6	92	3	L = 3 LWM = 15 T = 18
Nydick *et al* (2012)	UC	23 – 63	Maestro Total Wrist System	2.3	RP = 5 OE = 18	2	–	31	FE = 90 URD = 43	30	96	4	–
Ward *et al* (2011)	UC	24 – –	UTW	7.3	RP = 24 OE = 0	–	–	40	FE = 62 –	45	60	5	L = 45 LWM = 10 T = 55
Ferreres *et al* (2011)	UC	21 7F/14M 54	UTW = 2 UTW 2 = 19	5.5	RP = 14 OE = 7	0.2	24	–	FE = 68 URD = 26	10	100	0	L = 5 LWM = 10 T = 15

Krukhaug *et al* (2011)	MC	90 80F/10M 57	Biax	9.3	RP = 84 OE = 6	–	–	–	–	20	85 (5 years)		T = 13
		23 9F/14M 55	Elos	4.6	RP = 0 OE = 23	–	–	–	–	43	57 (5 years)		T = 43
		76 44F/32M 52	Gibbon	2.6	RP = 32 OE = 44	–	–	–	–	14	77 (4 years)		T = 34
Herzberg (2011)	UC	20 17F/2M 56	Remotion	2.7	RP = 13 OE = 7	–	–	–	PR : FE = 34 URD =15 OE : FE = 53 URD = 21	0	100	0	L = 10 LWM = 0 T = 10
Strunk and Bracker (2009)	UC	41 – 54	Meuli = 15 Biax = 16 UTW2 = 10	5.3	RP = 33 OE = 8	–	–	61	FE = 50 URD = 20	26	–	8	–
Radmer *et al* (2003)	UC	40 32F/8M 48	APH	4.3	RP = 36 OE = 4	–	–	–	–	100	0	100	L = 97 LWM = 3 T = 97
Rahimtoola and Rozing (2003)	UC	29 18F/11M –	RWS	4	RP = 24 OE = 3	–	–	–	FE = 59 URD = 25	11	–	11	L = 11 LWM = 40 T = 51
Divelbiss *et al* (2002)	MC	22 22F 48	UTW	1.4	RP = 22	–	–	22	FE = 76 URD = 28	23	–	9	L = 5 LWM = 40 T = 45
Menon (1998)	UC	37 24F/7M 58	UTW	6.7	RP = 23 OE = 8	–	–	–	FE = 77 URD = 20	26	–	8	–

MC : multicentric, UC : unicentric, F : female, M : male, RP : rheumatoid polyarthritis, OE : other etiology, FE : range of motion flexion/extension, URD : range of motion ulnar/radial deviation, L : loosening with implant migration, LWM : Peri-prosthetic line and/or loosening without implant migration, T : total percentage of prothesis loosening, * : quick DASH.

UTW (KMI, San Diego, CA, USA), Remotion (SBI, Morrisville, PA, USA), UTW2 (Integra, Plainsboro, NJ, USA), Maestro Total Wrist System (Biomet, Warsaw, IN, USA), Biax (DePuy, Warsaw, IN, USA), Gibbon (Swemac, Linkoping, Sweden), Meuli (Zimmer, Warsaw, IN, USA), APH (Implant-Service Vertreibs GmbH, Hamburg, Germany), RWS (Howmedica Stryker, Kalamazoo, MI, USA).

6.7 years. Ferreres *et al* (2011), however, reports 100% survival at 5.5 years in a series with UTW1 (KMI, San Diego, CA, USA) and UTW2 (Integra, Plainsboro, NJ, USA) implants. Nevertheless, the rate of carpal plate loosening in his series approaches 1/21 and two other cases have radiolucency around the screw in the second metacarpal, nuancing this favourable survival rate and foreshadowing possible complications and implant removal in the future. Herzberg's *et al* (2012) recent multicentric study reports a 4-year survival rate of 96% and 92% for patients suffering, respectively, from inflammatory arthritis of the wrist or from other pathologies. These figures are comparable to our observation in the Remotion (SBI, Morrisville, PA, USA) implant subgroup. Boeckstyns *et al* (2013) reports 90% survival at 6.5 years in a multicentric series with Remotion (SBI, Morrisville, PA, USA) implant. Once again, radiographic signs of implant loosening is not zero but close to 11% and in 21% of other cases, osteolysis without any loosening of implant components is reported.

For patients whose wrist implant remained in place, our study underlines the discordant nature of the outcomes between patients' subjective satisfaction and objectively mediocre clinical and radiological results. Indeed, despite lessened grip strength and limited preserved motion, prosthetic implantation seems to offer a high level of satisfaction with a low level of discomfort in everyday activities, along with effective pain relief (Nydick *et al*, 2012 ; Morapudi *et al*, 2012 ; Levadoux and Legré, 2000 ; Strunk and Bracker, 2009). Many other authors (Kretschmer *et al*, 2007 ; Herzberg, 2011 ; Ferreres *et al*, 2011 ; Strunk and Bracker, 2009) have also reported pain relief and patient satisfaction as target outcomes in wrist arthroplasty. Our functional results are relatively good and correspond to those generally found (Ward *et al*, 2011 ; Morapudi *et al*, 2012 ; Ferreres *et al*, 2011 ; Strunk and Bracker, 2009) ; our results for flexion/extension, however, fall somewhat below more commonly reported scores (ROM 33° compared to 50° and greater).

