Elbow Resection for Deep Infection After Total Elbow Arthroplasty

Surgical Technique

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Introduction

Deep infection at the site of a total elbow arthroplasty is best managed with definitive removal of the components with resection arthroplasty in selected patients¹⁻³.

The surgical management of deep infection complicating total elbow arthroplasty represents a challenge³. The goals of treatment include (1) eradication of the infection, (2) avoidance of complications, and (3) restoration of reasonable painless elbow function. Some patients are best treated medically with antibiotics for chronic suppression of the infection. Surgical options include irrigation and debridement, one or two-stage component reimplantation, resection arthroplasty, and rarely amputation⁴. Irrigation and debridement is the treatment of choice for acute infections with microorganisms sensitive to antibiotic therapy. Two-stage reimplantation is the most common procedure for chronic or resistant infections. However, in selected patients, definitive removal of the components with resection arthroplasty is the best surgical option for management of deep infection complicating total elbow arthroplasty¹⁻³.

Resection arthroplasty should be considered mainly for (1) infections that cannot be eradicated despite multiple salvage attempts and (2) frail patients who cannot tolerate lengthy or multiple surgical procedures. When resection arthroplasty is performed, it is extremely important to aim for the goals stated in Table I. Infection is more likely to be eradicated if all foreign material is removed. Nerve injuries and intraoperative fractures may severely affect the overall outcome of an already compromised joint and should be avoided at all costs. Finally, careful attention should be paid to soft-tissue closure and coverage to avoid wound complications and provide a reasonably stable and functional resection arthroplasty.

Careful patient evaluation is paramount for a safe and successful resection arthroplasty. An accurate patient history and careful physical examination should be complemented with a detailed review of all previous operative reports and microbiological studies. Good-quality radiographs, including those showing the entire length of the implant stems and cement columns, should be obtained in every case prior to surgery. The procedure should be planned with prior surgical exposures, the anticipated location of the main nerve trunks, implant fixation, and bone quality taken into account.

The procedure is divided into nine stages:

- Step 1: Skin incision and flap management
- Step 2: Identify ulnar and radial nerves
- Step 3: Deal with extensor mechanism
- Step 4: Remove humeral component and cement
- Step 5: Remove ulnar component and cement
- Step 6: Obtain samples for cultures and pathological analysis
- Step 7: Prepare and insert spacer
- Step 8: Close
- Step 9: Postoperative immobilization and care

Step 1: Skin Incision and Flap Management

Use a previous skin incision when possible, keep the subcutaneous flaps as thick as possible, and avoid inadvertent iatrogenic injury to the ulnar nerve.

- Place the patient supine on the operating room table (Fig. 1). We favor positioning the arm across the patient's chest; a bolster placed behind the ipsilateral scapula may facilitate

positioning. Prepare and drape the whole upper extremity from the wrist to the axilla using usual sterile technique. Use a sterile tourniquet as (1) tourniquet use facilitates identification and isolation of the ulnar and radial nerves, (2) a sterile tourniquet can easily be removed if proximal extension of the exposure is needed, and (3) there is less risk of accidental contamination at the proximal aspect of the sterile field.

- Use a previous skin incision whenever possible. Most elbows have been previously exposed through a posterior midline skin incision. The wound edges are resected only when they are devitalized because excessive skin debridement can compromise wound closure.
- Pay careful attention during flap elevation to (1) keep the subcutaneous flaps as thick as possible and (2) avoid inadvertent iatrogenic injury to the ulnar nerve, which may be located in the most unpredictable locations. Limit the extent of the skin flaps to the minimum required for adequate exposure of the elbow joint.

Step 2: Identify Ulnar and Radial Nerves

The location of the ulnar nerve may be unpredictable, and the radial nerve may be at risk in two different locations.

