EDITOR'S CHOICE

Five- to 10-Year Prospective Follow-Up of Wrist Arthroplasty in 56 Nonrheumatoid Patients

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Purpose The goal of the study was to evaluate the clinical and radiological outcomes of a cementless wrist arthroplasty with minimum 5-year follow-up in nonrheumatoid patients.

Methods Fifty-seven (40 male) patients with end-stage arthritis changes received an uncemented ball-and-socket total wrist arthroplasty (Motec Wrist). Function was evaluated before surgery and at yearly follow-ups. Visual analog scale at rest and activity, quick Disabilities of the Arm, Shoulder, and Hand (*Quick*DASH), active range of motion (AROM), and grip-strength were recorded. Standardized radiographs were taken to assess osteolysis, loosening, and subsidence.

Results Fifty-six patients were followed for a mean of 8 years (SD, 2 years). Eight wrists were reoperated with arthrodesis (4) or a new arthroplasty (4) owing to distal component loosening (3), infection (2), pain/fixed malposition (2), or proximal and distal component loosening (1). One radiocarpal dislocation was reduced closed and remained stable. Improved *Quick*DASH score and visual analog scale pain score both at rest and during activity were found at the last follow-up, as well as increased AROM (97° vs 126°) and grip strength (21 kg vs 24 kg). The radiological follow-up demonstrated loosening in 2 wrists. Thirty-five patients were working at surgery (17 manual labor) and 27 (11 manual labor) at follow-up. The 10-year Kaplan-Meyer survival of the implants was 86% for revision any cause, 2 additional arthroplasties are loose (but not revised), giving a survival rate of 82% if these are revised prior to 10 years of observation.

Conclusions An uncemented total wrist arthroplasty can provide long-lasting unrestricted hand function in young and active patients. *(J Hand Surg Am. 2017;■(■):■−■. Copyright © 2017 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words High-demand, osteoarthritis, nonrheumatoid, posttraumatic, total wrist arthroplasty.

THE ADVANCES IN HIP AND KNEE arthroplasty have stimulated the development of wrist prostheses with similar materials and fixation principles. A variety of articulations have been proposed including hinged, reverse, egg-shaped, cylindrical, and ball-and-socket designs. Early results were promising, but midterm follow-up was often disappointing.[1–4] The few reports on contemporary arthroplasties are mostly retrospective studies of patients with inflammatory arthritis.[5] The designs of the prostheses vary and few long-term results are reported.[6] Prospective short-term results with the Remotion (Stryker Medical, Kalamazoo, MI) and Motec (Swemac AB Orthopedics, Linkoping, Sweden) arthroplasties have been promising.[7,8] A registry-based multicenter study demonstrated a survival rate of 90% at 5 to 9 years follow-up with the Remotion prosthesis, which is comparable with total ankle and elbow replacements.[9] The Remotion and Motec prostheses have primarily been used in patients with inflammatory and posttraumatic arthritis, respectively. The purpose of our

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TABLE 1. Diagnoses

	n	%
SNAC wrist	16	28
SLAC wrist	14	25
Kienböck disease*	9	16
Distal radius fracture	7	12
Primary osteoarthritis	7	12
Other (eg, partial amputation [1], crush injury [1], prior infection [2])	4	7
Total	57	100

SLAC, scapholunate advanced collapse; SNAC, scaphoid nonunion advanced collapse.
*Four had Lichtman stage IIIB and 4 had Lichtman stage IV disease, 1 had a failed silicone lunate replacement.

TABLE 2. Wrist Surgery Prior to Arthroplasty

Fracture/nonunion surgery (radius/scaphoid-carpus)	21
Arthrodesis/resections (4CF, triscaph arthrodesis, lunate removal, stylodectomies, CMC1 interposition)	14
Miscellaneous procedures (arthroscopic procedures, tenosynovectomies, hardware removal, scapholunate (Brunelli) ligament reconstruction)	13
Distal ulna/Darrach	2
Total	50

4CF, 4-corner fusion.

prospective study was to assess the clinical and radiological results following cementless total wrist arthroplasty in nonrheumatoid patients with a minimum follow-up of 5 years.

MATERIAL AND METHODS

The study was approved by the Data Protection Officer at Oslo University Hospital (2006/10846 and 2011/20766), and all patients gave written informed consent to participate in the study.

