J Shoulder Elbow Surg (2021) 30, 913–917

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Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Revision total elbow arthroplasty with the ulnar component implanted into the radius for management of large ulna defects

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Background: Total elbow arthroplasty (TEA) has a higher rate of revision and complications than other total joint arthroplasties. Salvage options for failed TEAs are limited, especially when patients have poor ulna bone stock. The purpose of this study is to describe a surgical technique and report outcomes of patients who underwent revision TEA with implantation of the ulnar component into the radius to address ulna bony defects.

Methods: A retrospective review of 5 patients at a single institution from 2014 to 2019 in which the ulnar component was implanted into the radius to address large bony defects in the setting of revision TEA was performed.

Results: At follow-up of 2.1 ± 1.9 years, patients experienced an increase in total arc of motion from 86 ± 17° to 112 ± 8°, with infection eradication and no instances of distal component loosening.

Conclusion: This salvage technique was effective at providing a stable elbow in patients with large ulna bony defects as a result of prosthetic joint infection or periprosthetic fracture.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Elbow arthroplasty; total elbow; revision; prosthetic joint infection; periprosthetic; bone loss

Total elbow arthroplasty (TEA) is an effective treatment for acute distal humerus fractures in the elderly, post-traumatic arthritis, and inflammatory arthropathy. However, TEAs have lower survival rates than other total joint arthroplasties and higher overall complication rates, ranging from 24% to 44%.[3,15] Reported revision rates for TEA vary with some reporting annual rates of revision surgery as high as 12.8%.[2] Aseptic loosening is the most common reason for revision, followed by deep infection, and periprosthetic fractures.[12]

Salvage options for failed TEAs include revision arthroplasty, allograft augmentation, allograft prosthetic composite (APC), elbow arthrodesis, and resection arthroplasty. For patients with multiply revised TEAs and poor bone stock or with infections necessitating large segments of bony débridement, options for reconstruction are limited. APCs have high complication rates and are at risk for infection, especially in the setting of a prosthetic joint infection (PJI). Arthrodesis in the setting of TEA complicated by PJI is not advised due to high reoperation rates and low rates of union. Resection arthroplasty can result in instability, incomplete eradication of the infection, and nerve deficits.

Duke Health Institutional review board approved this study (study no. Pro001027333).

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1058-2746/$ - see front matter
https://doi.org/10.1016/j.jse.2020.08.018

We report on a surgical technique and outcomes of implantation of the ulnar component into the radius to address issues with large bony defects in the setting of revision TEA. This technique is a salvage procedure for patients with poor ulna bone stock, unable to accommodate the ulnar component due to prior bony resection from PJI or large cortical defects from aseptic loosening or periprosthetic fracture.

Materials and methods

This is a retrospective case series of patients who underwent revision TEA in which the distal component was implanted into the radius. Institutional review board approval was obtained before preforming chart review. Patients underwent revision surgery between 2014 and 2019 by 2 surgeons at a single institution. Five patients, 2 women and 3 men, were identified (Table I). Four patients had a PJI and 1 had a periprosthetic fracture at the distal ulna stem with associated ulna component loosening. All patients had substantial ulna bone loss with poor remaining bone stock or large cortical defects in the ulna, which could not be bypassed with the ulnar stem determined preoperatively and confirmed intraoperatively. Preoperative radiographs were examined and determined that the cortical defects could not be bypassed by 2 cortical diameters with the standard or extended ulnar stems available.

Patient demographics and details of the surgical procedure were collected along with pre- and postoperative radiographic and clinical data. Follow-up was performed in a standard outpatient clinic, with range of motion measurements and elbow radiographs performed at each follow-up. Standard follow-up was at 2 weeks, 6 weeks, 3 months, 6 months, and 1 year postoperatively and yearly thereafter.

Operative technique and postoperative treatment

The 4 patients who were revised for PJI underwent staged revision with removal of the TEA and placement of an antibiotic spacer. Patients were maintained in a hinged elbow brace while the antibiotic spacer was in place. Eradication of the infection was either confirmed with negative intraoperative cultures obtained at the time of repeat irrigation and débridement or negative cultures on sterile elbow aspiration.

The patient who sustained a periprosthetic fracture at the ulnar stem maintained the humeral component and underwent isolated revision of the distal component.

The first 2 revisions were performed with the Coonrad Morrey TEA (Zimmer Biomet, Warsaw, IN, USA), and the remaining 3 were performed with the DJO Discovery TEA (DJO Global, Lewisville, TX, USA).