Subjective satisfaction is confirmed by the percentage of patients wishing to repeat the same procedure. Such statements of opinion must, however, be nuanced, since after this type of treatment process, calling into question decisions made and efforts undertaken is not necessarily easy. Moreover, among those studies comparing functional outcome of arthrodesis to arthroplasty, some reveal no difference. These have often involved patients suffering from inflammatory disease where assessment did not focus solely on the wrist but on upper limb multi-joint impairment possibly explaining the absence of observed difference (Cavaliere*et al*, 2008 ; Murphy *et al*, 2003).

Impact on professional life is significant, frequently necessitating accommodations in the workstation. In this study, only 8 patients were still working at time of surgery. Only 2 of these patients were able to return to their same job. Few studies have reported on this difficulty, although a patient's profession, and notably the need to perform strenuous tasks, is a key element in the therapeutic decision.

The real problem posed by these implants is the absence of long-term performance of the carpal plate. This is not a recent question and recurs in numerous series (Krukhaug *et al*, 2011 ; Ward *et al*, 2011 ; Harlingen, 2011). Our series revealed 46% of cases of carpal plate loosening, with 40% sinking (respectively, 60% and 14% for the UTW1 (KMI, San Diego, CA, USA) and Remotion (SBI, Morrisville, PA, USA) prostheses). In our experience, more so than loosening, it is the plate sinking which predicts the need for arthrodesis. The literature reports comparable rates of loosening : Ward *et al* (2011) observes 55% in a UTW1 (KMI, San Diego, CA, USA) series ; Divelbiss *et al* (2002), 45% with the same prosthesis ; Rahimtoola and Rozing (2003), 51% in a RWS (Howmedica Stryker, Kalamazoo, MI, USA) series. More recently Herzberg *et al* (2012) observes 12% to 18% of loosening, depending on the indication, in a multicentric series with Remotion (SBI, Morrisville, PA, USA).

To explain the loosening of the implant, persistent mobility of the carpal bones might be pinpointed, in which case intracarpal arthrodesis should make it possible to limit these fixation problems. In our series, among the three patients with preprosthetic intracarpal arthrodesis, only one experienced no loosening. The number of cases is of course too small to draw large-scale conclusions, but preprosthetic arthrodesis in these patients did not appear to

solve the problem. Ward (2011) noted in a UTW1 (KMI, San Diego, CA, USA) series that the patients who had carpal component loosening were less likely to have radiographic evidence of intercarpal fusion than those who had stable prostheses. However, this difference did not reach significance.

The UTW1 (KMI, San Diego, CA, USA) prostheses have a statistically significant higher rate of carpal plate fixation failure than their Remotion (SBI, Morrisville, PA, USA) counterparts. Nevertheless, the two implants share very similar design and fixation methods. Both are comprised of a central stem to anchor in the capitate and two carpal screws for fixation in the trapezoid and the hamatate. Therefore, we cannot thus too readily conclude that the Remotion (SBI, Morrisville, PA, USA) prosthesis performs better since its follow-up period in our study was much shorter. Moreover, early signs of carpal plate migration have already been observed. In addition, analysis of the survival curve over the first 5 years is similar for both prostheses, since performance of the UTW1 (KMI, San Diego, CA, USA) implant falls off after that point in time. Only a comparably long follow-up period for the Remotion (SBI, Morrisville, PA, USA) implant will reveal its performance over time.

The ratio of capitate height to that of the third metacarpal was measured immediately following surgery and at final follow-up. The use of this ratio was based on the hypothesis that the height of the third metacarpal remains stable over time. When the ratio decreases, reflecting sinking of the carpal plate, arthrodesis revision surgery becomes inevitable in the short or medium-term. Indeed, the three patients needing arthrodesis because of symptomatic loosening all showed a frank, significant decrease of this ratio, to the order of 10% compared with less than 5% for patients with a loosened prosthesis and no clinical symptoms. We thus feel it important to monitor this ratio throughout the follow-up period, as it may well be a predictive factor for implant removal.

A major limitation of this study is the small number of patients and the use of two different implants with different surgical techniques : UTW1 (KMI, San Diego, CA, USA) cemented and with excision of the ulnar head ; Remotion (SBI, Morrisville, PA, USA) mainly uncemented and without excision of the ulnar head. Moreover, this is a retrospective study and the follow-up time is not the same for the two implants, shorter for the Remotion (SBI, Morrisville, PA, USA). Thus the comparison between the two implants should be cautious.

