Revision/Failed Total Wrist Arthroplasty

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Introduction

Fourth-generation implants for total wrist (TW) arthroplasty have been available for more than 20 years, and consequently, an increasing number need revision. The treatment options for the salvage of failed TW arthroplasty include arthrodesis, TW revision arthroplasty, resection arthroplasty, and interpositional pyrocarbon arthroplasty. TW arthrodesis is the reference treatment, but revision TW arthroplasty is an alternative option [1–5]. Interpositional and resection arthroplasties have been reported occasionally. In this chapter, published results and the author's personal experience are presented.

Survey of the Literature

Salvage by TW Arthrodesis

Revision of failed older-generation TW arthroplasties has been challenging due to the large bone defects resulting from the extraction of the bulky implants [4, 6–8]. Since total wrist arthrodesis was known to be a good solution for painful destroyed rheumatoid wrists, TW arthrodesis has been the most frequently used revision procedure in the days when rheumatoid arthritis was the main indication for TW arthroplasty. The technical challenges include extraction of osseointegrated components (typically the radial component), restoration of proper carpal height, and obtaining stable fixation. The radius may need to be split to facilitate removal of the implant, and cement and cerclage wires may be used to stabilize the radius in these cases. Bone grafting of the residual bony defect with an iliac crest autograft or an allograft – typically from a femoral head – is mandatory.

Intramedullary Steinmann pins, in some cases supplemented with staples, have been the most common method of fixation, but substantial complications and nonunion rates have been reported [9–12]. The series of Beer and Turner [9] included revision of eight silicone spacers and four older-generation implants. Only 7 out of 12 wrists achieved fusion, although non-fused arthrodeses could be well-tolerated. Carlson and Simmons [10] published a series of 12 wrists – 5 silicone and 7 older-generation TW arthroplasty – that were revised to a wrist arthrodesis. Complications included two patients with nonunions requiring secondary bone grafting procedures, and two patients requiring revisions of their intramedullary pins. Radmer et al. [13] revised 36 APH

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G. J. W. King, M. Rizzo (eds.), *Arthroplasty of the Upper Extremity*,
https://doi.org/10.1007/978-3-030-68880-6_9

prostheses (APH, Implant-Service Vertriebs-GmbH, Hamburg, Germany) to arthrodesis, 25 with intramedullary nail fixation and 11 with plate and screw fixation, and obtained primary union in 34: the 2 nonunions occurred in the intramedullary nail group. Rizzo et al. [12] examined the outcomes of wrist arthrodesis for failed total wrist arthroplasty in a study of 21 wrists. The arthrodesis was stabilized with pins or plate and screws and achieved primary fusion in 11 wrists, while 10 had a nonunion.

Brase and Millender [14] reported on 16 revisions of failed silicone implants. Twelve wrists were revised to another silicone implant and four were fused. While the results after revision with another implant were discouraging and only four of the patients revised with implants reported adequate strength for most normal activities, all four patients that had an arthrodesis obtained stable, pain-free wrists [14].

Ferlic et al. [11] revised 19 wrist arthroplasties – 7 silicone implants and 12 metal-on-plastic total wrist arthroplasties. Each of the seven silicone implants was successfully revised in one operation; the four fusions and three total wrist implants were functioning 6 or more years after surgery. Nineteen operations were needed to revise the metal-on-plastic implants. All of the loose prostheses eventually required arthrodesis, but, of these two required more than one attempt [11].

More recently plate and screw fixation has been the most used fixation method (Fig. 9.1). A locking plate is preferred owing to the poor bone quality in many rheumatoid patients and the prolonged time that may be required for fusion. Adams et al. [15] published a series of 20 wrists, including 15 revisions of a fourth-generation TWA and 5 older-generation implants, one of which was a silicone spacer. All patients were treated using a dedicated wrist arthrodesis dorsal plate (Synthes, West Chester, PA) and a contoured cancellous femoral head structural allograft. Nineteen of 20 wrists fused at the first attempt at a median of 4 months. Proximal plate loosening occurred in one wrist, but the joint still fused at 6 months [15]. Reigstad et al. published a series of 11 failed Motec or Elos wrist arthroplasties (Swemac Orthopaedics AB, Linköping, Sweden) for osteoarthritis which were subsequently converted to arthrodesis using an arthrodesis plate in 8 cases or a customized peg in 3 cases. Clinical and radiological bone union was achieved in all the operated wrists.