The patient's prior posterior approach to the elbow was used. The triceps was split to expose the distal humerus and antibiotic spacer. The triceps insertion was scarred in distally and was not dissected free of its distal attachment to maintain any active triceps strength the patient possessed, with most patients relying on gravity for elbow extension preoperatively. After removal of the antibiotic spacer, the humeral component was prepared first in a standard fashion. In the patient in whom the humeral component was retained, the TEA was unlinked and the ulnar component was removed. The ulna shaft was inspected visually and examined under intraoperative fluoroscopy. In each case, there was insufficient bone stock remaining, with either too short a segment of ulna shaft remaining or large cortical defects in the ulna shaft, precluding the ability to bypass the defect with the stem to sufficiently secure the ulnar component. One patient had previously been treated for a large ulna defect with an APC that failed secondary to PJI (Fig. 1). Therefore, it was necessary to place the distal component in the radius for sufficient fixation in all cases. The radial head was resected in the cases in which the radial head remained. Handheld reamers and broaches were used to size the distal component. A burr was used as necessary to create a better fit for the ulnar prosthesis on the anterior aspect of the radius. When possible, the surgeon attempted to contour the proximal radius like the native proximal ulna, creating a ''pseudo-coronoid'' for the implant. An appropriate ulnar prosthesis was identified and the trial implants were placed. In one patient, a small woman measuring 155 cm (5′1″) in height, the contralateral ulnar component was placed as it better fit the geometry of the radius.

Table I Details of patients undergoing implantation of the distal component into the radius

	Age (sex)	Reason for revision (organism)	Presenting symptoms	Number of prior TEAs	Component revised	Preoperative ROM	Postoperative ROM	Complications
1	64 (F)	Infected TEA (Candida)	Pain, squeaking, fluctuance, malaise	2	Both	45-120	10-120	Loosening of humeral component
2	61 (M)	Peri-implant fracture at ulnar stem	Pain, dysesthesia	3	Ulnar	0-95	25-130	None
3	54 (M)	Infected TEA (polymicrobial)	Drainage, pain, elbow instability	3	Both	15-120	5-130	None
4	49 (M)	Infected TEA (polymicrobial)	Pain, elbow instability	1	Both	20-90	10-120	None
5	73 (F)	Infected TEA (*Staphylococcus epidermidis*)	Drainage, warmth, erythema	2	Both	"Limited"	10-120	None

TEA, total elbow arthroplasty; *ROM*, range of motion.

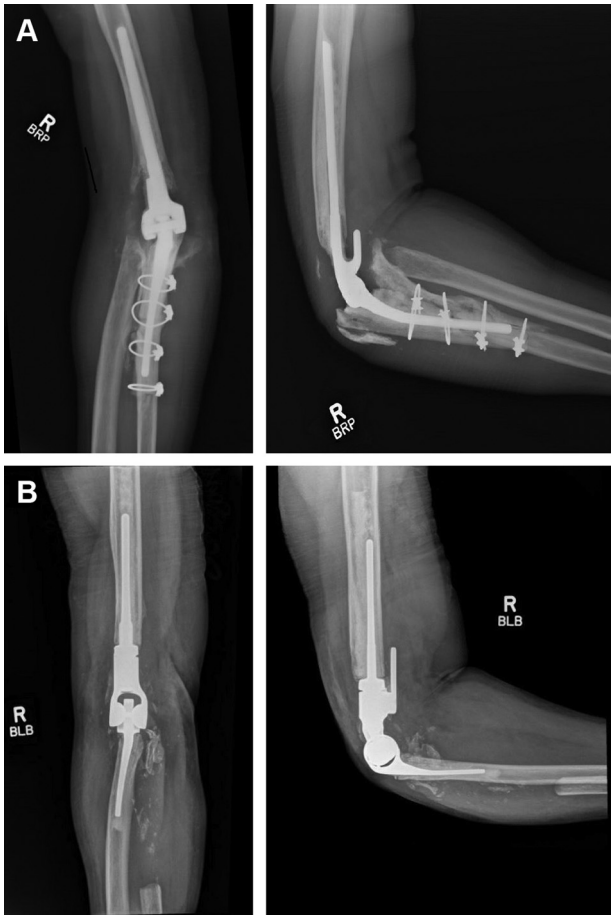

Figure 1 (**A**) Patient presented with drainage from the incision 8 months after undergoing revision total elbow arthroplasty (TEA) with an allograft prosthetic composite ulnar component. (**B**) Radiographs at 1 year postoperatively reveal a well-fixed TEA with no lucency around either component.

All other patients were of average US height or taller, and the ipsilateral ulnar component in either the smallest or second smallest size was placed in the radius.