Between 2006 and 2011, all patients with chronic wrist pain and degenerative (noninflammatory) arthritis of the wrist, eligible for wrist arthrodesis (68 patients altogether) were offered wrist arthroplasty. Fifty-seven patients (40 male) with a mean age of 52 years (SD, 11 years) preferred arthroplasty. There were 37 right wrists and 37 were operated on their dominant side. The cause of wrist degeneration is shown in Table 1. Osteoarthritis of the distal radioulnar joint was seen in 13 wrists at surgery (in addition to 2 patients with prior Darrach procedure).

Twenty-nine wrists had undergone a total of 50 surgeries prior to the arthroplasty (Table 2). Eleven bilateral wrist problems comprised primary osteoarthritis (4), scaphoid nonunion advanced collapse wrist (4), radius fracture (2), and scapholunate advanced collapse wrist (1). None of the patients underwent bilateral arthroplasty.

Fifty-seven total arthroplasties were performed with the modular screw-shaped uncemented Motec Wrist. The grit-blasted surfaces of the screws were coated with resorbable calcium phosphate Bonit (DOT Medical, Rostock, Germany). Three lengths of radius component (32, 38, and 44 mm) and 5 of capitate/third metacarpal (CMC3) component (45, 50, 55, 60, and 65 mm) screws were available, the latter in 2 thicknesses. The screws were intended for diaphyseal fixation in the radius and third metacarpal as well as fixation in the cancellous juxta-articular parts of the radius and CMC3. The CMC3 joint was fused (removing a wedge of the joint, extending the capitate, and transplanting cancellous bone) to create a one-bone CMC3 for fixation of the distal component. We used an 18-mm highly polished chrome-cobalt-vanadium metal-on-metal (MoM) ball-and-socket articulation (15 mm and metal-on-poly-ether-ether-ketone, a wear-resistant polymer are also available[10]) (Fig. 1).

The modular ball-and-socket taper-lock coupling has 3 neck lengths (giving a total of 5-mm difference) for tension adjustment. The metacarpal screws can be used for fixation in patients with a small radius and medullary canal. A detailed description of the implants and operative procedure has been reported by Reigstad et al.[8] At the start of the series, minimal bone resection was performed (limited to the lunate and proximal part of the scaphoid) to ease conversion to arthrodesis in cases for failure. Later, more bone (a proximal carpectomy and a radial styloidectomy) was removed during arthroplasty insertion to avoid the ulnar or radial impingement seen in some of the earlier cases. In 2 wrists, a simultaneous Darrach procedure was done. After 6 weeks of postoperative immobilization in a cast, formal hand therapy was initiated and a home exercise program was given. Unrestricted motion and load-bearing was permitted and encouraged.

The patients were evaluated before surgery as well as at 6 weeks, 6 months, 1 year, and yearly thereafter. They completed the quick Disabilities of the Arm, Shoulder, and Hand (*Quick*DASH) score[11] and graded radial- and ulnar-sided wrist pain at rest and during activity using a visual analog scale from 0 to 100 (0 indicating no pain). Active range of motion (AROM: flexion, extension, and radial and ulnar deviation) and active forearm rotation were measured using a

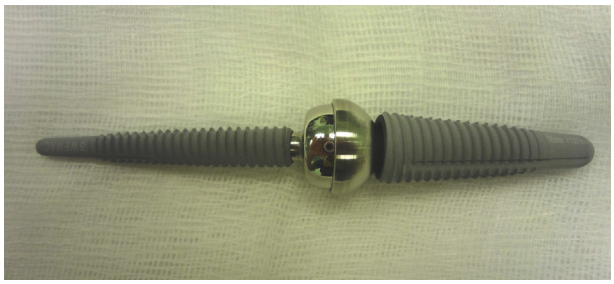

FIGURE 1: The Motec wrist arthroplasty. Long, thin screw-shaped distal component; thicker and shorter proximal component; and ball-and-socket articulation.

hand-held goniometer. Grip strength was assessed with a Biometrics G100 E-link Hand Dynamometer (Biometrics Ltd, Gwent, United Kingdom) using setting 2 and was the mean of 3 measurements. In addition, key pinch was measured with a JAMAR Key pinch dynamometer (JA 88 Preston Corp., Clifton, NJ) and the patients completed the validated Norwegian translation of the Patient-Rated Wrist and Hand evaluation (PRWHE),[12] which became available in 2013. Physiotherapists (B.B., T.L., S.R., J.H., and A.L.) independent of the surgeon performed the impairment measurements according to their standardized protocol. Wrists that underwent revision were excluded from the follow-up clinical evaluation.