Rizzo et al. [12] report on the functional results after TW arthrodesis for failed arthroplasty. Fourteen of 21 wrists had no pain, and there was an overall average pain score of 2.6

Fig. 9.1 Revision of a failed Remotion total wrist arthroplasty to a total wrist arthrodesis

(range 0–7) on a visual analogue scale from 0 to 10. The group of patients with persistent nonunion of the arthrodesis had an average pain score of 3.3 (range 0–7) versus an average pain score of 2.1 (range 0–4) in the group that fused. Overall DASH scores averaged 33 (range 11–59). The average DASH was 29 (range 11–45) in the fused group and 36 (range 13–57) in the nonunion cases. Return to work data were applicable in only ten patients, of whom four were able to return to their previous level of work, four returned to work with some degree of restriction, and two either ceased work or were unable to return to work.

Revision Arthroplasty

Rettig and Beckenbaugh used a Biaxial implant (DePuy Orthopedics, Warsaw, IN, USA) to salvage 13 failed total wrist arthroplasties of various designs, including 2 cemented Meuli (Protek AG, Bern, Switzerland), 7 Swanson Silastic (Wright Medical, Memphis, TN, USA), 2 Biaxial, and 2 Volz (Howmedica Company, Rutherford, NJ, USA) total wrist arthroplasties [2]. The distal component of the revision implant was cemented in all cases, the proximal component in 11 cases. Within a follow-up period of 31 months, two cases were converted to another prosthesis and one to a wrist arthrodesis. Two more implants showed radiographic signs of loosening. The clinical results were satisfactory in the remaining.

Cobb and Beckenbaugh published a series of ten cases of total wrist arthroplasty with a custom long-stemmed multipronged distal component, mostly a two-pronged component in the second and third metacarpal. Two had been converted to a TW arthrodesis. For the remaining eight patients, the mean follow-up period was 3.8 years (range, 3.0–4.8 years). All of the cases had functional total wrist arthroplasties at the latest follow-up evaluation [1].

Fischer et al. [16] reported on 16 revision TW arthroplasties after failure of TW arthroplasties of various designs. All patients suffered from rheumatoid arthritis. The types of revision surgery performed were exchange of the whole prosthesis in 11 cases, exchange of the proximal component in 1, and exchange of the distal component in 4. Biaxial, Remotion (Stryker, Kalamazoo, MI, USA), or Universal 2 (Integra LifeSciences, Plainsboro, NJ, USA) components were used for revision. Cement was used for fixation of the distal component of the Biaxial prosthesis in six cases. In the other cases, synthetic bone graft or allograft bone from a fresh-frozen femoral head was used to compensate for bone loss around the distal component. Four of the 16 revision arthroplasties were re-revised. Three wrists ended up with a TW arthrodesis and one with a resection arthroplasty. The 5-year cumulative implant survival was 74%, and the median DASH and PRWE scores were 60 and 37, respectively, at 5 years [16].

Pinder et al. published a series of 19 cases with various diagnoses. Five of the primary implants were silicone spacers, five were Universal 2, and eight were Biaxial. The implants used for revision were Universal 2 and Biaxial. The mean follow-up time was 10 years. The cumulative 5-year implant revision survival was 83%. Clinical outcome data were available for five patients only [17].

Talwalkar et al. report on ten failed Biaxial implants. Nine of these suffered from rheumatoid arthritis. Six underwent a revision to a second biaxial wrist replacement, three had a wrist fusion, and two were treated by excision arthroplasty. Nine of these patients were available for a clinical review. Follow-up time was 28 months. No re-revisions required further surgery or revision. Two patients with revision wrist replacements had good results, one had a fair result and one had a poor result [3].

Zijlker et al. [5] published a series of 40 wrists in 37 patients with a failed Biaxial prosthesis that were converted to a Universal 2 total wrist arthroplasty. In 24 patients the diagnosis was rheumatoid arthritis; in 11 it was osteoarthritis and in 2 Kienböck's disease. Autologous corticocancellous bone graft from the iliac crest was used in all patients. Sixteen of the 40 implants eventually failed. The cumulated 5-year survival was 87% and the 9-year survival 60%. There was no sig-

nificant difference between rheumatoid and non-rheumatoid patients in terms of implant failure. Sixteen of the 24 Universal 2 implants that remained in situ after a mean follow-up of 9 years functioned satisfactorily. Patient-Rated Wrist and Hand Evaluation scores and Quick Disabilities of the Arm, Shoulder and Hand scores were 53 and 47, respectively [18].

