Biaxial Long-Stemmed Multipronged Distal Components for Revision/Bone Deficit Total-Wrist Arthroplasty

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Revision total-wrist arthroplasty has a high incidence of complications. Loosening is a significant problem for the distal implant. Because of the high failure rate of single-pronged distal implants after revision total-wrist arthroplasty, a custom multipronged distal component (biaxial total-wrist implant) was designed for use in patients with deficient bone stock who undergo revision operation. Ten cases of total-wrist arthroplasty with a custom long-stemmed multipronged distal component are presented. The preoperative diagnosis was failed total-wrist arthroplasty in 9 cases. Mean time from previous total-wrist arthroplasty to revision procedure was 5.6 years. At follow-up evaluation (mean, 3.8 years; range, 3.0–4.8 years), 2 patients had undergone arthrodesis: 1 patient at an outside institution 1 year after surgery for periprosthetic fracture of the radius, and 1 patient at our institution for distal implant loosening. The 8 other patients had functional total-wrist arthroplasties. At follow-up evaluation, all patients reported they were satisfied. Six patients reported no pain and 2 reported mild pain. Mean range of motion at follow-up evaluation was within the previously defined limits that allow patients to function in activities of daily living: 78° for supination, 77° for pronation, 39° for extension, 17° for flexion, 12° for radial deviation, and 18° for ulnar deviation. Revision total-wrist arthroplasty with custom long-stemmed, multipronged distal components offers an alternative to those patients with deficient bone stock who refuse arthrodesis. Early results demonstrate greater longevity compared with single-pronged components for revision total-wrist arthroplasty. (J Hand Surg 1996;21A:764–770.)

Revision total-wrist arthroplasty is a challenging procedure with significant complications. Previous studies have shown that implant loosening is a significant problem after this procedure is performed.[1] This is particularly true in patients with poor bone stock, often those with severe rheumatoid arthritis and failed arthroplasty. Implant loosening has been a particular problem for the distal component. Because of the high failure rate of single-pronged distal implants after revision total-wrist arthroplasty,[1] a custom multipronged distal component for use with the biaxial total-wrist implant was designed for patients with deficient bone stock undergoing revision operation. The purpose of this study was to evaluate the results obtained with the use of this implant.

Materials and Methods

Ten patients underwent total-wrist arthroplasty with a custom long-stemmed, multipronged distal component between November 1989 and May 1992. Indications for use of this implant included revision total-wrist arthroplasty with loosening of the distal component (9 cases) and severe rheumatoid arthritis with poor bone stock and a history of failed total-wrist arthroplasty on the contralateral side (1 case). Patients were offered the option and chose custom

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total-wrist arthroplasty in an attempt to preserve motion rather than the more conservative choice of arthrodesis at the expense of wrist motion. All distal components were cemented.

The 10 patients, all with rheumatoid arthritis, included 8 women and 2 men (mean age, 56 years; range, 37–70 years). The dominant side was involved in 4 patients and the nondominant side in 6. All the operations were unilateral. The preoperative diagnosis was failed biaxial total-wrist arthroplasty in 7 patients, failed Volz total-wrist arthroplasty in 1, and failed Swanson implant in 1. *Implant failure* for the purpose of this review is defined as implant fracture or loosening requiring implant removal. One case was a primary arthroplasty with poor bone quality and a history of loosening of the distal implant of a contralateral total-wrist arthroplasty. The mean time from the previous total-wrist arthroplasty to the revision procedure was 5.6 years (Table 1).

Total-wrist arthroplasties were followed up through the Total Joint Registry system at our institution. Data were obtained prospectively and recorded on wrist function sheets. All patients were followed for a minimum of 3 years or until implant failure. The mean follow-up period was calculated based on the eight survivors. Specific data on failures are provided. Variables recorded included patient-rated pain (none, mild, moderate, or severe) and degree of improvement compared with preoperative status as rated by the patient (much better, better, same, or worse), range of motion, clinical alignment, synovitis, and grip (measured with dynamometer). Anteroposterior and lateral radiographs were evaluated for loosening, migration of components, prosthetic and cement fracture, cortical bone resorption/fracture, and radiolucency.