- Identify and protect the ulnar and radial nerves in every procedure (Figs. 2-A and 2-B). The ulnar and radial nerves do not need to be surgically dissected in all patients, but understanding the location of the nerves is paramount in order to avoid a nerve injury. The ulnar nerve has been previously transposed in most of the elbows requiring resection arthroplasty. It is important to realize that the location of the ulnar nerve may be unpredictable.
- Identify the ulnar nerve first either proximally or distally. If the ulnar nerve was previously transposed, its course is readily known, and the patient has no preoperative symptoms, dissection of the ulnar nerve along its whole course through the elbow region is unnecessary. Otherwise, the ulnar nerve should be carefully dissected free and protected during the rest of the procedure. Placement of a vessel loop around the nerve facilitates control and aids identification (Fig. 2-A). We favor tying a knot as a means to secure the vessel loop, since clamping the vessel loop with a

metal instrument may subject the nerve to inadvertent traction during the case.

- The radial nerve may be at risk in two different locations. Damage to the radial nerve may occur around the humeral shaft when dissection needs to be extended proximally and laterally, especially if the humeral implant and/or cement have created cortical defects. Formally identify and isolate the radial nerve in those circumstances (Fig. 2-B), to avoid damage when removing the implant or cement. The radial nerve can be palpated over the posterolateral aspect of the humeral shaft, approximately 10 to 15 cm proximal to the joint line depending on the amount of bone missing at the time of resection. Damage to the radial nerve may also occur distally, anterior to the radial head, when the anterior aspect of the elbow capsule needs to be resected or released for exposure or adequate debridement.

Step 3: Deal with Extensor Mechanism

Access the implants through windows on the medial and lateral aspects of the triceps; whenever possible, consider an extended olecranon osteotomy when the ulnar component and cement are well fixed.

- Try to obtain adequate exposure without further violating the extensor mechanism whenever possible. When the triceps insertion into the olecranon is well preserved, if possible gain access to the implants by working through windows on the medial and lateral aspects of the triceps; this is facilitated by the presence of preoperative bone loss at the medial or lateral humeral column.
- Alternatively, in patients with a well-fixed ulnar component and firmly retained cement, an extended olecranon osteotomy provides good exposure to the implants and cement, facilitates implant and cement removal from the ulna, and preserves the triceps attachment (Figs. 3-A through 3-G).
- Use previously nonunited olecranon osteotomy sites for exposure whenever they are encountered. When the triceps is found to be detached from the olecranon, use the area of triceps deficiency to expose the joint.

Step 4: Remove Humeral Component and Cement

Removal of all retained cement after removal of the humeral component is critical.

- Unlink the articulation between the ulnar and humeral components when the implant to be removed was linked. Dislocate the humerus from the ulna to facilitate circumferential exposure to the implant-cement-bone interface. The length of the humeral stem, the quality of stem fixation, and anticipated difficulties with the removal of all cement determine the need to consider some sort of humeral osteotomy. Proceed in a stepwise fashion. First, remove cement circumferentially around the humerus using a pencil-tip burr and flexible osteotomes. Loose components and those with precarious fixation may be removed with use of a slap-hammer extractor; cement around the distal portion of the implant should still be removed in these cases to facilitate extraction without inadvertent fracture of the humeral columns.
- Remove all retained cement after removal of the humeral component. This step is critical for eradication of the infection. Use intraoperative fluoroscopy to ensure that no cement is left behind. Osteotomes and long grasping instruments may be used under fluoroscopic control to remove cement fragments. Drilling across the cement and using flexible reamers over a guidewire may be considered to remove larger blocks of cement. Drill the block of cement perfectly centered on the anteroposterior and lateral planes. Otherwise, the reamers will violate the humeral cortex when used eccentrically in the canal. Use reamers to complete the debridement of the canal.
- An arthroscopy camera may be used to visually inspect the canal, guarantee that there is no retained cement, and aid in cement removal. Ultrasonic devices may also be considered for removal of cement and any cement restrictors, but they require dissection of the radial nerve to avoid thermal injury to the nerve. The radial nerve also needs to be formally isolated when the humeral cortex has been violated around the typical location of the nerve.
- When the humeral component cannot be safely removed by working around the stem, or the cement mantle is thick and very well bonded, a posterior cortical split or window is our technique of choice. To split the humerus (Figs. 4-A, 4-B, and 4-C), use a microsagittal saw along a vertical line centered on the posterior aspect of the humeral shaft. Cut through bone and cement until you feel the implant, and advance from distal to proximal the whole extent of the stem. Next, use several osteotomes to gently and slowly expand the split. After a few minutes, the implant and the cement may become debonded from the bone and can be

removed. Fix the split with circumferential wires or monofilament sutures, depending on the bone quality and planned future procedures.