Interpositional Pyrocarbon Arthroplasty

Case reports about revision of failed TW arthroplasties with the pyrocarbon radiocarpal Amandys (Tornier, Montbonnot, France) have been presented, but larger series have not been published [19].

Resection Arthroplasty

This solution is sometimes adopted in patients who are unfit for a major procedure, or in cases where implants are excised because of infection and the result turns out to be functionally acceptable. Reports are very scarce. Both cases in the series of Talwalkar et al. had excellent results [3].

Author's Preferred Techniques and Personal Experience

Technique for Revision Arthroplasty

The procedure is performed in general anesthesia or regional block and with a tourniquet applied at the upper arm. The previous skin incision over the dorsum of the hand and wrist is used. Usually the extensor retinaculum is well defined and can be divided in the fourth compartment (Fig. 9.2). The wrist capsule is opened making a U-shaped, distally based flap (Fig. 9.3). Typically, the carpal component can be removed with minimal force, especially if it is loose, which often is the case (Fig. 9.4). Removal of a well-fixed radial component can be challenging (Fig. 9.5). Burring and chiseling all around the component or an osteotomy of the radius is usually required to disrupt the osteointegration of an uncemented component or to break the cement mantle of a cemented component. Making the osteotomy at the radial side preserves the dorsal cortex. All cement, membranes, and necrotic bone are removed (Fig. 9.6). The cavities are filled with cancellous bone (Fig. 9.7). Subsequently, the radial diaphysis and the capitate are reamed (Fig. 9.8). The trial components are placed (Fig. 9.9), and their position is checked under the image intensifier. In the case of severe bone loss, a bone allograft is intercalated between the carpal plate and the reaming distal bone. The stability of the arthro-

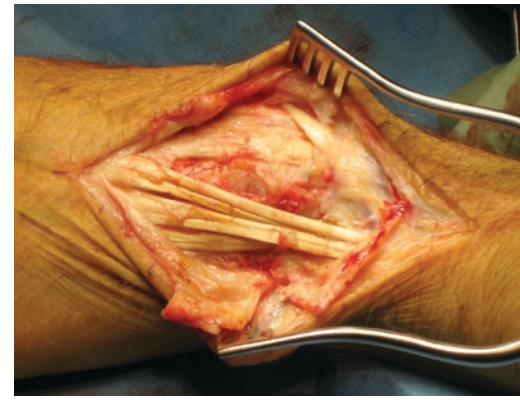

Fig. 9.2 Intraoperative photograph showing the well-defined, reflected extensor retinaculum, divided in the fourth compartment

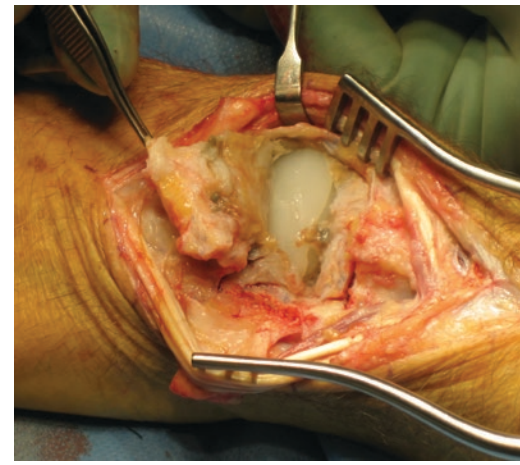

Fig. 9.3 A distally based U-shaped capsular flap has been reflected, exposing the implant

