

## ■ UPPER LIMB

# Promising one- to six-year results with the Motec wrist arthroplasty in patients with post-traumatic osteoarthritis

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**The Motec cementless modular metal-on-metal ball-and-socket wrist arthroplasty was implanted in 16 wrists with scaphoid nonunion advanced collapse (SNAC; grades 3 or 4) and 14 wrists with scapholunate advanced collapse (SLAC) in 30 patients (20 men) with severe (grades 3 or 4) post-traumatic osteoarthritis of the wrist. The mean age of the patients was 52 years (31 to 71). All prostheses integrated well radiologically. At a mean follow-up of 3.2 years (1.1 to 6.1) no luxation or implant breakage occurred. Two wrists were converted to an arthrodesis for persistent pain. Loosening occurred in one further wrist at five years post-operatively. The remainder demonstrated close bone-implant contact. The clinical results were good, with markedly decreased Disabilities of the Arm Shoulder and Hand (DASH) and pain scores, and increased movement and grip strength. No patient used analgesics and most had returned to work.**

**Good short-term function was achieved using this wrist arthroplasty in a high-demand group of patients with post-traumatic osteoarthritis.**

Arthrodesis offers a permanent painless solution for destroyed wrists, where it is less disabling than in other joints because of the compensatory movement of the forearm, elbow and shoulder. Some fused wrists, however, remain painful,<sup>1</sup> and any associated loss of movement in more proximal joints will lead to further reduction of hand function. A painless wrist with a range of movement > 110° provides almost normal function,<sup>2</sup> and just 25° of movement permits significantly more activities of daily living than arthrodesis.<sup>3</sup> Proximal row carpectomy and four-corner or other limited arthrodeses can preserve some movement in wrists that retain intact joint surfaces.<sup>4</sup> Arthroplasty of the wrist is usually only considered for elderly patients, those with an inflammatory arthritis, those with bilateral involvement and those with a low-demand lifestyle.<sup>5,6</sup>

We present the short-term results of the Motec wrist arthroplasty (Swemac Orthopaedics AB, Linköping, Sweden) in a group of young, active patients with non-inflammatory arthritis of the wrist.

### Patients and Methods

**Patients.** Between January 2006 and January 2011 all patients with symptomatic scaphoid nonunion advanced collapse (SNAC 3 or 4)<sup>7</sup> or scapholunate advanced collapse (SLAC 3 or 4)<sup>7</sup> scheduled for arthrodesis of the wrist were offered arthroplasty instead; of 35

patients, 30 selected the arthroplasty. The indication was severe pain associated with destruction of the radiocarpal joint, confirmed if necessary by CT,<sup>8</sup> as this is considered by our institution to be a contraindication for proximal row carpectomy or four-corner fusion. Of the 30 patients, 20 were men; there were 16 SNAC and 14 SLAC wrists; 23 right wrists and 23 dominant hands were affected. Previous surgery had been undertaken in 22 wrists (13 patients); this included fixation of fractures, ligament reconstruction, bone resection or limited arthrodesis, and eight wrists had been operated on more than once. A total of five patients had bilateral osteoarthritis of the wrist and eight had osteoarthritis of the ipsilateral distal radio-ulnar joint, one of whom had previously undergone a Darrach's procedure.<sup>9</sup> The mean age of the patients at surgery was 52.4 years (31.0 to 71.4) and 16 were American Society of Anesthesiologists (ASA) grade<sup>10</sup> 1, 12 were grade 2 and two grade 3.

**Implants.** The cementless Motec total wrist arthroplasty (Swemac Orthopaedics AB, Linköping, Sweden) (Fig. 1) relies on primary screw fixation with secondary bony ingrowth. The grit-blasted surfaces of the screws are coated with Bonit (DOT Medical, Rostock, Germany) (54 components: 26 metacarpal and 28 radial) or hydroxyapatite (HA) (Medical-Group, Lyon, France) (six components: four metacarpal and two radial), according to the

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Fig. 1

Photograph of the Motec wrist, showing the radial screw, the ball and socket articulation, and the longer and thinner capitare/third metacarpal screw (reproduced with permission of Swemac Orthopaedics AB).

surgeon's preference. Bonit is a 15  $\mu\text{m}$ -thick ( $\pm 5$ ) resorbable electrochemically deposited calcium-phosphate coating with osteoconductive properties.<sup>11,12</sup> Three lengths of radial (32, 38 and 44 mm) and five of capitare/third metacarpal (45, 50, 55, 60 and 65 mm) screws are available, the latter in two thicknesses. The cobalt–chrome–molybdenum articulation is highly polished and available in two diameters (18 and 15 mm); 18 mm was chosen for all our patients. The modular taper-lock coupling includes balls with three neck lengths and a total length variation of 5 mm. The maximum movement in all directions permitted by the coupling is almost 80° with the long and standard necks and 65° with the short neck. The arthroplasty was introduced in 2006 under the name Gibbon; in 2010 the name was changed to Motec without any changes in the design.