- Alternatively, a posterior window provides excellent access to the bone-cement-implant interface (Figs. 5-A, 5-B, and 5-C). Outline the window with electrocautery or a marking pen so that it has a trapezoidal shape that is wider distally than proximally. The window preserves at least 5 mm of intact posterior humeral cortex on each side. The length of the window will vary depending on the length of the stem and the cement column. We typically place the window in the posterior cortex to expose the distal two-thirds of the construct to be removed. The proximal third of the implant and the remaining cement can typically be removed through the access provided by such windows; longer windows could lead to severe bone loss in case of iatrogenic fracture through the most proximal extent of the cortical window. Replace the removed window at the end of the procedure and secure it with circumferential wires or heavy monofilament sutures.

Step 5: Remove Ulnar Component and Cement

The ulna is much more delicate and fragile than the humerus and is prone to iatrogenic fracture.

- Use similar maneuvers to remove the ulnar component and cement. Start removing cement around the proximal aspect of the component with a pencil-tip burr. Loose components and those with precarious fixation can be removed with use of a slap-hammer extractor. Cement can be removed with very thin flexible osteotomes, burs, or a dedicated set of ulnar flexible reamers, with the same precautions as mentioned above. Exposure of the subcutaneous border of the ulna is associated with very little morbidity. When in doubt regarding areas of accidental perforation of retained cement, formally expose the ulna subperiosteally as much as is needed.
- The ulna is much more delicate and fragile than the humerus and is prone to iatrogenic fracture. We have a low threshold at which we osteotomize the ulna in a controlled fashion to remove all cement and well-fixed implants. An extended olecranon osteotomy may have already been performed if the triceps was found to be well attached to the olecranon at the time of exposure (Figs. 3-A through 3-G). Other-

wise, perform the osteotomy with the extensor mechanism already detached.

- Mark the osteotomy site with electrocautery or a marking pen. Typically, the medial aspect of the ulna is already stripped of soft tissues, whereas the lateral and anterior aspects have relatively well-preserved soft-tissue covering. Use a microsagittal saw to cut through bone and cement along the medial cortex of the ulna. The length of the osteotomy depends on the length of the ulnar stem and the cement column. Use a pencil-tip burr to create the transverse distal limb of the osteotomy, creating round corners to avoid stress-risers. The same pencil-tip burr may be used to perforate the opposite lateral cortex every 10 mm. Then, use osteotomes through the medial osteotomy line to crack open the osteotomy site with soft tissues attached. The implant and cement may then be removed. Secure the osteotomy site at the end of the procedure with circumferential wires or monofilament sutures.
- Once the implant and all cement are removed, flexible reamers may be used to complete the debridement of the ulnar canal. Make sure that the guidewire is perfectly centered in the canal and that the remaining cement does not cause the course of the reamer to deviate, leading to perforation of the ulnar cortex (Fig. 6).

Step 6: Obtain Samples for Cultures and Pathological Analysis

Send three separate samples for culture when there was at least one preoperative positive culture, and five samples when there were no positive preoperative cultures.

- Take intraoperative specimens for culture in every resection procedure, even when the causative microorganism has been previously identified by preoperative aspiration. Some infections may become polymicrobial over time, or sensitivities may change. We recommend sending three separate samples for culture when there was at least one preoperative positive culture, and five samples when there were no positive preoperative cultures. Taking only one or two samples may complicate postoperative decision-making, as it makes it more difficult to differentiate contaminants from true pathogens. We favor tissue samples for culture, as opposed to swabbing tissue surfaces. Typically, one tissue sample is taken from the humeral canal; one, from the ulnar canal; and one, two, or three, from the joint pseudocapsule or synovium. Where available,

the culture of fluid obtained after implant sonication may increase the yield of intraoperative cultures.