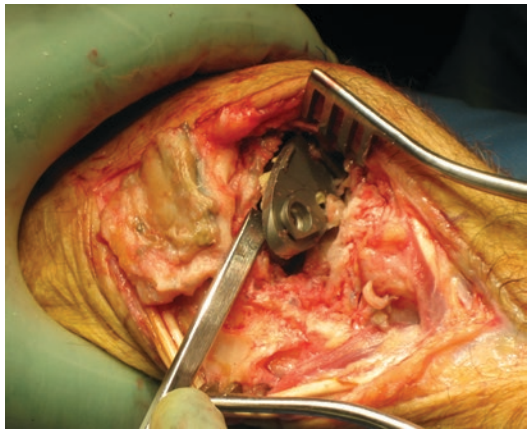

Fig. 9.4 Removal of the distal component is usually easy

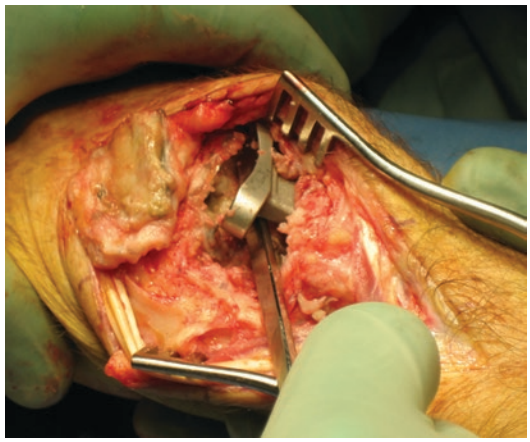

Fig. 9.5 Removal of the loose proximal component was easy in this case, but removal of a solidly osseointegrated component can be challenging

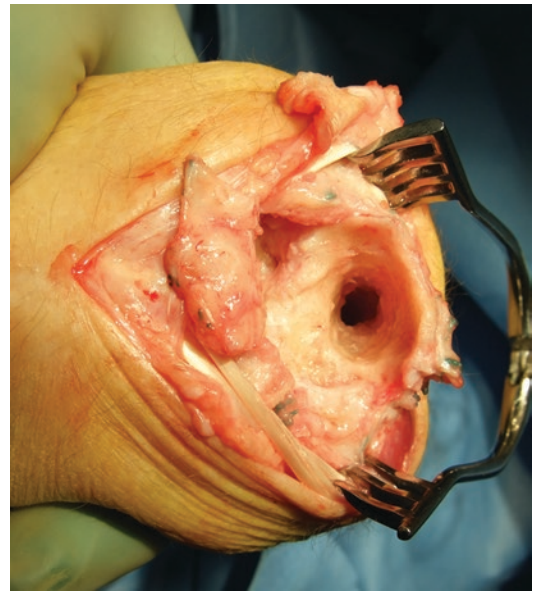

Fig. 9.6 The radial cavity has been completely cleaned for cement, membranes, and necrotic bone

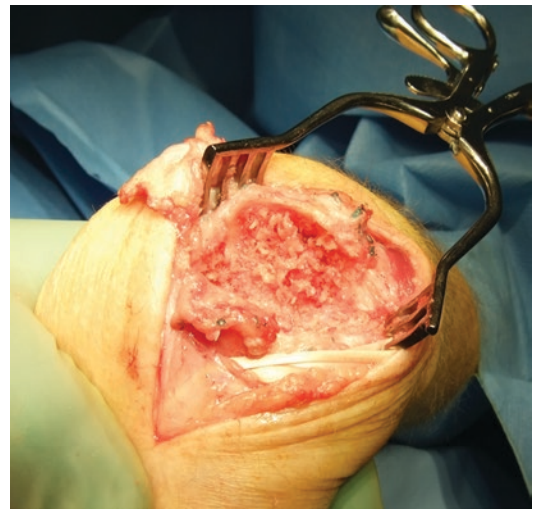

Fig. 9.7 The radial cavity has been packed with cancellous allograft

plasty is tested during passive wrist motion as well as by longitudinal traction: this is subjective and requires experience. Finally, the implant components are impacted. I use a plastic or bony plug to obliterate the bottom of the radial cavity (Fig. 9.10) and mostly a cemented technique. Any excess cement is removed and remaining cavities are filled with cancellous bone (Fig. 9.11). A standard layered closure is performed (Fig. 9.12). The wrist is protected in a cast for 2 weeks and thereafter mobilized with gradually increasing loads. In case of a subsided carpal component that needs revision and a solidly implanted radial component, it suffices to exchange the carpal component alone, provided the same type of prosthesis is available.