Before surgery, anteroposterior and lateral radiographs and computed tomography scans were taken of the affected wrists. X-rays were obtained at each follow-up, as well as computed tomography scans when further clarification was required (ie, for evaluation of impingement and implant fixation if the radiographs were difficult to evaluate). Migration and subsidence were measured from the articular margins of the screws to the articulation of the head of the third metacarpal and to the ulnar notch of the radius, respectively. Scalloping or focal or linear osteolysis was described corresponding to the pattern of osteolysis seen in hip arthroplasties.[13] Loosening was defined as a surrounding radiolucency or migration/subsidence of the implant. Revision was defined as any operative procedure involving the exchange of the components or conversion to a total wrist arthrodesis. All surgeries around the operated wrist during the follow-up period are described independent of underlying cause. The radiological evaluation was done by the orthopedic surgeon authors (O.R., T.H.-G., C.G., R.T., and M.R.) without having the patients' clinical result available.

A minimum of 2 serological tests were obtained from every patient to assess the full blood cobalt and chrome levels by inductively coupled plasma mass spectrometry during the follow-up period after reports on high blood levels in hip MoM resurfacing arthroplasties.[14]

Statistical analysis

Histograms and QQ plots showed that the data were normally or approximately normally distributed, and therefore, parametric tests were applied. Data are presented as means with SD or range. Student *t* test was used to compare continuous variables. Confidence intervals are given, *P* values are 2-tailed, and the statistical significance level was set at *P* less than or equal to 0.05. A Kaplan-Meier survival graph was estimated using the time from operation to revision of any component for any cause (all patients still alive) as well as a Kaplan-Meier estimate including non-revised loosenings.

RESULTS

Fifty-six of 57 eligible patients were followed-up at a mean of 8 years (range, 5−11 years) (with 1 drop-out). The duration of the operation was a mean of 105 minutes (SD, 24 minutes). There were no complications during surgery; 1 postoperative wound discharge, identified 1 week after surgery, was treated with oral antibiotics and healed uneventfully. No deep infection developed in this patient during 8 years of subsequent follow-up. One dislocation that occurred after 1 year required a closed reduction and immobilization in a cast for 6 weeks. Nineteen additional surgeries were performed on 13 wrists including 9 bone resections (triquetrum, scaphoid, radial styloid, exostosis), 6 Darrach operations or ulna shortenings, 1 extensor pollicis longus reconstruction (extensor pollicis longus tendon rupture on a bony edge on a distal radius fracture patient), 2 tenosynovectomies (1 flexor and 1 extensor/De Quervain), and 1 volar ganglion causing carpal tunnel syndrome. The radiocarpal bone resections were performed in patients complaining of pain on radial or ulnar deviation and in whom there were radiological signs of bony impingement on subsequent follow-ups. A Darrach procedure was done if the patients had increasing pain and radiological signs of distal radioulnar joint (DRUJ) arthrosis. In 2 patients with a prior Darrach procedure, painful ulnar impingement on the radius was experienced and a further ulna shortening was done. The arthroplasties of none of the patients operated with distal ulna resection has been revised. The Darrach procedure increased motion and function and reduced the reported pain after the procedure. The patients reported similar clinical results as the patients with intact DRUJ at final follow-up. The other surgeries (bone