**Surgery.** Of the patients, 16 had general anaesthesia and 14 had plexus anaesthesia. A tourniquet was used in all patients, with a standard inflation pressure of 280 mmHg. A longitudinal incision is made on the ulnar side of Lister's tubercle from 3 cm proximal to the wrist joint to just distal to the third carpometacarpal (CMC 3) joint. The extensor retinaculum is elevated subperiosteally across to the radial styloid and close to the distal radio-ulnar joint. A longitudinal capsular incision is made from the radius to the CMC 3 joint. The lunate is removed together with the proximal half of the scaphoid, and a generous radial styloidectomy is performed. If ulnar impingement is suspected the triquetrum is excised. The distal radio-ulnar joint is left untouched. The CMC 3 joint is opened. Cartilage and bone is removed in a wedge-shaped fashion to establish an arthrodesis in slight extension. Under fluoroscopic control a guide wire is passed through the capitare, across the CMC 3 joint up to the head of the third metacarpal. A reamer is

introduced over the guide wire and advanced until it fills the proximal metacarpal diaphysis, optimally passing through the isthmus. The appropriate size of capitare/third metacarpal screw is inserted, and the CMC 3 arthrodesis is completed by inserting cancellous bone from the resected pieces.

The distal radius is opened with an awl in the middle of the ridge between the lunate and scaphoid fossae. A guide wire is passed under fluoroscopic control to the junction between the distal and middle thirds of the radius. The reamer engaging both cortices on the lateral view establishes the appropriate size of screw. After countersinking for the cup, the screw is inserted. Trial cup and balls optimise tension and range of movement.

Patients receive intravenous cefalotin/Keflin (EuroCept Pharmaceuticals, Ankeveen, The Netherlands) four  $\times$  2 g doses or clindamycin/Dalacin (Pfizer Inc. New York) four  $\times$  600 mg doses, the first dose pre-operatively. A dorsal plaster slab from the metacarpals to the proximal forearm secures the wrist in slight extension and radial deviation. The sutures are removed after two weeks and another cast is applied for four weeks, after which a programme of wrist exercises is started. The patients were reviewed at six weeks, six months, one year and yearly thereafter. Pre-operatively and at follow-up they completed the Disabilities of the Arm Shoulder and Hand (DASH) score.<sup>13</sup> They graded radial and ulnar-sided wrist pain at rest and with activity using a scale from 0 to 10 (0 indicating no pain). They were asked if they regretted choosing arthroplasty over arthrodesis, and whether they had used analgesia for symptoms from the wrist during the previous week. Active and passive movement of the wrist (AROM and PROM: flexion, extension, radial and ulnar deviation) and forearm rotation were measured using a hand-held goniometer. Grip strength was assessed with a Biometrics G100 E-link Hand Dynamometer (Biometrics Ltd, Gwent, United Kingdom), and key pinch with a JAMAR Key pinch dynamometer (JA 88 Preston Corp., Clifton, New Jersey). The measurements were done by physiotherapists who were neither involved in the treatment nor affiliated to our department. Revision was defined as any change of components or conversion to arthrodesis, and was considered a failure.

AP and lateral radiographs were taken pre- and post-operatively and at follow-up. They were compared and examined for CMC 3 arthrodesis, bone–implant contact and migration, by three authors (OR, MR and CG). Subsidence of the distal component was measured from the distal end of the metacarpal screw to the distal aspect of the metacarpal. Peri-prosthetic radiolucent lines were recorded. Loosening was defined as a continuous radiolucent line surrounding the component, or measurable migration. Focal osteolysis was defined as any round or scalloped area of bone loss. The results for the patients who underwent revision were excluded from the analysis.