- In our opinion, intraoperative pathology is of value only as one more piece of information when the diagnosis of infection has not yet been established. If there were positive preoperative cultures or gross purulence, we do not send samples for histological examination. Preliminary data from our institution reveal that intraoperative pathological examination has a high negative predictive value (approximately 90%) but only a moderate positive predictive value (approximately 60%) for the diagnosis of deep infection after total elbow arthroplasty. In other words, absence of acute inflammation is useful for the exclusion of deep infection, but the presence of acute inflammation is not predictive enough to be of value.

Step 7: Prepare and Insert Spacer

Use the nozzles of cement guns to create cylinders of cement to be inserted in the ulna and humerus.

- This step is required only when a staged reimplantation or additional debridement are planned. When performing a definitive resection arthroplasty, it is best not to leave spacers behind in order to avoid the need of future surgery.
- Select the antibiotic to be mixed with the cement on the basis of preoperative sensitivities when available. Otherwise, you can add vancomycin (2 g per batch of cement) and tobramycin (2.2 g per batch of cement). Adding methylene blue to the mix colors the cement to facilitate its identification in future procedures.
- Use the nozzles of cement guns to create cylinders of cement to be inserted in the ulna and humerus (Figs. 7-A and 7-B). A thinner nozzle is required for the ulna. Place a wire inside the cylinder while the cement is hardening to provide some additional strength against fracture. Additionally, cement beads or wafers may be used if there is a large enough space. When cement beads are used, count the number of beads implanted and record this number in the operative report, to help guarantee that all beads are removed in the subsequent procedure.

Step 8: Close

For patients with compromised soft tissues, we often consult with a plastic surgeon prior to surgery to con-

template improved coverage with rotation or free flaps at the time of the resection arthroplasty.

- Careful wound closure is paramount to avoid additional procedures. Use monofilament suture for all layers. Osteotomies may require wire fixation. Avoid cables, since they are quite expensive, they may crush the underlying bone, and their braided nature makes them ill-advised in the setting of infection. In the ideal situation, it is possible to achieve some elbow stability by placing the ulna between the medial and lateral humeral columns. In the absence of sufficient osseous stability, the ulna and humerus may be stabilized with heavy monofilament sutures through bone.
- When the extensor mechanism is detached from the olecranon, place heavy monofilament sutures through bone tunnels in the olecranon to reattach the triceps. Place one or two drains to help decrease the risk of seroma or hematoma. Use 2-0 vertical mattress monofilament suture for skin closure.
- We have a low threshold at which we obtain a consultation with a plastic surgeon prior to the surgery for patients with compromised soft tissues in order to contemplate improved coverage with rotation or free flaps at the time of the resection arthroplasty (Figs. 8-A, 8-B, and 8-C).

Step 9: Postoperative Immobilization and Care

Early motion in an articulated brace may be allowed with a “stable” resection; unstable resections with substantial bone loss are best protected longer with no motion and may require a static brace.

- Apply a compressive dressing and an anterior plaster or fiberglass splint to keep the elbow in extension. The elbow should be kept elevated for one to three days, depending on the status of the soft tissues. After the first few days, we favor placing the elbow in a well-molded cast to allow for soft-tissue healing.
- Remove the sutures at two weeks. The elbow can then be placed in a cast or a commercial or custom-made splint for four to six weeks. Early motion in an articulated brace may be allowed when a patient has a “stable” resection—i.e., when the ulna sits in between the fork-like distal part of the humerus with both columns preserved (Figs. 9-A and 9-B). Unstable resections with substantial bone loss are best protected longer with no motion and may require a static brace to avoid late soft-tissue complications. Articulated or static brace

es are recommended to all patients, but compliance varies.

Results

We recently reviewed the Mayo Clinic experience with resection arthroplasty for the treatment of infection after total elbow replacement⁵. Fifty-one consecutive elbows that had been treated with resection for a deep infection following total elbow arthroplasty were identified. Twenty patients (twenty-one elbows) had either died (sixteen elbows) or declined follow-up (five elbows), but they were included in the analysis of complications and early outcome. Twenty-nine patients (thirty elbows) were contacted at an average of eleven years (range, 2.7 to twenty-eight years) postoperatively. The most common bacteria identified included *Staphylococcus aureus* and *Staphylococcus epidermidis*.