After the TEA was trialed, the components were removed. A cement restrictor was placed in the humeral and radial canals. The humeral and radial canals were thoroughly irrigated and dried. Cement was placed in the radial canal, and the prosthesis was coated with cement. When inserting the prosthesis into the radial shaft, the forearm was maintained in neutral rotation. The humeral component was cemented in place in a similar fashion in the instances in which it was revised. The distal component was then articulated and secured with the standard polyethylene bushings to the humeral component. The elbow was taken through the range of motion to evaluate for impingement. Fluoroscopic imaging was used to confirm no cortical penetration of the distal component, appropriate seating of both components, and sufficient cement mantle. The incision was closed in layers, and a plaster splint was placed anteriorly with the arm in relative extension. At 2 weeks postoperatively, patients were transitioned into a hinged elbow brace and gentle elbow ROM was initiated. Postoperative restrictions are more restrictive than our standard TEA restrictions of 5 pounds single lift and 2 pounds repetitive lift. Patients are told to consider the arm as a helper hand and to avoid lifting with the operative extremity.

Statistical analysis

Paired *t*-tests were performed (Excel 2010; Microsoft, Seattle, WA, USA) with $P < .05$ set as the threshold for statistical significance.

Results

All patients received their initial total elbow arthroplasties for injuries sustained as a result of trauma and underwent their index procedure 24 ± 14 years prior (8-41 years). The average age was 60 ± 9 years (49-73 years) at the time of revision. Patients underwent an average of 5.8 ± 3.6 surgeries (3-12) on the operative elbow before the revision TEA.

Four patients underwent 2-stage revision for PJI, and 1 patient underwent single-stage revision for a periprosthetic fracture at the ulnar stem and maintained the humeral component. For those undergoing staged revision, the time between explant and replant averaged 12.6 ± 6.9 months (7.3-22.3 months). Of the 4 infections, 2 were polymicrobial, 1 was infected with *Staphylococcus epidermidis*, and 1 was infected with Candida.

Follow-up time averaged 2.1 ± 1.9 years (8 months to 5.4 years). Although not a statistically significant increase, the range of motion was 20 ± 19° to 106 ± 16° preoperatively and 12 ± 8° to 124 ± 5° postoperatively ($P = .59$ for extension and $P = .11$ for flexion). There was a significant increase in the arc of motion from 86 ± 17° preoperatively to 112 ± 8° postoperatively ($P = .03$). Pronosupination was fixed postoperatively, as implantation into the radius eliminates forearm rotation.

No patients experienced the recurrence of their infection at the most recent follow-up. There was no lucency around the distal components identified radiographically. One patient developed pain and crepitus of the humerus at her most recent follow-up visit (5.4 years). At the time of her revision TEA, she underwent the placement of allograft tibial struts and cerclage wiring around the humerus to address concomitant humeral bone loss. Radiographs revealed lucency around the humeral component with no evidence of lucency around her distal component. The patient is currently being managed in a brace with no evidence of elevated inflammatory markers, erythema, swelling, drainage, or indications of ongoing infection.

One patient developed radial nerve neurapraxia several weeks after TEA explantation and antibiotic spacer placement from failure to comply with brace wear. The neurapraxia did not resolve and was treated with tendon transfers after revision TEA. No other patient underwent subsequent surgical intervention on the operative extremity at the most recent follow-up.

Discussion

Implantation of the ulnar component into the radius was effective at providing a stable elbow in patients with large ulna bony defects as a result of PJI or periprosthetic fracture. Patients experienced an increase in the total arc of motion from 86 ± 17° to 112 ± 8° at the expense of forearm rotation. At the most recent follow-up, those with prior infection had no signs of ongoing infection and there were no instances of distal component loosening or a peri-implant fracture.

In the setting of infection, we advocate for 2-stage revision, as staged revision is the most effective treatment for elbow PJI with the lowest recurrence rate and highest rate of infection eradication ranging from 72% to 81.2%.[1,5,11] Zmistowski et al[17] report their experience with 2-stage revision and note the infection-free survival rate of 88.5% at 1 year and 68.4% at 3 years. In the current study, no infections recurred after the 2-stage surgery to date, with an average of 2-year follow-up.

In the patient who sustained a peri-implant fracture at the distal ulnar stem with ulnar component loosening, single-stage revision with retention of the humeral component was effective. The humeral component was well fixed, and the polyethylene bushing was replaced.

Three other groups have reported a similar technique of implantation of the distal TEA component into the radius. Lee[6] reports on 9.5-year follow-up of a single patient who underwent radialization of the ulnar component due to a fractured long ulnar stem in the ulna. The patient underwent 2 subsequent surgeries for revision of worn polyethylene bushings at 30 and 98 months since the placement of the distal component in the radius. The range of motion was 10°-135° with 10° of pronation. The author notes that positioning the distal component in the radial canal to prevent hyperextension of the elbow is critical as hyperextension will lead to faster component loosening. Furthermore, he notes that the placement of the ulnar component into the radius likely results in increased rotational forces on the prosthesis, which may be the cause of the accelerated bushing wear experienced.