CONCLUSION

In conclusion, neither of the two recent implants studied in this series, so-called anatomically non-constrained, convincingly solved the problem of poor anchoring of the carpal plate. This question thus remains the weak point of these prostheses. Our series confirms the discordance habitually observed between patients' fairly favourable subjective satisfaction and mediocre clinical and radiological results over the long term. Hence, monitoring the ratio of capitate height relative to the height of the third metacarpal may well serve as a predictive factor of the need for implant removal. Indications must, however, be nuanced. The prosthesis should be a solution proposed to patients whose sole alternative is total wrist arthrodesis, a professional activity involving limited strenuous tasks and the desire to maintain a certain degree of mobility, all the while understanding that the solution is probably not definitive.

REFERENCES

1. **Boeckstyns ME, Herzberg G, Merser S.** Favorable results after total wrist arthroplasty : 65 wrists in 60 patients followed for 5-9 years. *Acta Orthop* 2013 ; 84 : 415-9.
2. **Cavaliere CM, Chung KC.** A Systematic Review of Total Wrist Arthroplasty Compared with Total Wrist Arthrodesis for Rheumatoid Arthritis. *Plastic and Reconstructive Surgery* 2008 ; 122 : 813-25.
3. **Chantelot C.** Les prothèses du poignet. *Chirurgie de la Main* 2006 ; 25 : 271-9.
4. **Divelbiss BJ, Sollerman C, Adams BD.** Early results of the Universal total wrist arthroplasty in rheumatoid arthritis. *J Hand Surg Am* 2002 ; 27 : 195-204.
5. **Ferreres A, Lluch A, Del Valle M.** Universal total wrist arthroplasty : midterm follow-up study. *J Hand Surg Am* 2011 ; 36 : 967-73.
6. **Harlingen D van, Heesterbeek PJC, J de Vos M.** High rate of complications and radiographic loosening of the biaxial total wrist arthroplasty in rheumatoid arthritis : 32

wrists followed for 6 (5-8) years. *Acta Orthop* 2011 ; 82 : 721-6.

7. **Herzberg G.** Prospective study of a new total wrist arthroplasty : short term results. *Chir Main* 2011 ; 30 : 20-5.
8. **Herzberg G, Boeckstyns M, Sorensen AI, Axelsson P, Kroener K, Liverneaux P *et al.*** "Remotion" total wrist arthroplasty : preliminary results of a prospective international multicenter study of 215 cases. *J Wrist Surg* 2012 ; 1 : 17-22.
9. **Kretschmer F, Fansa H.** BIAX total wrist arthroplasty : management and results after 42 patients. *Handchir Mikrochir Plast Chir* 2007 ; 39 : 238-48.
10. **Krukhaug Y, Lie SA, Havelin LI, Furnes O, Hove LM.** Results of 189 wrist replacements. A report from the Norwegian Arthroplasty Register. *Acta Orthop* 2011 ; 82 : 405-9.
11. **Levadoux M, Legré R.** 58 Arthroplastie totale de poignet par prothèse Destot pour arthrose radiocarpienne post-traumatique. Analyse retrospective de 25 cas. *Chirurgie de la Main* 2000 ; 19 : 331-2.
12. **Menon J.** Universal Total Wrist Implant : experience with a carpal component fixed with three screws. *J Arthroplasty* 1998 ; 13 : 515-23.
13. **Morapudi SP, Marlow WJ, Withers D, Ralte P, Gabr A, Waseem M.** Total wrist arthroplasty using the Universal 2 prosthesis. *J Orthop Surg (Hong Kong)* 2012 ; 20 : 365-8.
14. **Murphy DM, Khoury JG, Imbriglia JE, Adams BD.** Comparison of arthroplasty and arthrodesis for the rheumatoid wrist. *The Journal of Hand Surgery* 2003 ; 28 : 570-6.
15. **Nydick JA, Greenberg SM, Stone JD, Williams B, Polikandriotis JA**, **Hess AV.** Clinical outcomes of total wrist arthroplasty. *J Hand Surg Am* 2012 ; 37 : 1580-4.
16. **Radmer S, Andresen R, Sparmann M.** Total wrist arthroplasty in patients with rheumatoid arthritis. *J Hand Surg Am* 2003 ; 28 : 789-94.
17. **Rahimtoola ZO, Rozing PM.** Preliminary results of total wrist arthroplasty using the RWS Prosthesis. *J Hand Surg Br* 2003 ; 28 : 54-60.
18. **Reigstad A, Reigstad O, Grimsgaard C, Rokkum M.** New concept for total wrist replacement. *J Plast Surg Hand Surg* 2011 ; 45 : 148-56.
19. **Strunk S, Bracker W.** Wrist joint arthroplasty : results after 41 prostheses. *Handchir Mikrochir Plast Chir* 2009 ; 41 : 141-7.
20. **Ward CM, Kuhl T, Adams BD.** Five to ten-year outcomes of the Universal total wrist arthroplasty in patients with rheumatoid arthritis. *J Bone Joint Surg Am* 2011 ; 93 : 914-9.