**Statistical analysis.** Data are given as mean with standard deviations (SD). Student's *t*-test was used to compare continuous variables. A Kaplan-Meier survival graph was

**Table I.** Clinical results

Mean (SD) outcome*	Pre-operative (n = 30)	1 year (n = 27)	2 years (n = 21)	3 years (n = 14)	4 years (n = 8)	5 years (n = 4)†
Pain as measured by VAS						
Radially at rest	3.8 (2.3)	0.7 (1.2)†	1.0 (1.8)†	0.8 (2.0)†	0.5 (1.1)†	0.5 (1.0)
Radially at activity	7.4 (1.3)	1.9 (2.3)†	2.1 (2.6)†	1.6 (2.4)†	2.1 (2.3)†	4.3 (4.3)
Ulnarly at rest	2.6 (2.7)	0.8 (1.3)†	0.3 (0.8)†	0.4 (0.9)†	0.4 (0.7)	0.0 (0)
Ulnarly at activity	4.7 (3.5)	2.2 (2.6)†	0.8 (1.1)†	1.0 (1.7)†	1.5 (1.9)	0.5 (1.0)
ROM of operated wrist (°)						
Active	104 (32)	120 (24)	122 (20)	131 (26)	137 (22)	124 (32)
Passive	117 (35)	125 (24)	127 (20)	135 (26)	143 (24)	134 (41)
ROM of contralateral wrist (°)						
Active	188 (33)					
Passive	194 (36)					
Active supination (°)	83 (10)	85 (8)	87 (5)	89 (2)†	88 (8)	87 (5)
Active pronation (°)	87 (6)	82 (10)†	84 (5)	85 (4)	85 (6)	85 (7)
JAMAR operated (kg)	22.6 (12.7)	22.8 (10.5)	28.5 (10.8)†	28.6 (10.1)†	25.4 (9.7)	23.2 (4.6)
JAMAR contralateral (kg)	36.0 (12.9)					
DASH	43.0 (18.5)	19.2 (18.2)†	17.5 (14.7)†	17.1 (17.7)†	19.5 (13.2)†	22.9 (22.7)

\* VAS, visual analogue scale; ROM, range of movement; DASH, Disabilities of the Arm Shoulder and Hand

† p < 0.05 compared with pre-operative values

‡ statistics not performed on the five-year results due to small numbers

**Table II.** Working status of the patients

	Pre-operative (n)	Follow-up (n)
Heavy manual labour	7	6
White collar work	12	12
Disabled	4	7
Long-term sick leave	5	2
Pensioner or housewife	2	3
Total	30	30

estimated using the time from operation to revision for any cause, or death. All p-values were two-tailed, and the significance level was set at  $p \leq 0.05$ . The data were analysed with SPSS for Windows version 16.01 (SPSS Inc., Chicago, Illinois).

## Results

The mean operating time was 103 minutes (SD 20; 74 to 170). A concomitant Darrach's procedure was performed in one patient with symptomatic distal radio-ulnar osteoarthritis. There were no per-operative complications. A superficial post-operative wound infection occurred in one patient; it resolved with oral antibiotics. A plaster cast was retained for a mean of 44 days (SD 8; 17 to 62), and one patient declined follow-up after removal of the cast. However, four years later this prosthesis had not been revised. All the remaining patients were followed up according to the schedule for a mean of 3.2 years (1.1 to 6.1).

The clinical outcome improved rapidly during the first year and the improvement continued slowly up to three years and stabilised thereafter (Table I). Satisfactory pain relief, increased movement and grip strength were achieved. The mean key pinch at the latest follow-up was 8.9 kg (SD 2.7; 5 to 14) compared with 9.5 kg (SD 3.3; 2 to 14) on the opposite side ( $p = 0.44$ ). Most working patients

returned to their former occupations (Table II), and three of five patients on long-term sick leave pre-operatively were disabled at follow-up owing to general medical comorbidities. All the prostheses integrated well radiologically, without subsidence, osteolysis or radiolucent lines (Fig. 2).

Two patients with a painful well-fixed arthroplasty and a stable articulation and no soft-tissue metallosis underwent conversion to an arthrodesis without resolution of the pain. One developed symptoms six months post-operatively and underwent fusion at 16 months. The other developed symptoms five months post-operatively and exploration at seven months revealed inflammation with greenish exudate. Multiple bacterial cultures were, however, negative. The components were removed and a gentamicin-impregnated cement spacer introduced. A further arthroplasty was introduced four months later. The symptoms recurred without evidence of loosening, and fusion was performed eight months later. Both fusions healed and the latter patient returned to work. Loosening developed in one arthroplasty between the four- and five-year post-operative radiographs (Fig. 3). There were only minor symptoms and no further surgery has been undertaken.