In our study, elbow resection resulted in an improvement of the Mayo Elbow Performance Score (MEPS), from an average preoperative value of 37 points to a mean final value of 60 points. Most of the increase in the score resulted from improvements in the pain component. On the basis of the MEPS, the overall result was considered good in eight (27%) of the thirty elbows in patients contacted at the time of long-term follow-up. The Disabilities of the Arm, Shoulder and Hand (DASH) score averaged 71 points (range, 51 to 91 points).

Complications included transient or permanent nerve injury in nine elbows (18%) and intraoperative fracture in eighteen elbows (35%). In addition, twenty-four elbows (47%) required additional surgery to treat persistent infection or wound complications. One patient sustained an iatrogenic vascular injury requiring an amputation.

What to Watch For

Indications

- Temporary resection
 - First stage of a two-stage reimplantation procedure for deep infection
- Definitive resection arthroplasty
 - A medically frail patient who cannot tolerate multiple surgical procedures
 - Severe immunosuppression that will make control of the infection unlikely
 - Infection by resistant microorganisms leading to failure of previous attempts to eradicate the infection with debridement or reimplantation procedures

- Patient unwilling to undergo multiple surgical procedures
- Severe bone loss not amenable to reconstruction

Contraindications

- Acute periprosthetic infection with sensitive microorganisms amenable to irrigation, debridement, and polyethylene exchange
- Chronic periprosthetic infection with sensitive microorganisms amenable to chronic suppression with antibiotics or two-stage reimplantation
- Severe bone loss, soft-tissue defects, multiple nerve injuries, or sequelae of compartment syndrome requiring amputation

Pitfalls & Challenges

- Intraoperative fracture of one or both humeral columns will compromise elbow stability.
- Intraoperative fracture of the humeral or ulnar shaft will compromise future reconstructive efforts and the overall outcome.
- Failure to remove all foreign material, use drains, and/or carefully close the soft tissue and protect the elbow may lead to persistent infection, soft-tissue complications, and a reoperation.
- Failure to identify and protect the ulnar and radial nerves may lead to permanent nerve injury.

Clinical Comments

- When do you recommend that a patient with an infection at the site of a total elbow arthroplasty strongly consider a permanent resection?

Patients with severe medical comorbidities, immunosuppression, or multiple failed attempts to treat a resistant infection are often better off with a permanent resection arthroplasty. Patients need to understand that the main benefits of the procedure are (1) eradication of infection, (2) pain relief, and (3)

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avoidance of additional procedures or future implant-related failures. However, a resection arthroplasty seldom leads to a satisfactory elbow joint in terms of stability and function.

- Should you formally dissect the radial nerve in most resections, or can you feel confident palpating the nerve and knowing where it is without formal nerve isolation?

The relatively high rate of temporary or permanent radial nerve injury in resection arthroplasty should lower the threshold for most surgeons to formally isolate and protect the radial nerve during the procedure. This is not required in every resection. However, it should be considered almost mandatory when there is violation of the humeral cortex by the implant or cement as well as when ultrasonic devices or motorized instruments are used for cement removal.

- Is it necessary to remove every bit of cement in a resection arthroplasty even if there are no plans for future reimplantation?

Retained cement is considered a potential source of persistent infection. When a two-stage reimplantation is considered, every effort should be made to remove all foreign material, including intraoperative use of fluoroscopy or an arthroscopic camera. When a permanent resection is planned, the need to remove all cement needs to be balanced with the risk of intraoperative fracture. However, a number of elbows will require a reoperation to treat persistent infection or wound problems after the resection, so all accessible foreign material needs to be removed.

- How often should you obtain a consultation with a plastic surgeon for a patient with an infection at the site of a total elbow arthroplasty?

Patients requiring a permanent resection usually have undergone multiple procedures and their soft-tissues are quite frail. Patients contemplating a two-stage reimplantation after resection will require an adequate soft-tissue envelope for the success of the reimplantation. For these reasons, the help of a plastic surgeon may be invaluable in the treatment of the infection at the site of the total elbow arthroplasty.