The amount of subsidence was measured for both components. The distance from the distal tip of each metacarpal stem to the distal extent of the metacarpal was measured and compared with that seen on the immediate postoperative radiographs. For the proximal component, the vertical distance from the distal aspect of the component with respect to the metaphyseal flare was measured.

Implant Design

The biaxial multipronged revision total-wrist arthroplasty system (DePuy, Warsaw, IN) uses the standard BIAX proximal component of the primary total-wrist arthroplasty system. This portion of the prosthesis has not been associated with significant loosening in revision total-wrist arthroplasty. However, the distal component has been shown to loosen at an unacceptable rate after revision total-wrist arthroplasty.[1] The standard BIAX distal component has a single stem for the third metacarpal and a short stud for the trapezoid, which aids in rotational control. The distal component has been modified to include a longer third metacarpal stem to bypass the weakened area of the long metacarpal bone from the previous failed implant. These custom implants were designed without a porous coating surface. The rest of the design is the same as previously described.[1–4] A three-pronged distal component was used in one

Table 1. Demographic and Clinical Data for 10 Patients Who Had Custom Total-Wrist Arthroplasty

*Patient No.**	*Sex*	*Age (years)*	*Operative Diagnosis*	*Pain*	*Amount of Improvement*	*Implant Survival*
1	F	37	Second revision failed BIAX	—	—	Arthrodesis for periprosthetic fracture
2	M	48	Failed BIAX	Mild	Much better	Implant intact
3	F	70	Failed BIAX	None	Much Better	Implant intact
4	F	61	Failed Volz	None	Better	Implant intact
5	F	62	Failed BIAX	None	Much better	Implant intact
6	M	56	Failed Swanson	None	Much better	Implant intact
7	F	57	Failed BIAX	—	—	Arthrodesis for distal implant loosening
8	F	67	Failed BIAX	None	Much better	Implant intact
9	F	62	Poor bone stock with history of implant loosening on contralateral side	None	Much better	Implant intact
10	F	43	Failed BIAX	Mild	Better	Implant intact

*All patients received two-pronged distal components except for patient 10, who received a three-pronged distal component. All the patients were right-handed; no intraoperative complication occurred in any patient.

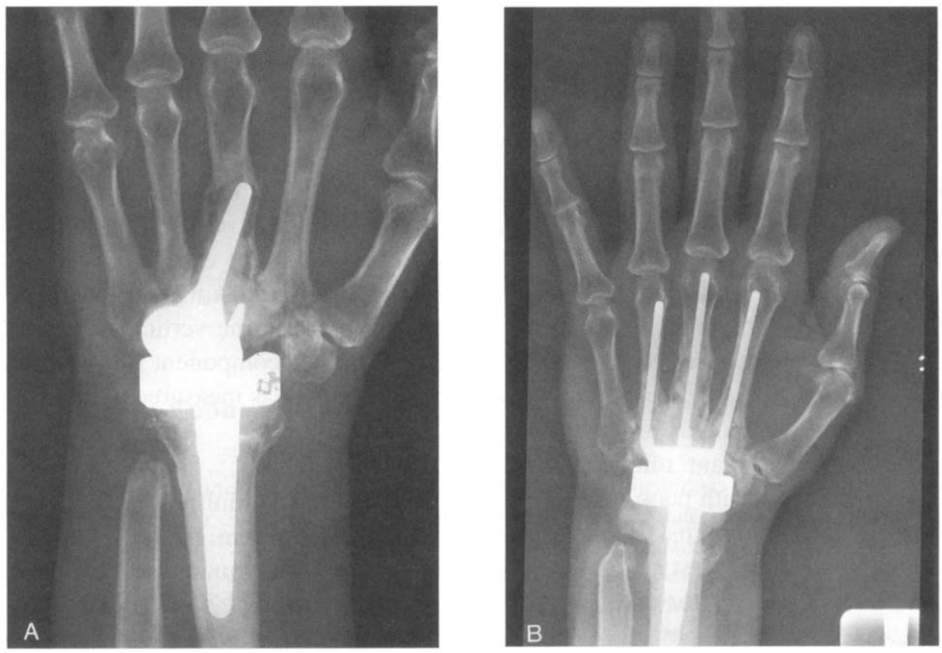

Figure 1. A 37-year-old woman with rheumatoid arthritis. (A) Anteroposterior radiograph 2 years after total-wrist arthroplasty, with loosening and migration of distal component. (B) Anteroposterior radiograph 4.8 years after revision total-wrist arthroplasty using custom three-pronged distal component.

case (Fig. 1). In all other cases, a two-pronged component was implanted (Figs. 2, 3).

