Impaction Grafting in Revision Total Elbow Arthroplasty for Aseptic Loosening and Bone Loss

Surgical Technique

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Based on an original article: *J Bone Joint Surg Am.* 2013 Jun 5;95(11):e74.

Introduction

Impaction grafting in revision arthroplasty for aseptic loosening of a semiconstrained total elbow replacement with severe bone loss can provide adequate implant fixation and stability with minimal resorption. The total elbow arthroplasty provides the pain relief and improvement in activities. The bone graft is an adjunct to achieve stability of the implant.

An increasing number of total elbow arthroplasties have been performed over the past several decades, and it is a treatment option for some patients with arthritic elbows^{1,2}. With the increase in total elbow arthroplasties, there has been a parallel increase in technically demanding revision surgery, similar to the experience with other joint arthroplasties such as hip or knee replacements³.

Aseptic loosening is one of the main causes of failure of total elbow arthroplasty⁴, and the failure is often associated with extensive bone destruction, osteolysis, cortical thinning, or ballooning of the cortex⁵. When failed elbow arthroplasty is associated with limited or minimal bone loss, replacement with a new, longer stem bypassing the area of bone deficiency can be an option for reconstruction surgery^{6,7}. However, more extensive bone deficiency adds complexity to the revision surgery, and it can be difficult to obtain stability and adequate length of the upper extremity⁸. Several methods to deal successfully with bone deficiency using cancellous autograft, impaction grafting, an allograft-prosthesis composite, or cortical strut allograft have been described^{5,9-11}. The use of allograft to restore skeletal defects has become increasingly popular in tumor resection surgery and lower-limb revision arthroplasty¹². There have also been reports on the use of allograft to reconstruct areas of skeletal deficiency around the elbow¹³⁻¹⁶. Allograft is an attractive option because it is readily available, eliminates the morbidity from harvesting autologous bone, and shortens surgical time³.

The following steps describe a useful surgical

technique using allograft in revision total elbow arthroplasty.

Step 1: Preoperative Assessment

Confirm aseptic loosening by preoperative radiographic evaluation and a workup for infection.

- Take a thorough history, perform a complete physical examination, and obtain radiographs of the elbow. Using this clinical and radiographic information, determine the cause of the failure of the total elbow arthroplasty.
- Evaluate radiographic evidence of prosthetic loosening, the presence of cortical ballooning, and the degree of radiolucency at the bone-cement interface.
- Assess the preoperative complete blood cell count (CBC) with differential count, erythrocyte sedimentation rate (ESR), and C-reactive protein level to rule out the possibility of infection.
- Routine use of preoperative intravenous antibiotics is recommended.
- A supine position is preferred for easy access to fluoroscopy. The patient's arm is forward flexed 90°, and the elbow is gently flexed to expose the previous posterior skin incision with supporting pads underneath the elbow.

Step 2: Surgical Approach

Use the previous incision.

- Perform the operation with the patient under general anesthesia, in the supine position, and draped up to the base of the neck, with the shoulder girdle exposed. Apply an automatic pneumatic tourniquet and use an Esmarch elastic bandage to exsanguinate the upper extremity prior to inflating the tourniquet.

- Use the previous posterior skin incision and reflect the triceps laterally from the olecranon with continuity to the periosteum of the ulna and the fascia of the forearm along with the anconeus without releasing the ulnar nerve.
- Palpate and mark the ulnar nerve to prevent possible ulnar nerve injury.
- The ulnar nerve does not need to be released unless the patient has ulnar symptoms because in most cases the ulnar nerve was already transposed anteriorly at the time of the primary arthroplasty.

Step 3: Implant Removal

Thoroughly debride soft tissue while saving as much cortex as possible.

- Thoroughly remove hypertrophic synovium, cement fragments, small bone, fragments, and areas of metallosis (Figs. 1-A and 1-B).
- Remove loosened implants. It is sometimes difficult to remove both the humeral and the ulnar implant. If either is removed and the other is tightly stabilized, revision of only the loosened component is adequate.
- Remove all of the cement fragments, areas of metallosis, and fibrous tissue in the medullary canal.
- A small-tip rongeur and a curved small curet can be useful for removal of the debris.
- Tightly adhered cement fragments can be left in place as long as they do not interfere with the placement of the revision stem.
- Preserve thin cortex of the cortical balloon as much as possible.

Step 4: Ulnar Side Preparation

Insert the guidewire under fluoroscopic guidance and use a cannulated flexible reamer; placing the guidewire past the sclerotic dome (pedestal) of the cortical balloon prevents misplacement of the revision stems (Figs. 2-A and 2-B).

- Under fluoroscopic guidance, pass a guidewire into the ulnar medullary canal. The guidewire must penetrate the sclerotic dome of the cystic cortical balloon and sit in the normal medullary canal distal to the ballooned cortex (Figs. 3-A, 3-B, and 3-C).
- Confirm with fluoroscopy that the guidewire has been correctly placed in the medullary canal past the cortical balloon because misplacement of the revision implant could result in catastrophic shifting, loosening, or fracture in the future.
- Widen the distal part of the medullary ulnar

canal using a cannulated flexible reamer along the previously passed guidewire (Fig. 4). The depth should be sufficient to pass the sclerotic dome of the cortical balloon.

Step 5: Humeral Side Preparation

Prepare the humeral side in a manner similar to that on the ulnar side.

- Once the medullary canal is thoroughly debrided, insert the guidewire so that it passes the sclerotic dome, and confirm this with fluoroscopy (Fig. 5).
- Pass a cannulated flexible reamer over the guidewire, as was done on the ulnar side.