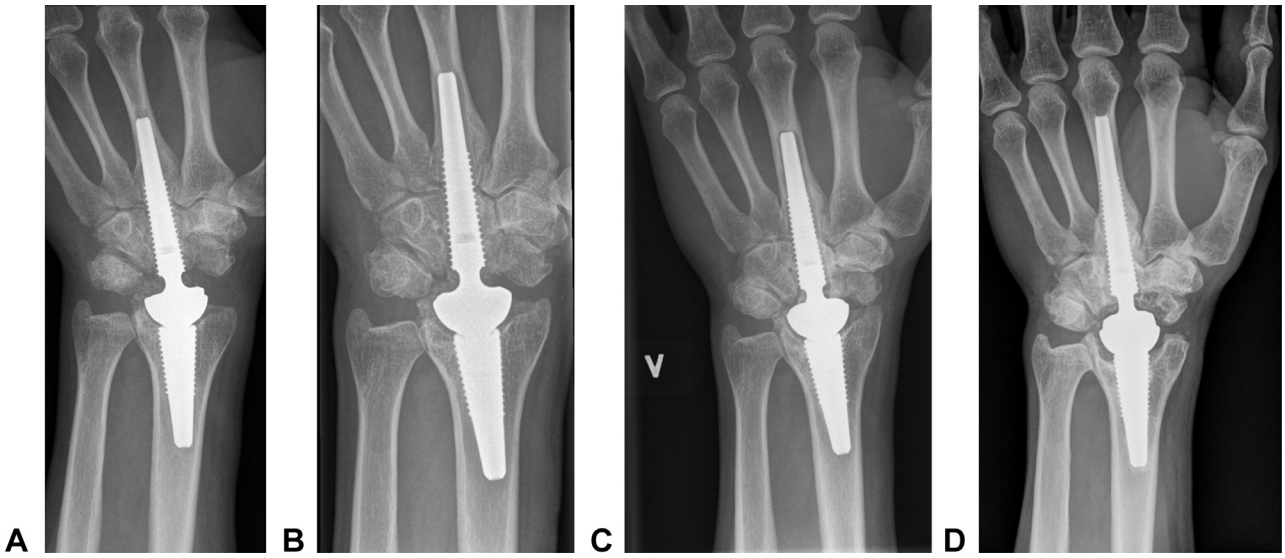

FIGURE 2: Distal loosening in a 42-year-old man with radiocarpal degeneration owing to Kienböck disease. **A** At 6 weeks, the screw did not pass through the isthmus of the third metacarpal and did not reach the end of the reamed cavity. Arthrodesis of the CMC 3 joint was unsuccessful. **B** Six months after surgery, a radiolucent line enveloped the distal component and the distal component had subsided. **C** At 1 year, distal loosening manifested. The radiolucent line surrounding the distal component had subsided. Note impingement between the distal radius and the carpus. **D** Eight years after revision, the distal component is well fixed. The new component has penetrated the isthmus of the third metacarpal and a successful CMC 3 arthrodesis is achieved. Note intimate bone-implant contact in the metacarpal. Periprosthetic radiolucent lines have been present in the capitate after the revision. The original radius screw is still well-fixed with spot-welding proximally. Good clinical result (*Quick*DASH, 21; AROM, 121°).

removal/carpal tunnel syndrome tenosynovitis) increased motion and function and reduced the pain at further follow-up.

An additional 8 patients who were an average age of 47 years (range, 31−63 years) at primary arthroplasty insertion (3 women, 4 dominant wrists) had revision surgery. Four were converted to arthrodesis and 4 to a new arthroplasty after a mean of 2 years (range, 1−6 years). Four were done because of implant loosening (3 distal loosenings, 2 of both components). They were exchanged to new, uncemented components (Motec) (Fig. 2). The remaining wrist fusions included inflammation (2), pain (1), and fixed malposition of the wrist (1). Radiological analysis demonstrated loosening in 2 additional wrists; both components in 1 wrist after 5 years and the distal component only in the other after 7 years. These 2 latter patients have been offered revision, but this has been postponed owing to the minor nature of their symptoms. They are followed at yearly intervals. The 2 wrists with inflammation disclosed pus in the joint at revision, but the bacterial cultures were negative. They were treated with a gentamycin-impregnated cement spacer and antibiotics for 3 months. The revision patients had scaphoid nonunion advanced collapse (3), Kienböck disease (2), distal radius fracture (1), and other secondary arthritis as primary diagnosis. Six of the 8 revisions and 15 of 19 additional surgeries were done on the 28 first-operated patients.

The last follow-up demonstrated significantly reduced pain (except for ulnar pain at rest) and *Quick*DASH scores as well as significantly increased AROM and grip strength, compared with the preoperative level in the 48 nonrevised patients (Table 3). Pronation and supination were unaffected by the surgery. The unoperated contralateral wrists showed 10% decrease in grip strength during the follow-up period (Table 4). The mean PRWHE for these 48 patients was 27 (SD, 23) at the last follow-up (PRWHE not available at primary arthroplasty insertion point).

Radiological examination at final follow-up in the remaining 46 patients (excluding the 2 loose but not revised patients) revealed minor osteolytic lines developing adjacent to the joint in the trabecular part of the radius (12) or capitate (19) in 23 wrists. The lines progressed slowly, halted after 2 to 3 years (in 1 after 4−5 years), and did not progress to the cortical bone in the radius or metacarpal. Focal osteolysis was seen in the radius of 9 patients (in 5, this was large, and in 4, limited) and in the capitate of 2. The largest osteolysis included most of the radial styloid (Fig. 3). All osteolysis appeared after 1 year and stabilized within 2 to 3 years. Their clinical results were similar to those of patients in whom this was not observed.