The surgical technique for revision total wrist arthroplasty with the BIAX system has been described.[1,2] The technique used in our series differs from the standard BIAX only in that the distal component requires canal preparation and fixation of both the second and third metacarpals.

Results

Two failures occurred during the study period, one at 1 year and the other at 3.5 years. One patient underwent arthrodesis at another institution 1 year after the revision operation for periprosthetic fracture of the radius. The distal two-pronged component was well seated and not involved. Another patient underwent arthrodesis at our institution 3.5 years after surgery for distal implant loosening.

For the remaining 8 patients, the mean follow-up period was 3.8 years (range, 3.0–4.8 years). All had functional total wrist arthroplasties at latest follow-up evaluation; 6 stated that their wrist was much better than before the operation and two stated that their wrist was better than before the operation. At follow-up examination, 6 of the patients had no pain and 2 had mild pain.

Radiolucent lines were present in 3 of the 8 survivors (patients 3, 6, and 10). All of these patients were asymptomatic. One patient (patient 6) had an incomplete 1-mm lucent line around the radial stem. In the other patients (patients 2 and 10), a 1-mm lucent line was present around the distal implant. In both patients, the lucent lines were incomplete and nonprogressive. In 1 of these patients (patient 2), the tip of the third metacarpal stem had migrated completely above the level of the cortex of the metacarpal. Reactive bone had formed and had elevated the native cortex to a more superficial level, producing a bump on the dorsum of the hand.

Clinical evaluation demonstrated a neutral stance in 6 wrists; the 2 other patients held their wrist in ulnar deviation. The mean range of motion at follow-up evaluation was 78° (range, 65°–85°) for supination, 77° (range, 65°–90°) for pronation, 39° (range, 5°–65°) for extension, 17° (range, 5°–14°) for flexion, 12° (range, 5°–20°) for radial deviation, and 18° (range, 5°–40°) for ulnar deviation. Mean final grip strength was 10 kg (range, 1–25 kg) (Table 2).

Complications

Three patients sustained fractures or perforations in the cortex of the third metacarpal caused by the stem