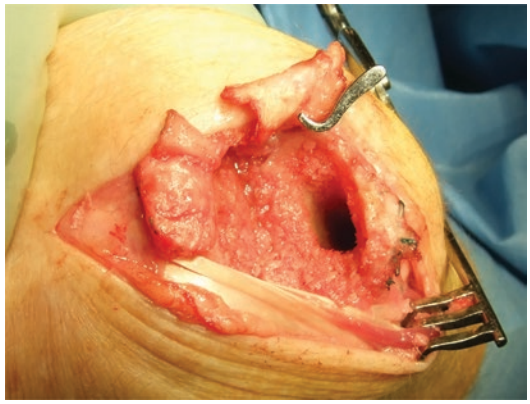

Fig. 9.8 The grafted radial cavity has been reamed

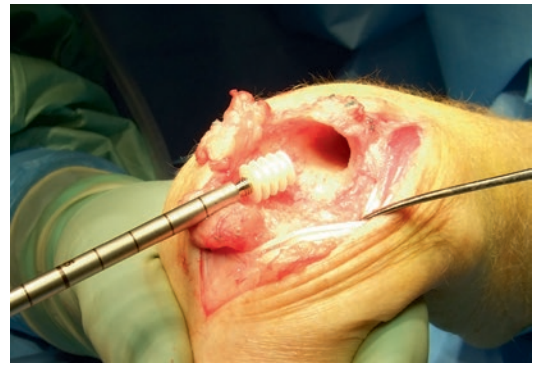

Fig. 9.10 A plastic plug is inserted to close the bottom of the radial cavity before cementation of the radial implant

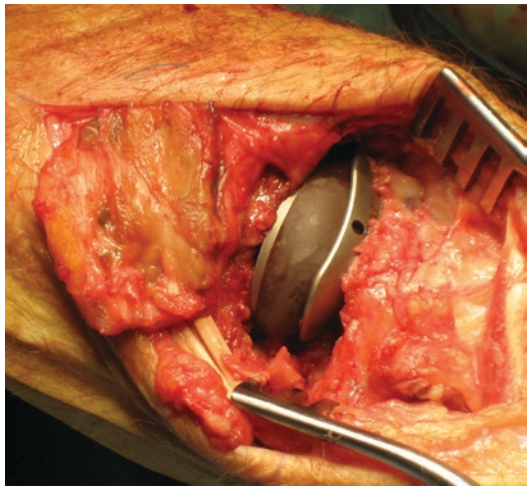

Fig. 9.9 The trial components are impacted, ready for stability testing. Carpal height and stability can be adjusted by choosing the right thickness of the intercallated carpal ball

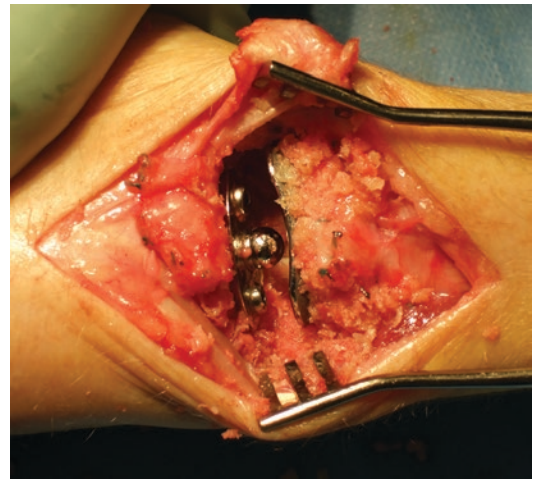

Fig. 9.11 The final components are in place, and residual bone defects have been grafted before impacting the intercallated polyethylene carpal ball

Technique for Conversion to TW Arthrodesis

The approach and the removal of the failed components are performed as described above. A femoral head structural allograft is prepared to fit the bone defect and preserve the carpal height (Fig. 9.13). Care is taken to fuse the third carpometacarpal joint by removing its articular surfaces and packing the defect with cancellous bone. A stainless steel or titanium wrist arthrodesis plate is applied to the radial shaft and third metacarpal using a standard technique. Whenever possible, I prefer a pre-contoured plate to position the wrist in slight extension (Fig. 9.14). Screws are not inserted through the central portion of the plate in order to avoid fracture of the graft.

Clinical Series

I reviewed a consecutive series of failed TW arthroplasties that were revised at Gentofte Hospital, Denmark, between 2008 and 2018 (Table 9.1). The primary implants were nine Remotion, two Motec, and one Universal 1.