TABLE 3. Clinical Result for All Nonrevised Patients, n = 48

	Preoperative n (SD)	Follow-Up n (SD)	95% CI n (SD)	*P* Value
*Quick*DASH	39 (18)	25 (19)	8 to 20	< .05
Radial pain at rest	34 (23)	8 (14)	19 to 34	< .05
Radial pain at activity	69 (20)	20 (22)	42 to -57	< .05
Ulnar pain at rest	25 (26)	15 (26)	−7 to 20	.067
Ulnar pain at activity	48 (31)	23 (28)	14 to 36	< .05
AROM (°)	97 (35)	126 (37)	16 to 41	< .05
Supination (°)	81 (12)	83 (11)	−6 to 1	.19
Pronation (°)	82 (16)	83 (7)	−6 to 4	.66
Grip strength operated wrist (kg)	21 (11)	24 (10)	0 to 7	< .05
Grip strength unoperated wrist (kg)	35 (14)	32 (13)	3 to 6	< .05

95% CI, 95% confidence interval.

TABLE 4. Comparisons Between the Operated and the Contralateral Nonoperated Wrist, Preoperative (n = 57) and at Follow-Up (n = 48)

	Operated n (SD)	Nonoperated n (SD)	95% CI n (SD)	*P* Value
Key pinch (kg; n = 48)	7 (3)	8 (3)	−2 to 1	.35
Grip strength preoperative (kg; n = 57)	20 (11)	35 (13)	10 to 20	< .05
Grip strength follow-up (kg; n = 48)	24 (10)	32 (13)	3 to 12	<.05
AROM (°; n = 48)	126 (37)	182 (48)	38 to 73	< .05

95% CI, 95% confidence interval.

The remainder demonstrated radiologically intimate bone-implant contact (Fig. 4). Ectopic bone was present in 20 wrists, in which it was minor (spots in the joint space) in 15. None of the wrists demonstrated radiographic ankylosis due to ectopic bone.

At the final follow-up, 8 additional patients had developed degenerative changes in the DRUJ, giving a total of 23 patients with DRUJ degeneration (8 having had surgery performed on the ulna). Forty patients had an intact DRUJ with little or no pain at follow-up. In 5 of 6 distal loosenings, arthrodesis of the CMC3 joint had failed (Fig. 2).

Thirty-five patients were working (17 manual labor) at the time of surgery and 27 at follow-up (11 manual labor). The 10-year Kaplan Meier plot demonstrates estimated survivorship at 86% for revision for any cause (Fig. 5). Two additional arthroplasties are loose (but not revised), giving a survival rate of 82% if these are revised prior to 10 years' observation.

The blood−metal ion levels in all the patients were generally low, mean f-chrome of 0.6 (0.3) μg/L and f-cobalt of 0.8 (0.4) μg/L; the highest values were f-chrome of 1.6 μg/L and f-cobalt of 3.2 μg/L. Nine patients who had 1 to 3 other metal-on-plastic (MoP) hip, knee, or shoulder arthroplasties had slightly higher chrome-blood levels as compared with those with only wrist arthroplasty, having mean f-chrome of 0.8 (0.3) versus 0.6 (0.3) (95% CI, 0.06 to 0.32, $P < .05$). The difference of f-cobalt was nonsignificant (mean f-cobalt, 0.9 [0.3] versus 0.7 [0.4]; 95% CI, −0.33 to 0.05; $P = .15$), but the number of patients is low and a difference could be present (type II statistical error). The 10 patients with highest f-chrome and cobalt (mean, 1.2) had *Quick*DASH of 26, radial pain at rest (1), during activity (2), and ulnar pain at rest (1), and during activity (2), and mean AROM of 127°, results similar to the primary cohort of patients.

DISCUSSION

Long-lasting wrist arthroplasties in high-demand patients have previously been unavailable. We found

