Arthrodesis for failed total elbow arthroplasty with deep infection

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\textbf{Background:} Elbow arthrodesis is typically reserved as a salvage procedure. Current literature suggests that satisfactory outcomes can be expected if fusion occurs. There is a paucity of literature on outcomes of elbow arthrodesis after failed elbow arthroplasty with deep infection.

\textbf{Methods:} Five elbow arthrodeses were performed after a failed elbow arthroplasty due to deep infection. Clinical data were retrospectively reviewed for all surviving patients. Fusion angle, complications, and time to fusion or resection arthroplasty were recorded. The procedure was considered a failure if resection arthroplasty was required or there was a failure of bone union after 1 year.

\textbf{Results:} The average age at arthrodesis was 49 years (range, 35-69 years). One patient died 3 months after arthrodesis and was excluded from analysis. No patients had confirmed union at final follow-up. Two developed a fibrous union and were not symptomatic. All patients required at least 1 reoperation; 6 reoperations were required in total for the entire group. Three patients required revision arthrodesis after hardware failure. Two patients ultimately underwent a resection arthroplasty. One patient required débridement and hardware removal after wound dehiscence. Other complications included 2 patients with transient ulnar neuritis.

\textbf{Conclusion:} Elbow arthrodesis is not recommended as a salvage procedure for failed total elbow arthroplasty after infection because of a high reoperation rate and difficulty in achieving solid fusion.

\textbf{Level of evidence:} Level IV, Case Series, Treatment Study.

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\textbf{Keywords:} Total elbow arthroplasty; arthrodesis; joint fusion; deep infection; salvage procedure; arthritis

Total elbow arthroplasty (TEA) can restore a painless, functional range of motion in a variety of destructive conditions of the elbow. Deep infection after elbow arthroplasty leads to poor outcomes and is difficult to treat.\textsuperscript{1-4,14} The reported incidence of deep infection after TEA is 3\% to 9\%.\textsuperscript{7,8,14} Reconstructive options include débridement with prosthetic salvage, 2-stage revision, resection arthroplasty, and arthrodesis.\textsuperscript{2,3,6,10,14}
Elbow arthrodesis is typically reserved as a salvage procedure. Current literature suggests that satisfactory outcomes can be expected if fusion occurs. However, there is a paucity of literature about outcomes of elbow arthrodesis after failed TEA. The purpose of this study was to evaluate the use of elbow arthrodesis for the treatment of failed TEA for deep infection.

Materials and methods

We retrospectively reviewed all patients with failed TEA for deep infection who were treated with a salvage arthrodesis at our institution from 2000 to 2010. All surgeries were performed by 1 of 2 shoulder and elbow fellowship-trained orthopaedic surgeons.

Exclusion criteria were follow-up of less than 12 months, failed TEA for reasons other than deep infection, and salvage treatment other than arthrodesis. Demographic data were collected including age, gender, arm dominance, indication for index TEA, from time index surgery to documented infection, and time to fusion or resection arthroplasty (Table 1).

We identified 5 patients (4 men, 1 woman) who underwent elbow arthrodesis after failed elbow arthroplasty due to deep infection. One patient died 3 months after arthrodesis and was excluded from analysis. The age at time of arthrodesis was 49 years (range, 35-69 years). The index elbow arthroplasty was performed for post-traumatic arthritis in 3 patients and for rheumatoid arthritis in the fourth. All 4 patients had a history of cigarette smoking of more than one pack per day.

Surgical technique

All patients underwent a staged procedure for conversion from TEA to arthrodesis to allow adequate débridement and administration of antibiotics before arthrodesis.

All procedures were performed in a lateral decubitus position with the affected arm over a post. A sterile tourniquet was used to assist in hemostasis. A straight midline incision was used through the prior incision, and it was extended proximally and distally to allow mobilization of soft tissues and to identify normal tissue planes. Full-thickness skin flaps were elevated.

Attention was first directed to identification and protection of the neurovascular structures. Special care was taken to follow the ulnar nerve from normal tissue planes proximally, distally to the flexor carpi ulnaris. This is especially important with a history of previous surgery. The medial intermuscular septum was removed to prevent any unnecessary tension on the nerve, and Osborne ligament and the flexor carpi ulnaris fascia were divided to identify the first motor branch. The ulnar nerve was then transposed anteriorly.