Further surgery was performed in five other patients due to distal radio-ulnar joint or wrist pain. One underwent a Darrach's procedure 9.5 months post-operatively and four underwent resection of bone due to impingement. Focal osteolysis in the radius developed in three patients without affecting the clinical outcome, the largest including most of the radial styloid (Fig. 4), which stabilised after one year. Early peri-prosthetic radiolucent lines appeared in the capitate in one and in the third metacarpal in another. Both wrists were stable without signs of loosening, and their function was excellent. In these two patients the CMC 3 fusion had failed, which was also the case in the revised wrist with inflammation; the remaining CMC 3 fusions



Fig. 2a



Fig. 2b



Fig. 2c

Radiographs in a 59-year-old male patient, a) pre-operatively, showing a wrist with symptomatic scaphoid nonunion advanced collapse and osteoarthritis of the distal radio-ulnar joint; and b) and c) at three years post-operatively, showing intimate bone-implant contact without radiolucent lines or osteolysis. The Darrach's procedure had been performed at the index surgery.

healed. With two revised arthroplasties the six-year estimated survival was 93.3% (CI 5.1 to 6.1) (Fig. 5).

All would have chosen arthroplasty again knowing the outcome, except for the two who underwent revision.

**Discussion**

The development of the Motec wrist revealed surgical and technical shortcomings as well as problems with the fixation of the distal component due to the size and design of the reamers and screws. Movement of the CMC 3 joint prevented distal bone ingrowth, leading to loosening of the component.<sup>14</sup> The outcomes using the current version suggest that these difficulties have been resolved. The rounded tips of the reamers and screws help hold the components within the diaphysis. The CMC 3 arthrodesis (removing a wedge and thereby extending the CMC 3) creates a 'one-bone' capitate/third metacarpal unit that secures better fixation, especially distally, of longer and thinner distal



Fig. 3

Radiograph in a patient aged 49 years who was treated for symptomatic scaphoid nonunion advanced collapse, at a follow-up of 5.5 years, showing loosening of both components with radiolucent lines, subsidence and metacarpal diaphyseal widening.



Fig. 4

Radiograph in a male patient aged 47 years at operation showing focal peri-articular radial osteolysis filling the radial styloid at three years. There is sclerosis limiting the non-progressive lesion; the patient had an excellent clinical result.

screws. Creating 'one bone' in this way provides a long, solid bone block with distal cortical attachment similar to that for the fixation of cementless femoral stems.<sup>15</sup> Fixation of the distal component has been a problem with all previous wrist arthroplasties.<sup>16-18</sup> Most designs have limited the attachment to the carpal bones and the most proximal part of the second to the fourth metacarpals, and radiolucent lines and loosening have been reported despite fixation with two (Meuli) or three (Biax, Universal and Universal 1, Guepar) prongs.<sup>16,17</sup> Our results suggest that screw fixation in a 'one-bone' capitate/third metacarpal may prove satisfactory. Close follow-up is necessary, because further surgery is sometimes needed.

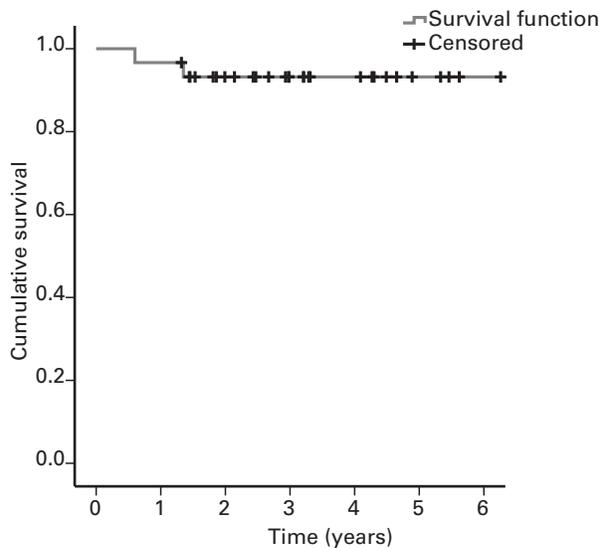


Fig. 5  
Kaplan-Meier survival curve.

Osseo-integration is a prerequisite for lasting fixation of a wrist prosthesis capable of withstanding the demands of a normal lifestyle. Primary screw fixation proved sufficient to allow secondary bone ingrowth. The osteoconductive coating has probably promoted osseo-integration,<sup>12</sup> consistent with the development of radiologically intimate bone-implant contact in all our patients. This is supported by the favourable clinical results in most of the well-fixed components.<sup>14</sup>

Infection seems to be a more frequent complication of arthroplasty of the wrist than of arthroplasty of the hip and knee.<sup>18-29</sup> We suspected one infection without loosening and one late septic loosening. In a study describing the development of this arthroplasty in eight patients at a follow-up between seven and nine years, one patient experienced implant loosening after a haematogenous infection.<sup>14</sup> Thin soft-tissue cover and previous surgery may contribute to an increased infection risk.