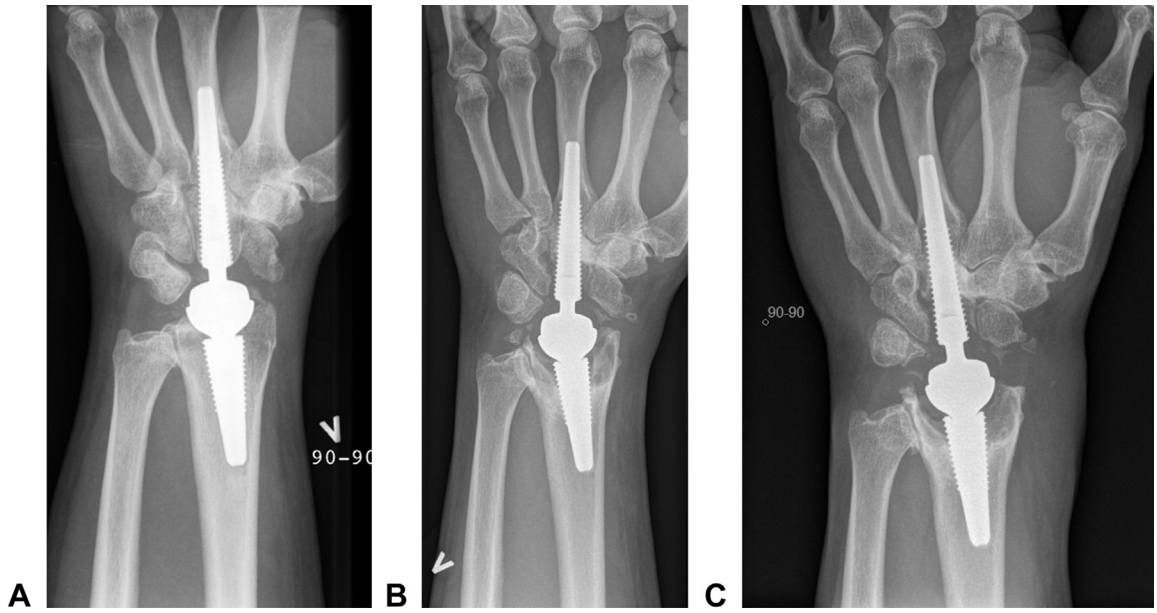

FIGURE 3: Focal osteolysis in 47-year-old man with scapholunate advanced collapse wrist. **A** At 1 year, note intimate bone-implant contact. **B** At 3 years, note focal, scalloped osteolysis, mainly in the radial styloid with minor ectopic bone on the radial and ulnar sides of the joint. **C** At 8 years, stabilization of the osteolysis has occurred. Sclerotic line delineates bone from osteolysis. No signs of loosening (no linear osteolysis or subsidence); ectopic bone is unchanged. Minor DRUJ degeneration is present. Good clinical result (*Quick*DASH, 4.5; AROM, 163°; pain free).

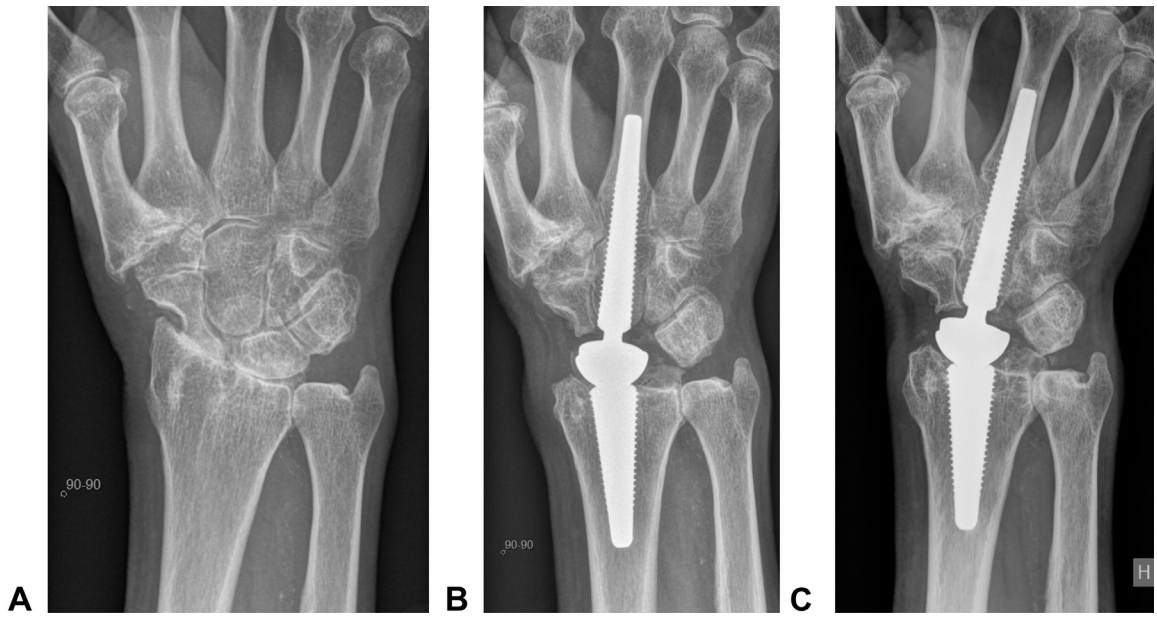

FIGURE 4: **A** Painful scaphoid nonunion advanced collapse wrist (bilateral) in a 70-year-old man. **B** At 1 year, note intimate bone-implant contact. Well-functioning. **C** At 7 years, there is still direct bone contact with both components. Spot weldings around the tips and CMC 3 arthrodesis. Well-functioning arthroplasty (*Quick*DASH, 53; AROM, 158°). Pain from the CMC1 interposition arthroplasty and trapezoid-scaphoid degeneration. The patient was scheduled for arthroplasty of the opposite wrist.