The triceps was split midline, and the elbow joint was exposed by subperiosteal elevation of the anconeus laterally and the flexor carpi ulnaris medially off of the subcutaneous border of the olecranon and proximal ulna. The common extensors and flexor-pronator mass were then elevated subperiosteally off of the distal humerus for adequate exposure of the elbow prosthesis.

For the first stage, the prosthesis was unlinked and the components were removed with the use of burs and osteotomes in an attempt to minimize bone loss. Residual cement was also removed from the medullary canal with curets, flexible osteotomes, and a bur.

Care was taken not to cause any further bone loss. If there was a question of causing further damage or fracture to the already poor-quality bone, the cement was left within the medullary canal. A thorough débridement was performed, and intraoperative culture specimens and tissue were sent for pathologic analysis. An antibiotic cement spacer was loosely inserted, and the soft tissues were closed in layers with monofilament sutures. All patients were receiving intravenous antibiotics to which the organisms being treated were sensitive for 3 to 6 weeks at the discretion of the infectious disease physician. Each patient was then converted to an oral antibiotic and continued this antibiotic until the inflammatory markers (C-reactive protein level, erythrocyte sedimentation rate, white blood cell count) had normalized. At this point, the patient underwent the second stage of the salvage procedure. The average time between the first and second stages was 4.75 months (range, 1-10 months).

The previous incision and surgical approach were used in the second-stage procedure with generous flaps to avoid devitalizing tissue. Intraoperative culture specimens and tissue were sent to pathology to confirm the absence of acute inflammation.

Because of a history of deep infection, structural allograft was not used for bone deficits. Therefore, the fusion angle varied between patients. The ulnohumeral joint was positioned to allow maximal bone contact and definitively fixed with a 3.5-mm low-contact dynamic compression plate, which was bent to follow the contour of the fusion position. Local, morselized autogenous radial head or condyle bone graft was used in all cases to augment the fusion site. This was thought to be sufficient without the added morbidity of harvesting autogenous iliac crest bone graft.

Wound drains were placed to prevent hematoma formation, and the wounds were closed in layers. Shoulder, wrist, and hand motion was initiated on the first postoperative day, but the elbow was immobilized until evidence of bone healing to prevent any stress across the fusion site.

Radiographs were evaluated at each postoperative visit by an independent reviewer not involved in the care of the patients to evaluate the fusion angle and evidence of bone or fibrous union. Complications and reoperation rates were also recorded. The procedure was considered a failure if resection arthroplasty was required or if there was a failure of union at 1 year.

Results

The average time from TEA to documented deep infection was 12 months (range, 3-38 months). The average length of follow-up after arthrodesis was 33.87 months (range, 12-73 months). Fusion angles ranged from 45° to 90°. All patients had positive results of intraoperative pathologic examination, with >10 white blood cells per high-power field on multiple cultures.

There were no patients with a confirmed union at final follow-up. Two patients developed a fibrous union and were not symptomatic. All patients required at least 1 reoperation. In total, there were 6 reoperations. Three patients required revision arthrodesis after hardware failure. Two patients ultimately underwent a resection arthroplasty. One patient required débridement and hardware removal after wound dehiscence (Table 1). Other complications included 2 patients with transient ulnar neuritis.
Case 1

A 37-year-old woman sustained a complex elbow fracture in 1991 and was treated with open reduction and internal fixation (ORIF). The patient was revised to a TEA after the development of post-traumatic arthritis in 2001. She developed a deep infection 4 months after arthroplasty and required multiple débridements and a resection arthroplasty. Intraoperative findings at the time of implant removal were notable for gross purulence, and tissue samples were positive with >10 white blood cells per high-power field. The causative organism in this case was not identified, and all specimens sent to the infectious disease laboratory were negative. Dissatisfied with her outcome 11 months after resection, the patient underwent an elbow arthrodesis in 2001 (Fig. 1, A). She developed a fibrous union with chronic pain and sustained a failure of the hardware after a fall in 2004. She elected to proceed with a revision arthrodesis later that year but had another fall resulting in hardware failure in 2005. The patient underwent a resection arthroplasty at that point with no further attempts at fusion (Fig. 1, B).