Fig. 9.12 A standard layered closure is performed

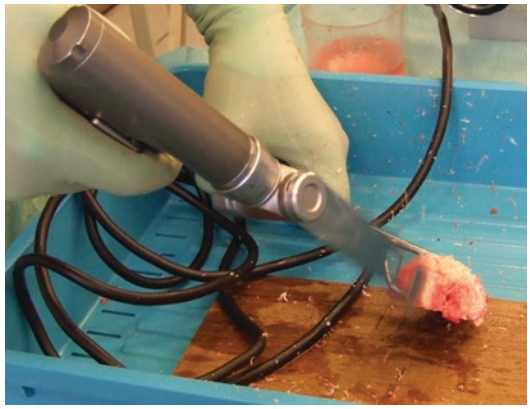

Fig. 9.13 Preparation of a fresh-frozen femoral head to fit into the defect left after extraction of the implant to be revised

Fig. 9.14 Revision arthrodesis positioned in slight, functional extension. The degree of extension can be adjusted according to individual needs

Mean age at primary operation was 58 years (range: 28–78). The choice of revision technique was based on stability and bone stock and finally decided by shared decision-making with the informed patients. The mean follow-up time was 31 months (range 3–102). Arthrodesis was used as the first revision procedure in four cases, using plate and screw fixation. Revision arthroplasty was performed in ten cases, using a Remotion TW prosthesis (Fig. 9.15).

Results

Five of the ten revision Remotions were re-revised and all finally ended up with a TW arthrodesis. All arthrodeses went on to fuse at the first attempt. The median QuickDASH score for patients with a functioning Remotion prosthesis was 36 at follow-up (range 18–54) and median VAS score for pain 0 (range 0–2.5). Median QuickDASH score for patients with fused wrist was 34 (range 25–63) and VAS score 2 (range 0–2). The differences of the scores between the Remotion and the fused groups were neither statistically nor clinically significant ($p = 0.23$ and 0.35, Mann-Whitney U test).

Discussion

Total wrist arthrodesis for the salvage of failed TWA results in a complete limitation of wrist flexion/extension and radial/ulnar deviation. In order to prevent these limitations, failed implants could be salvaged by a revision implant. However, the reported implant survivals seem definitely lower compared with the survival rate in primarily implanted fourth-generation TW prostheses reported by some authors (91–100% at 8–10-year follow-up) [20–23] but not much different from the survival reported by others (50–69% at 8–10 years) [24–28]. In my personal series, half of the revised TW arthroplasties were ultimately converted to TW arthrodesis. Conversely, all

Table 9.1 Characteristics of 14 revised wrist arthroplasties

Patient number	Characteristic										
	Sex	Age	Diagnosis	Primary implant	Indication for revision	Revision technique	Re-revision	Final wrist status	QuickDASH score	VAS score for pain	Patient satisfaction
1	F	39	RA	Remotion	Fixed flexion deformity	Arthrodesis	No	Fused wrist	31	0	Very pleased
2	F	56	RA	Remotion	Loosening carpal and radial component	Cemented Remotion	No	Remotion	36	2	Very pleased
3	F	28	PT (SLAC)	Remotion	Malposition	Cemented Remotion	Arthrodesis	Fused wrist	63	2	Pleased
4	F	57	RA	Remotion	Loosening carpal component	Uncemented Remotion	Arthrodesis	Fused wrist	54	2	Pleased
5	M	65	RA	Remotion	Loosening radial component	Cemented Remotion	1. Implant removal 2. Arthrodesis	Remotion	16	2	Pleased
6	F	73	OA	Remotion	Loosening carpal component	Cemented Remotion	Arthrodesis	Fused wrist	No follow-up		
7	M	54	OA	Remotion	Loosening radial component	Cemented Remotion	No	Remotion	22	2.5	Pleased
8	M	68	SNAC	Universal 1	Loosening radial component	Cemented Remotion	No	Remotion	18	0	Very pleased
9	F	51	SLAC	Motec	Loosening carpal component	Cemented Remotion	1. Re-arthroplasty 2. Arthrodesis	Fused wrist	26	2	Pleased
10	F	55	RA	Motec	Loosening carpal component	Cemented Remotion	No	Remotion	54	0	Very pleased
11	F	78	RA	Remotion	Loosening carpal component	Arthrodesis	No	Fused wrist	43	1	Very pleased
12	F	61	Kienböck's disease	Remotion	Loosening carpal component	Cemented Remotion	No	Remotion	36	0	Pleased
13	M	68	OA	Remotion	Pain and osteolysis	Arthrodesis	No	Fused wrist	36	2	Pleased
14	F	57	PT (SLAC)	Remotion	Loosening carpal component	Arthrodesis	No	Fused wrist	25	1	Pleased