good clinical performance with the cementless MoM ball-and-socket Motec wrist after a mean of 8 years' follow-up in 48 of 56 high-demand patients as well as a rate of revision we found acceptable. Still, we encountered some problems such as component loosening (6), fixed malposition (1), and inflammation (2). Initially, we focused on bone preservation to ease the conversion to arthrodesis in cases of failure, and we applied a proactive policy toward offering patients to remove bone if the patients experienced impingement.

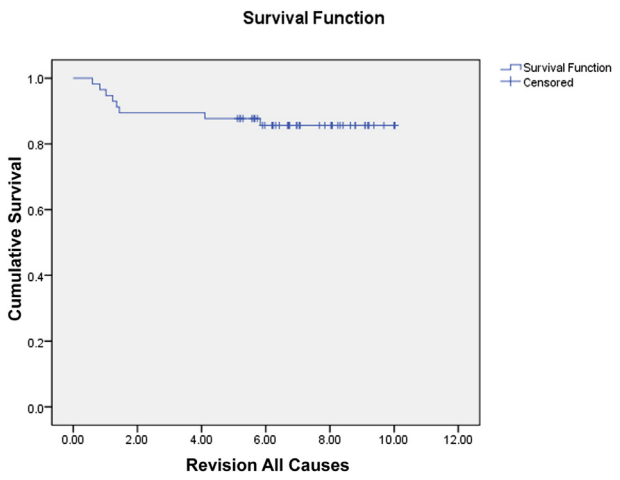

FIGURE 5: Kaplan-Meyer survival plot. Revision of components or conversion to arthrodesis.

This led to a high number of additional bone removals. Conversion to arthrodesis was relatively uncomplicated,[15] and a more extensive removal of bone during primary arthroplasty insertion was performed in the latter half of the series. The observation period was longer for the initial patients in whom the revision and reoperation rate was higher. The revisions were performed within 2 years for all, except 1 (in the latter, shorter observational part of the study) (Fig. 5). A similar trend was seen in the patients in whom additional surgery/other reoperations were performed. This change in focus during primary surgery has reduced complications, but we cannot rule out more revisions/reoperations, in the latter half of the series, with increasing observation time. We recommend a full proximal row carpectomy and a generous radial styloidectomy during the initial procedure to reduce impingement and secondary surgery. The Motec arthroplasty demonstrated increased range of motion and increased strength after 8 years compared with before surgery. More than 120° of relatively pain-free AROM and increased grip strength has been associated with the majority of patients continuing to work. The patients reported increased function and reduced pain. About 50% of our patients were referred to our hospital from other hospitals because the patients rejected having an arthrodesis performed. These patients were highly motivated for arthroplasty surgery and the rehabilitation needed. This could represent potential for selection bias resulting in higher patient satisfaction and lower pain scores owing to the motivation for the treatment given and the ownership the patients have in the decision of actively choosing arthroplasty.

A prospective series on the Remotion arthroplasty by Herzberg[7] demonstrated good short-term (32 months) results in 20 wrists (7 nonrheumatoid) and a complication rate of 2 components loosenings. The patients were included in a 5- to 10-year registry report of the same arthroplasty with 57 patients (25% men, 25% nonrheumatoid). Five (10%) had been revised, and a further 6 were considered radiologically loose. These patients experienced satisfactory reduction of pain and DASH scores, but no increased AROM nor strength was found in the nonrheumatoid patients.[9] Sagerfors et al[16] reported similar average 7-year results, with significant reduction of pain and DASH/PRWHE in 87 Remotion wrists. The 5-year survival was 94%, and 18% were considered loose. The Maestro arthroplasty (Biomet, Warsaw, IN) (with a cylindrical articulation and polyethylene on the concave side) has no published prospective reports, but promising 28 months' retrospective results in a study by Nydick et al.[6] Good pain relief and range of motion were achieved. The shortest follow-up was only 4 months, and no preoperative DASH, grip strength, nor wrist scores were provided. All arthroplasties were considered stable radiologically. Sagerfors et al[16] found excellent clinical results in 68 Maestro wrists (80% were women and 80% had rheumatoid arthritis) with 95% 5-year survival and only 2% loosening. Gaspar et al[17] reported retrospectively on 47 Maestro arthroplasties (Biomet) after 35 months. They experienced a high rate of complications, including 10 component failures/loosenings, 2 deep infections, and 2 instabilities as well as 28 other complications or follow-up surgeries. About two-thirds of the patients were women with inflammatory wrist disease, and the patients were older (65 years) than ours.[17]