Case 2

A 56-year-old man sustained an open, complex elbow fracture in 2000 and was treated with débridement and ORIF. The patient developed a deep infection after ORIF and underwent multiple débridements and subsequent removal of hardware at an outside hospital (Fig. 2, A). After developing post-traumatic arthritis, the patient was referred to our office for continued care and underwent a TEA in 2004. The patient developed a deep infection 3 months after arthroplasty requiring débridement and resection arthroplasty. The organism involved in the infection was determined to be methicillin-resistant Staphylococcus aureus. He underwent salvage to an arthrodesis 2 months later. This patient had significant soft tissue compromise after wound dehiscence, requiring removal of a compression plate to allow soft tissue healing (Fig. 2, B). The revision arthrodesis allowed only screw fixation across the fusion site through the humeral plate for the avoidance of further soft tissue compromise with the addition of another plate over the olecranon. Although this is not biomechanically ideal, the patient went on to heal the wound but developed a fibrous union, which was asymptomatic. He declined to proceed with any further surgical treatment and was placed in a custom brace.

Table 1 Patient demographic information for all cases

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Time from infection to arthrodesis (weeks)</th>
<th>Infecting organism</th>
<th>Treatments before arthrodesis</th>
<th>Graft used at index procedure</th>
<th>Final outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37</td>
<td>F</td>
<td>4.1</td>
<td>Undetermined</td>
<td>ORIF → TEA</td>
<td>None</td>
<td>Resection arthroplasty</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>M</td>
<td>8.3</td>
<td>MRSA</td>
<td>ORIF (infected) → (treated with intravenous antibiotics and 6 débridements) → TEA</td>
<td>None</td>
<td>Fibrous union; placed in custom brace</td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td>M</td>
<td>4.4</td>
<td>MSSA</td>
<td>Multiple unspecified surgeries → fascial interposition arthroplasty → TEA</td>
<td>Bone graft</td>
<td>Fibrous union</td>
</tr>
<tr>
<td>4</td>
<td>69</td>
<td>M</td>
<td>37.6</td>
<td>MSSA</td>
<td>TEA → revision TEA → revision TEA with ulnar plate → revision TEA → revision TEA</td>
<td>RIA graft</td>
<td>Resection arthroplasty</td>
</tr>
</tbody>
</table>

MRSA, methicillin-resistant Staphylococcus aureus; MSSA, methicillin-sensitive S. aureus; ORIF, open reduction, internal fixation; TEA, total elbow arthroplasty; RIA, reaming irrigation aspirator.

Case 3

A 35-year-old man involved in a motorcycle accident in 1993 sustained a complex elbow fracture requiring ORIF. After developing post-traumatic arthritis, he underwent removal of hardware and a fascial interposition arthroplasty in 1999. He continued to have 7/10 pain at rest and 10/10...
pain with activity and subsequently underwent revision to TEA in 2000. This was complicated by a deep infection by methicillin-sensitive *S. aureus* 4 months after arthroplasty, requiring débridement and prosthetic resection. The patient subsequently underwent salvage to arthrodesis in 2001 after continued pain. He had transient ulnar neuritis postoperatively and sustained hardware failure after a fall in 2002. He underwent a revision arthrodesis but developed a

**Figure 1** Radiographs of the patient in case 1. (A) Patient after primary arthrodesis. (B) Patient’s elbow after hardware failure due to a fall.

**Figure 2** Radiographs of the patient in case 2. (A) Patient after primary total elbow arthroplasty. (B) Elbow revision arthrodesis after plate removal from initial arthrodesis due to wound dehiscence.
fibrous union at last follow-up in 2003, which was asymptomatic. No further surgical treatment was warranted.

Case 4

A 69-year-old man was treated at another institution with a primary TEA in 1986 for severe rheumatoid arthritis and was revised in 1996. In 2002, the patient required a second revision, which included plating of an ulnar fracture. In 2006, the patient was referred to our institution and underwent a third revision TEA requiring ulnar bone grafting (Fig. 3, A). In 2009, he presented with progressively worsening pain and was found to have a loose humeral component. Results from intraoperative cultures returned positive for methicillin-sensitive \textit{S. aureus}. He was treated with débridement and removal of the humeral component. In 2010, he underwent a radiohumeral arthrodesis after conservative treatment failed (Fig. 3, B). His postoperative course was complicated by transient ulnar neuritis. The patient went on to develop a nonunion and ultimately his hardware failed. He was revised to a resection arthroplasty in 2012 (Fig. 3, C), which has yielded good function and minimal discomfort at the most recent follow-up.