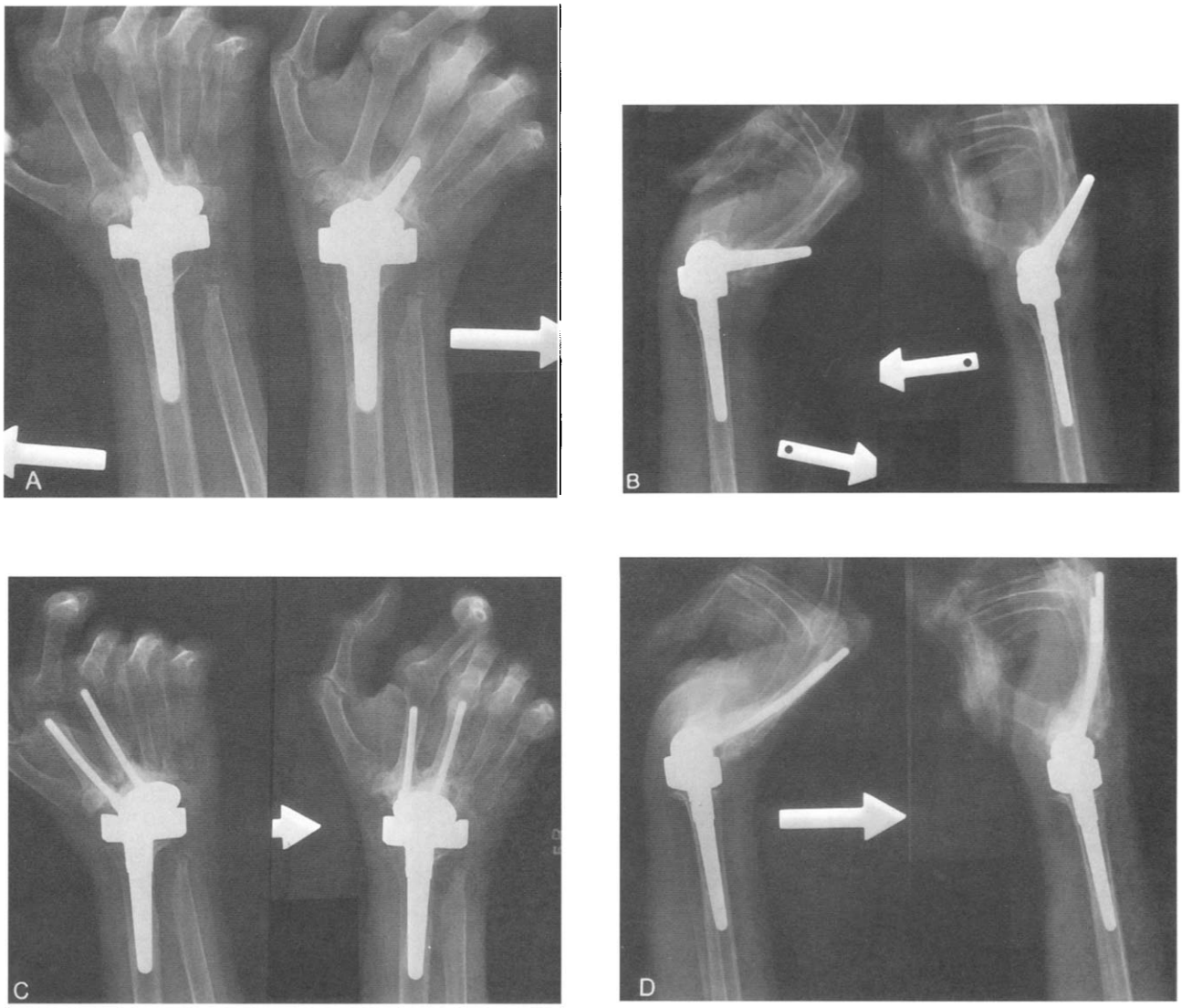

Figure 2. A 66-year-old woman with severe rheumatoid arthritis. Figures A and B, are radiographs at 6 years after primary total-wrist arthroplasty. (A) Anteroposterior view with radial and ulnar deviation. (B) Lateral view with flexion and extension; note loosening of distal implant with dorsal migration and gross motion with wrist range of motion. Figures C and D are radiographs at 15 months after revision arthroplasty with custom two-pronged distal component. (C) Anteroposterior view with radial and ulnar deviation. (D) Lateral view with flexion and extension.

of the primary component before revision. These were evident radiographically by the presence of cement extrusion into the soft tissues. This did not seem to affect implant stability, because none of these patients had loose distal components radiographically or clinically at follow-up evaluation. One patient sustained a periprosthetic fracture of the radius after a fall that was treated by her local physician with component removal and arthrodesis. The distal implant was intact and well seated. Revision for loosening of the distal implant occurred in only 1 patient.

Subsidence did not occur in the proximal component of any of the patients. In 2 patients, subsidence of the distal component was demonstrated. The subsidence was 2 mm in 1 and 3 mm in the other. Subsidence in one of these patients (patient 5) was not associated with radiographic lucency (Fig. 2).