The threads of the conical screws of the Motec provided primary fixation essential for bone ingrowth to take place. We propose that the surface roughness of the titanium alloy implants and the additional calcium-phosphate coating contribute to the bony anchoring. Titanium alloy screws with similar surface roughness and coating have demonstrated favorable osteointegrative properties in histological *in vivo* studies.[18] In hip arthroplasties, uncemented titanium alloy arthroplasties have given long-term stable fixation and excellent function in young patients, emphasizing primary, stable bone fixation and ingrowth as a prerequisite for long-term performance.[19] We have not found reports on wrist arthroplasties performing well in high-demand, young patients while performing poorly in low-demand patients. The 6 patients (4 revised and 2 not revised) with loose implants demonstrated a rapid, linear osteolytic pattern. In the wrists with juxta-articular scalloping osteolysis, the progression halted after 1 to 2 years.

Scalloping osteolysis has not correlated with component loosening or an unsatisfactory outcome. In well-fixed uncemented hip arthroplasties, scalloping osteolysis in trabecular bone has been attributed to stress shielding and is believed to be of lesser concern than linear osteolysis.[13] In cases of loosening, new larger-sized components can be used for revision. In cases of fixed malpositions or infections, we recommend conversion to arthrodesis. The 18-mm ball-and-socket MoM articulation has provided stability to the joint and increased the range of motion. Wrist range of motion greater than 120° is perceived as almost normal wrist function,[20] and a motion of 60° makes the majority of daily tasks possible compared with a stiff wrist.[21] Two-thirds of the wrists had more than 120° AROM, and 2 cases had less than 60°. A spherical articulation has been the choice in multidirectional arthroplasties in hip and shoulder replacements owing to high stability with maximum range of motion as well as low friction. The MoM articulations in poorly designed, large-diameter resurfacing hip arthroplasties demonstrate extreme blood ion levels, pseudotumour formation, and loosening.[14,22] In our patients, the measured levels of ions were low. The patient with the highest levels has a good clinical and radiological result. The recommended threshold level for further observation is 7.0 μg/L, set by the Medicines and Healthcare products Regulatory Agency in England.[23] A relatively small diameter and minor loading compared with hip resurfacing arthroplasties are plausible explanations for the low metal ion levels. We cannot exclude high levels of metal particles in the wrist joint. Like all arthroplasties, these prostheses should be monitored closely. Excessive wear has been a major issue in MoP wrist articulations and has contributed to high rates of revision with the BIAX (withdrawn in 2004)[24] and the Universal arthroplasties.[25] In the latter, revision of half of the wrists revealed polyethylene wear, metallosis, and carpal component loosening.[25] Boeckstyns and colleagues[26] performed histopathological examinations after a minimum of 3 years in 13 consecutive Remotion MoP wrists. Some of them demonstrated extensive osteolysis, and 3 prostheses were loose. They found polyethylene wear products in 19 of 24 specimens.[26] The authors emphasized the importance of close follow-up of these patients.

The limitation of our study is mainly its prospective cohort design without a comparable treatment group (either another arthroplasty or arthrodesis). Neither the surgeon nor the patient was blinded to the treatment given. A sample bias on the patients choosing arthroplasty over arthrodesis (being more motivated and reporting higher satisfaction) can be a possible limitation. The physiotherapist performing the clinical evaluation was independent of the treatment choice, but not blinded to the treatment. Evaluation of the radiographs was done by the surgeons involved in the study and not by independent radiologists. The strength of the study is the high number of patients with yearly follow-up, low drop-out frequency, and clinical evaluation performed by a therapist independent of the treatment choice.

Wrist arthroplasty is complicated. We have demonstrated favorable 8-year' results and acceptable rates of complications with a modern, osseointegrated MoM ball-and-socket prosthesis. The arthroplasty allows unrestricted hand function in high-demand patients with noninflammatory wrist arthritis.

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