Terlecky et al[14] presented 9-year follow-up for 1 patient who underwent revision TEA for osteolysis resulting in ulnar component loosening with the placement of the distal component into the radius. At 9 years postoperatively, she was reported to have adequate flexion/extension with minimal pronosupination, satisfactory prosthesis alignment, and no pain.

Gong et al[4] reported on 4 patients who underwent revision TEA, 3 for infection and 1 for aseptic loosening. They implanted the contralateral distal component into the radial stem given the small size of their patient population and need to use the XS components. Follow-up was done at 3 months postoperatively and thereafter via phone call, with radiographs only available at the 3-month postoperative time point. In 1 patient, we implanted the contralateral ulnar stem, due to her small stature. However, for the other 4 patients, we were able to implant the ipsilateral distal component in either the smallest or second smallest size without difficulty or cortical penetration. Similarly, Gong et al[4] noted no recurrence of infection, though follow-up was limited to phone call, which may not detect elbow PJI, especially given the lack of characteristic infectious symptoms present with elbow PJI.[5] Final ROM measurements were not available, but the authors note that in most patients full or almost complete preoperative ROM was restored.

In the current study and prior case reports, implantation of the distal component into the radius provides promising results, especially when compared with other methods of treatment. Prior experience with APC reveals an approximately 50% complication rate, the most common being infection.[8,9] A 12%-31% infection rate is reported after APC, despite some cohorts excluding prior infection as an indication for APC. Additional complications of APC include periprosthetic fracture and nonunion. In those patients with infection, management was with resection arthroplasty.[9] In the present study, 1 patient underwent prior APC, which failed due to infection. Impaction grafting has also been used to manage severe osteolysis in TEA; however, the technique can only be used if there is sufficient cortex remaining and is contraindicated instances of infection.[13] Furthermore, complications are common with 50% of patients requiring additional surgical intervention.[7]

Otto et al[10] reported on their experience with elbow arthrodesis after failed TEA due to PJI. No patient in their series achieved radiographic union, and all patients underwent additional operative intervention. Fifty percent (2 of 4) of their patients were definitively treated with resection arthroplasty with the other patients achieving a fibrous union managed in a brace. Resection arthroplasty has poor outcomes and high complication rates. Zarkadas et al[16] note a Mayo Elbow Performance score and Disabilities of the Arm, Shoulder and Hand (DASH) score both in the poor to fair range. Complications included a 47% infection rate and permanent nerve injury, either radial or ulnar, in 18% of patients. Additional bracing was used when sufficient stability was not achieved, and approximately half of the patients in the study found lifelong bracing beneficial. Although no patient reported outcomes or outcome scores were included in the current study, patients retained a functional arc of motion without instability, had no instances of infection or new nerve injury after revision TEA, and were not required to wear a brace. The only instance of nerve injury was a patient who developed radial nerve neurapraxia several weeks after TEA explantation with antibiotic spacer placement from failure to comply with brace wear postoperatively.

This is the largest study with the longest follow-up using the technique of implantation of the ulnar component into the radius for revision TEA with large ulnar bony defects. Thus far, the technique has proven reliable at reconstructing

the elbow and providing stability with poor ulna bone stock available for revision with consistent infection eradication. Patients sustained improved arc of motion after surgery by nearly 30° with no evidence of ongoing infection.

The limitations to the study involve the small sample size and short-term follow-up. As with many TEA studies, the procedure is relatively uncommon, so sample size, especially when dealing with complex revisions, is limited. The length of follow-up ranged from 8 months to 5.4 years, but with clinical examination and radiographs at all time points. PJI in TEA may be difficult to detect due to the lack of classic infectious symptoms and no definitive tests to reliably diagnose PJIs. Although no patient at the most recent follow-up was diagnosed with PJI or loosening of the distal component, it is possible that ongoing infection or lucency of the distal component may be detected with longer follow-up. Patients were counseled preoperatively that they would lose all pronosupination of the forearm. It is possible that the loss of pronosupination may lead to increased rotational forces on the implant and may lead to bushing wear or loosening of the distal component. Finally, many failures of TEA occur after the longest follow-up in this study, and long-term evaluation is needed to understand the survival of this technique.

Conclusions

This study describes a surgical technique and reports the clinical and radiographic outcomes of management of the complex problem of massive ulna bone loss in patients undergoing revision TEA. Implanting the ulnar component into the radius in revision TEA can effectively restore elbow stability, increase the total arc of motion, and eradicate infection in patients with large ulnar bony defects as a salvage procedure at the expense of forearm rotation.

Disclaimer

Marc Richard reports association or financial involvement with Acumed, Bioventus, DJO, Depuy Synthes, Field Orthopaedics, and Medartis.

David Ruch reports association or financial involvement with Acumed.

The other authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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