Discussion

Arthrodesis is considered a salvage operation for severe elbow joint diseases. The inability of other joints to compensate adequately for the loss of elbow motion has limited its use as a salvage procedure.\textsuperscript{4,5,10,12,14} In the presence of adequate bone stock and viable soft tissues, arthrodesis with compression plating has been shown to result in a high rate of fusion and satisfactory outcomes.\textsuperscript{5,10,11} Thus, a satisfactory outcome may be expected in treating a deep infection after TEA with elbow arthrodesis if fusion of the joint occurs. However, there are few data sets in the literature examining the use of elbow arthrodesis to treat an infected TEA. The treatment of a deep infection after elbow arthroplasty is difficult. The removal of elbow components often results in significant bone loss, and the vascularity of soft tissue envelope is compromised. In addition, the combination of a long lever arm and strong bending forces across the fusion site places the elbow at a disadvantage when an arthrodesis is attempted.

Despite agreement in the literature that a standard fusion angle should be 90° for optimum function, variables such as age, gender, occupation, and hand dominance, among other factors, must all be taken into consideration in deciding on an angle.\textsuperscript{9} When an arthrodesis is being considered for an infected TEA, massive amounts of bone or soft tissue loss\textsuperscript{13} will likely need to be addressed. Therefore, even in the best case scenario, arthrodesis of the elbow after an infected TEA must be approached with careful preoperative planning.

In our patient population, the fusion angle ranged from 45° to 90°. The fusion angle was determined by the amount of bone loss present. The ulnohumeral or radiohumeral joint was positioned to allow maximal bone contact without

![Figure 3](image_url) Radiographs of the patient in case 4. (A) Patient after revision total elbow arthroplasty (TEA) for a failed primary TEA. (B) Radiograph of elbow arthrodesis after revision TEA. (C) Patient after resection arthroplasty due to failed fusion hardware.
the need for structural bone graft. This was thought to provide the best chance of bone union of the fusion site while minimizing risk of infection that could be associated with a structural allograft.

Four patients were included in this study. At the final follow-up, 2 were revised to a resection arthroplasty and 2 developed a fibrous union. One fibrous union patient was treated in a range of motion brace after declining further intervention. None of the 4 patients managed to achieve fusion at least 12 months after elbow arthrodesis.

Other authors have reported on the difficulty of achieving union with arthrodesis after failed TEA. Wolfe et al\(^4\) described 12 patients with infection after TEA, 2 of whom were treated with arthrodesis. One patient developed a fibrous union and continued to have pain. The other patient had persistent pain and drainage, requiring further débridement and revision arthrodesis; both these procedures failed, and this patient continued to have intractable pain and persistent infection 2 years after the initial arthrodesis attempt. Presnal and Chillag\(^10\) reported on a case of a patient with multiple failed TEAs, in which an ulnohumeral arthrodesis was not possible, and the authors resorted to a radiohumeral arthrodesis as salvage. This patient ultimately gained bone fusion and “was able to use the arm for most functions.” One patient in the series reported by Koller et al\(^4\) had a fusion after an infected TEA. Because of massive bone loss, a double fibular strut graft technique (unclear whether it was autograft or allograft) was used, and fusion was achieved at 12 months. The patient had a satisfactory outcome.

Despite the paucity of literature that addresses arthrodesis as salvage for an infected TEA, this study has its limitations. The sample size was small, with only 4 patients meeting the inclusion criteria for analysis. In addition, we did not collect functional outcome scores on the patients before and after arthrodesis. Therefore, we cannot comment on their postoperative function and satisfaction. However, the objective of this review was to describe the difficulty of obtaining a solid bone fusion in these patients and to outline the potential complications that may arise.

**Conclusion**

Elbow arthrodesis in patients with a failed TEA with deep infection is difficult to achieve. The bone loss and compromised soft tissues encountered in these patients present a surgical challenge. Structural bone grafting may improve union rates but must be considered carefully in the setting of a previous deep infection. Because of the difficulty in achieving solid fusion and an increased complication rate, we cannot recommend elbow arthrodesis as a salvage procedure for failed TEA with deep infection.

**References**


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