Discussion

The component loosening that develops after total-wrist arthroplasty is salvaged best with arthrodesis. The advantage of arthrodesis is that it offers patients a single procedure that effectively resolves their problem permanently (in most instances). However, many patients who undergo total-wrist arthroplasty

Figure 3. A 70-year-old woman with severe rheumatoid arthritis. (A) Anteroposterior and (B) lateral radiographs 4 years after primary total-wrist arthroplasty, with loosening and migration of distal component. (C) Anteroposterior and (D) lateral radiographs after revision total-wrist arthroplasty using custom two-pronged distal component. (E) Anteroposterior and (F) lateral radiographs 3 years after revision total-wrist arthroplasty, with good clinical results despite radiolucent changes and slight migration of distal component.

do so because they are unwilling or unable to compensate for loss of motion. In patients with severe rheumatoid arthritis, numerous joints of the upper extremity are often involved and these patients may be unable to compensate for the loss of wrist motion. Furthermore, these patients generally have bilateral disease that interferes further with their ability to compensate for a stiff wrist. At our institution,

Table 2. Comparison of Preoperative and Postoperative Range of Motion in Eight Patients Who Had Custom Total-Wrist Arthroplasty

	Preoperative Motion (degrees)				*Motion at Follow-up Evaluation (degrees)*				
*Patient No.**	*Extension*	*Flexion*	*Radial Deviation*	*Ulnar Deviation*	*Extension*	*Flexion*	*Radial Deviation*	*Ulnar Deviation*	*Grip Strength (kg)*
1†	—	—	—	—	—	—	—	—	—
2	50	45	0	30	45	20	5	10	2
3	45	40	15	30	45	40	15	30	1
4	60	10	5	25	5	10	—	—	15
5	60	25	45	50	65	10	10	40	—
6	30	20	7	5	20	25	20	20	—
7†	—	—	—	—	—	—	—	—	—
8	55	5	5	15	45	10	10	5	6
9	0	50	5	35	—	—	—	—	—
10	40	10	10	0	45	5	10	5	25
Average	43	26	12	27	39	17	12	18	10

*All patients received two-pronged distal components except patient 10, who received a three-pronged distal component.
†Components removed; therefore, no data were available.

patients who require a salvage procedure for failed total-wrist arthroplasty are generally advised to undergo arthrodesis. However, those who are unwilling to accept loss of motion are offered revision total-wrist arthroplasty.

Results of revision total-wrist arthroplasty have been disappointing, with a high rate of loosening of the distal component. In an earlier evaluation of 13 revision total-wrist arthroplasties, the reoperation rate was 23% at a mean follow-up period of 31 months.[1] One patient underwent reoperation for failure attributed to fracture of the radius. In two patients, additional operations were required because of prosthetic loosening, and in two other patients, asymptomatic radiographic loosening was found. In the current study, with a longer follow-up period, only one revision was due to component loosening. One patient underwent arthrodesis because of a periprosthetic fracture of the radius sustained in a fall. Radiographic analysis of one other wrist demonstrated probable loosening of the distal component. However, this patient has remained asymptomatic, and the components appear stable.

Previous work on problems associated with implant failures in total-wrist arthroplasty has defined two factors in addition to loss of fixation that appear important for implant survival: centering of the prosthesis and soft tissue balance.[5] In our study, two patients had soft tissue-related deformities with ulnar deviation. These were minor deformities that, to date, have not markedly affected either functional outcome or satisfaction of the patients. Both patients were happy with the outcome and have adequate motion, with active radial deviation of 10° and 15°, respectively.

Prosthetic loosening after revision total-wrist arthroplasty is a considerable problem, especially in the setting of poor bone stock. All the patients in our series were selected for this new custom prosthesis, because a standard single-pronged component was not considered a viable alternative in view of the poor bone stock and the short stem length of the standard single-pronged component. The early results of this series suggested that this implant is a viable option for patients who might otherwise be candidates only for arthrodesis in a setting in which the preservation of small amounts of motion has a marked impact on functional ability. In our practice, this is encountered most frequently in patients with severe rheumatoid arthritis of several joints of the upper extremity. For these patients, compensation for loss of motion after arthrodesis is not ideal. A range of motion of 30° of extension, 5° of flexion, 10° of radial deviation, and 15° of ulnar deviation allows patients to perform activities of daily living.[6] The mean range of motion for the present series was 39° of extension, 17° of flexion, 12° of radial deviation, and 18° of ulnar deviation, which is within the functional boundaries.

Revision total-wrist arthroplasty with custom biaxial multipronged distal components offers an alternative to arthrodesis in patients with deficient bone stock who have special requirements or requests for motion. Early results demonstrate greater longevity in comparison with standard components for revision total-wrist arthroplasty.[1]

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