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Figures

Fig. 1

The patient is positioned supine, the upper extremity is draped free, and the surgery is performed with the arm across the chest. Accidental contamination of the surgical field is prevented with careful skin preparation, use of adhesive iodine-coated plastic coverage, and a sterile tourniquet. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 2-A

The ulnar nerve is best identified either proximally or distally, is isolated and protected with a vessel loop, and is dissected thorough its whole course only when needed. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 2-B

The radial nerve is best identified by deep palpation along the posterolateral aspect of the humeral shaft. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-A

Figs. 3-A through 3-G Extended olecranon osteotomy. **Fig. 3-A** Radiograph prior to resection of a well-fixed cemented ulnar component. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-B

The medial longitudinal and distal transverse limbs of the osteotomy have been created with a microsagittal saw and a high-speed burr. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-C

Perforations are created on the opposite cortex through the soft tissues prior to elevation of the dorsal cortex with osteotomes. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-D

Elevation of the osteotomy provides excellent access to the ulnar component and cement. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-E

The components and cement have been removed. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-F

Wires are passed in preparation for osteotomy closure. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 3-G

Postoperative radiograph with the osteotomy closed and antibiotic spacers in place. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 4-A

Figs. 4-A, 4-B, and 4-C Longitudinal humeral split. **Fig. 4-A** The posterior humeral cortex and cement are divided with a microsagittal saw to the tip of the prosthesis. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 4-B

The split is gently pried open with osteotomes over a period of three to five minutes. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 4-C

Once the cement is debonded from bone, the component and cement are removed with a slap-hammer extractor. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 5-A

Figs. 5-A, 5-B, and 5-C Posterior humeral window. **Fig. 5-A** A trapezoid window is created in an attempt to preserve the humeral condyles and expose two-thirds of the length of the cement column. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 5-B

Elevation of the osteotomy provides access to the humeral component and cement. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 5-C

The osteotomy site can be fixed with circumferential wires or sutures. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 6

When reamers are used in the humerus or ulna, care must be taken to avoid cortical perforation if cement causes the course of the reamer to deviate. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 7-A

Figs. 7-A and 7-B Cement spacers are created after mixing polymethylmethacrylate with antibiotics and methylene blue. **Fig. 7-A** Cement nozzles may be used to create small well-sized cylinders for the canals. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 7-B

Spacers may be reinforced with small wires. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 8-A

Figs. 8-A, 8-B, and 8-C Inadequate soft-tissue coverage is a major source of wound complications and persistent infection. **Fig. 8-A** Prior to resection, the soft tissues have been judged to be inadequate. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 8-B

A radial forearm flap is raised to assist in wound closure at the elbow. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 8-C

The forearm flap has been completed. (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 9-A

Fig. 9-B

These anteroposterior (**Fig. 9-A**) and lateral (**Fig. 9-B**) postoperative radiographs show a “stable” elbow resection; preservation of both humeral condyles facilitates a fulcrum for elbow flexion and extension). (Copyrighted and used with permission of the Mayo Foundation for Medical Education and Research; all rights reserved.)

Fig. 1

Fig. 2-A

Fig. 2-B

Fig. 3-A

Fig. 3-B

Fig. 3-C

Fig. 3-D

Fig. 3-E

Fig. 3-F

Fig. 3-G

Fig. 4-A

Fig. 4-B

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Fig. 4-C

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Fig. 5-A

Fig. 5-B

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Fig. 6

Fig. 7-A

Fig. 7-B

Fig. 8-A

Fig. 8-B

Fig. 8-C

Fig. 9-A

Fig. 9-B

TABLE I The Goals of Resection Arthroplasty

Goal	Method
Eradicate infection	Remove components Remove all cement and other foreign material Adequate soft-tissue debridement and closure
Avoid complications	Prevent iatrogenic fractures Prevent nerve injuries Protect extensor mechanism Ensure adequate soft-tissue coverage (flaps?)
Restore function	Preserve humeral condyles whenever possible Achieve as much joint stability as possible Braces