F female, *M* male, *OA* osteoarthritis, *RA* rheumatoid arthritis, *PT* post-traumatic arthritis, *SLAC* scapholunate advanced collapse, *QuickDASH* short version of the Disabilities of the Arm, Shoulder and Hand questionnaire, *VAS* visual analogue scale

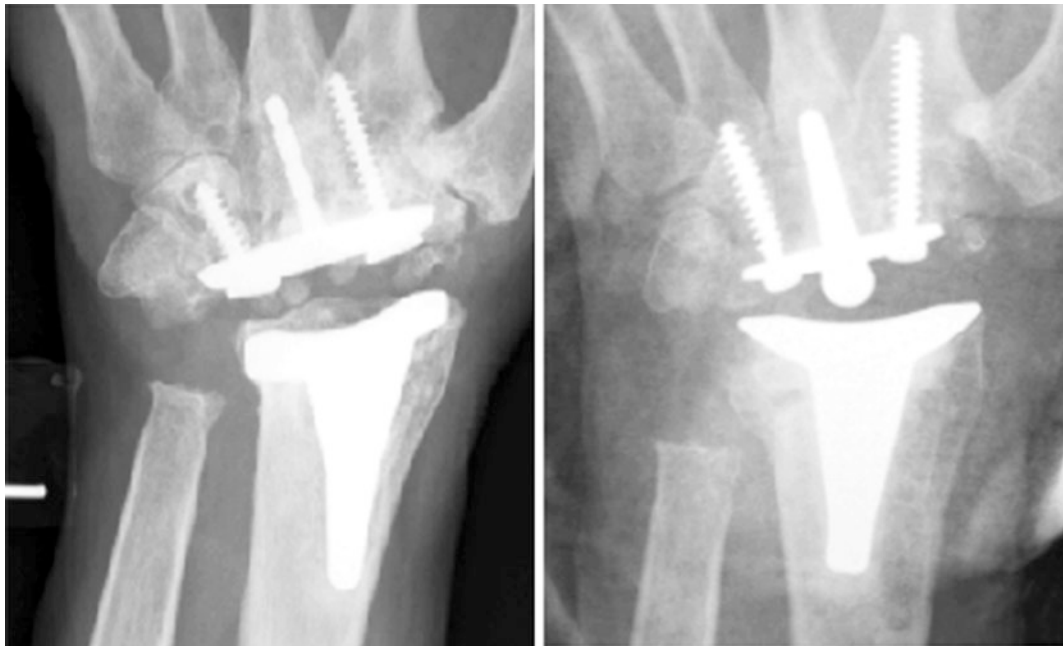

Fig. 9.15 Pre- and postoperative radiograph of the implant exchange shown in Figure 9.2–9.14

arthrodesis healed by first intention and the patient-reported outcomes in the patient with fused wrists did not differ significantly from those in the patients with functional revision arthroplasties. The range of scores is similar to that reported by Rizzo et al. [12]. There is no doubt that the added costs, the difficulty, and the risks of each supplemental revision procedure are high. It can also be questioned whether there are patient-related factors that caused failure of the primary arthroplasty, which in turn can cause failure of a revision implant if not identified and eliminated. For these reasons, today it is my believe and current strategy that TW arthrodesis is the first choice procedure for most cases and that revision arthroplasty should be performed in very carefully selected patients only. Future studies must be carried out to identify the patients that most likely would benefit from a revision arthroplasty and which patients would be better off with an arthrodesis.

Tips and Tricks

- If removal of an osseointegrated radial component requires osteotomy of the radius, this can advantageously been done on the radial side, leaving the dorsal radial cortex intact for the placement of the fusion plate.
- Use plate locking screws rather than pins and staples for the fixation of an arthrodesis in osteoporotic bone.
- Weakening of finger extension and grip strength can result from reduction of carpal height and tendon bowstringing. Repair the extensor retinaculum whenever possible and restore carpal height.
- Placement of the wrist in extension and restoring carpal height favor grip strength.
- When performing re-arthroplasty, crossing the CMC joints may be necessary for the fixation of an intercalated bone graft. In these cases, the CMC joints must be fused.

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