The scalloped juxta-articular osteolysis of the radius appears to mimic the peri-articular femoral osteolysis following total hip replacement and is not associated with loosening.<sup>21</sup> The radiolucent lines in the capitate and those in the metacarpal with intimate bone contact were probably caused by movement due to unsuccessful CMC 3 fusion. So far, screw fixation in the metacarpal or capitate only has allowed painless function of the wrist.

Conversion of the complex wrist joint into a single ball-and-socket articulation proved to be stable and mobile. Instability, subluxation and wear have been seen in egg-shaped arthroplasties such as the Biax and the Universal Total Wrist arthroplasty.<sup>17,22,23</sup> Good stability despite implant perforation and loosening have been reported following the use of the Meuli III arthroplasty that has a

reverse ball-and-socket articulation<sup>24,25</sup> although subluxation has been reported in rheumatoid patients.<sup>18</sup>

So far there are no indications of wear and particle-related problems with the Motec wrist arthroplasty. A new chromium-nitride surface coat has demonstrated a low wear rate experimentally<sup>26</sup> and might improve the wear properties and longevity of the implant.

Total wrist arthroplasty has mostly been limited to low-demand patients because of problems with loosening, instability and implant breakage.<sup>27-29</sup> Few publications report wrist arthroplasty in high-demand patients. Levadoux et al reported the outcome of the Destot arthroplasty in 25 patients with post-traumatic arthritis (SNAC and SLAC), with good results that were similar to ours regarding movement and strength, but six carpal components migrated, three metacarpal stems loosened and two fractured.<sup>20</sup> The arthroplasty was made of rough blasted 316-L steel, so poor bone conductive properties might explain the distal fixation problems. This arthroplasty has, however, been withdrawn from the market. Kretschmer et al<sup>17</sup> implanted the Biax arthroplasty mainly in post-traumatic wrists in 42 patients. The results at one year were promising, but within a mean of 2.6 years polyethylene wear, foreign body reaction, synovitis, loosening and subluxation led to revision in 11 patients, and the authors recommended abandoning the prosthesis.<sup>17</sup> Radmer<sup>30</sup> reported encouraging results at a mean of 18 months in 30 rheumatoid patients with a newly developed cobalt-chrome (APH) wrist arthroplasty with a titanium-coated articulation.<sup>30</sup> After two to six years, however, all wrists were revised or scheduled for revision.<sup>31</sup>

There are few reports of contemporary arthroplasties. After initial promising results with the Universal wrist arthroplasty, Ward et al<sup>16</sup> recently reported the five- to ten-year results in 20 rheumatoid patients; there were ten revisions due to polyethylene wear, metallosis, carpal component loosening or dislocation. A total of 38 modified Universal 2 wrist arthroplasties, mainly in rheumatoid patients, reviewed at a mean of 3.8 and 5.5 years respectively demonstrated increased movement and satisfaction (although strength was not reported), with distal loosening in two patients and subluxation in one.<sup>32,33</sup> The results of the Remotion wrist arthroplasty at a mean of 2.7 years were good in 13 rheumatoid patients (mean ROM 70°, mean grip strength increased from 7 kg to 11 kg), and acceptable in seven non-rheumatoid patients (mean ROM 50°, mean grip strength increased from 13 kg to 14 kg) with loosening occurring in one distal and one proximal component in rheumatoid patients.<sup>34</sup> The Norwegian Arthroplasty Register (NAR) published the results after wrist arthroplasty including the Biax and the Motec wrist.<sup>35</sup> The survival rate was approximately 80% at five and four years, respectively, with a higher revision rate in women than in men. The patients with the Biax arthroplasty had a longer follow-up but consisted almost exclusively of those with an inflammatory arthritis. For the Motec arthroplasty there were similar revision rates in non-inflammatory

and inflammatory patients, but the findings must be interpreted with caution owing to the incompleteness of registration of wrist arthroplasties (52%) in the NAR.

The Motec arthroplasty demonstrates good clinical results with acceptable rates of revision and complications at a mean of 3.2 years in high-demand patients with post-traumatic osteoarthritis of the wrist. Additional surgery is necessary in some patients, predominately for impingement.

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