Step 6: Impaction Allografting and Linking Prosthesis

Using a trial stem in situ, tightly pack morselized bone graft into the medullary canal of both the ulna and the humerus.

- For impaction grafting, use either a commercially prepared, prepackaged cancellous allograft or a suitable allograft (e.g., a sterile femoral head) from a bone bank. If a femoral head is used, place it in 500 mL of saline solution mixed with 1 g of gentamicin for defrosting. Then morselize it into 3 to 4-mm fragments using a bone mill. When additional bone graft is required, autogenous bone graft can be harvested from the iliac crest if it is not available commercially.
- Insert a long trial ulnar stem into the previously widened intramedullary canal of the ulna. Then pack the bone defect surrounding the long trial implant with morselized bone graft. Tightly pack a sufficient amount of morselized graft with a small, long bone impactor to give stability to the ulnar trial implant (Fig. 6).
- Carefully remove the trial implant without disrupting the structural integrity of the tightly packed morselized grafts and, using a 50-mL syringe, inject low-viscosity cement into the medullary canal that was previously occupied by the trial implant.
- Insert the ulnar component into the medullary canal under fluoroscopic guidance, confirming correct placement (Figs. 7-A and 7-B). An extra-small-diameter ulnar component is useful because a standard small-sized ulnar component requires additional bone removal at the entry site in order to place the implant deep enough. In addition, use a longer stem to bypass the area of bone deficiency.
- Once the ulnar component is stabilized, insert

the humeral revision implant with a similar technique under fluoroscopic guidance (Fig. 8).

- We prefer to use a semiconstrained prosthesis with an anterior flange on the humeral implant. The anterior flange is positioned to sit just anterior to the humeral cortex. Although it could impinge and increase the pistoning effect on the ulnar component, it helps resist torsional and posterior translation of the humeral stem and extra strut graft can be placed under the anterior flange when optimal contact on the backside of the humeral flange is not obtained.
- Link the ulnar and humeral components and check the range of motion and stability of the inserted revision implant.
- Repair the triceps back to the olecranon using two transosseous drill-holes in a cruciate configuration through the ulna. Pass heavy braided suture through the drilled holes on the ulna. Close the skin layer by layer and apply a long arm splint.

Step 7: Postoperative Care

Active flexion and extension with the patient wearing a brace starts at two weeks postoperatively, the brace is removed at six weeks postoperatively, and the patient is allowed to return to daily activity beginning three months postoperatively.

- An elbow splint applied at 90° of flexion and neutral rotation is worn during the day, and an elbow splint in full extension is worn during the night for two weeks after the surgery.
- At two weeks postoperatively, active flexion and extension with the patient wearing a brace is allowed, and the brace is removed at six weeks postoperatively.
- Return to daily activity is allowed beginning three months postoperatively, with the patient allowed to lift no more than 1 kg on a repetitive basis and no more than 5 kg as a single event.
- Return to light recreational activity is allowed beginning six months postoperatively.

Results

We retrospectively analyzed sixteen cases of revision arthroplasty performed following aseptic loosening of

semiconstrained total elbow replacements¹⁷. There were three men and thirteen women with a mean age of 58.4 years (range, twenty-eight to seventy-five years). The mean duration of follow-up was 7.4 years (range, 4.1 to 11.2 years). The pain, arc of flexion, and stability according to the Mayo Elbow Performance Score (MEPS) significantly improved, on average, from 15.0 points to 32.8 points, 60.3° to 115.6°, and 2.2 to 9.4 points, respectively. The total MEPS improved from a mean of 41.0 points to a mean of 82.8 points ($p = 0.001$). The result was rated as excellent for four elbows, good for eleven, and fair for one.

Follow-up radiographs demonstrated fifteen cases with grade-I resorption of the bone graft and one case with grade-II resorption. A type-I radiolucent line was observed in twelve elbows; a type-II line, in three; and a type-IV line, in one.

What to Watch For

Indications

- Aseptic loosening of a semiconstrained total elbow replacement with severe bone loss, osteolysis, cortical thinning, or ballooning of the cortex.

Contraindications

- Failed elbow arthroplasty associated with active infection.

Pitfalls & Challenges

- Confirm correct placement of the implant into the intramedullary cavity with fluoroscopy.
- Use a small-diameter long stem to penetrate the sclerotic dome and avoid misplacement in a false track outside the medullary canal.
- Pack a sufficient amount of bone graft to give the implant stability.
- Obtain implant stability during the operation.
- Use a flanged humeral stem.

Clinical Comments

It is critical to place the revision stem past the sclerotic dome on a false track. Use of a small-diameter long stem could be helpful. Correct placement of the revision stem must be confirmed with fluoroscopy.

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Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

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Figures

Fig. 1-A

Metallosis, hypertrophic synovium, cement, and bone fragments are found.

Fig. 1-B

Metallosis, hypertrophic synovium, cement, and bone fragments should be excised as thoroughly as possible.

Fig. 2-A

Preoperative anteroposterior radiograph showing both the humeral and the ulnar component in a false track formed by cortical ballooning and osseous breakage. The arrows indicate the sclerotic dome.

Fig. 2-B

Preoperative lateral radiograph showing both the humeral and the ulnar component in a false track formed by cortical ballooning and osseous breakage. The arrows indicate the sclerotic dome.

Fig. 3-A

Preoperative lateral radiograph showing the ulnar component in a false track formed by cortical ballooning.

Fig. 3-B

The guidewire in the false track must pierce through the sclerotic dome and enter into the normal medullary canal under fluoroscopic guidance.

Fig. 3-C

Schema of the passing of the sclerotic dome of cortical ballooning to prevent misplacement of revision stems.

Fig. 4

Along the guidewire inserted into the ulnar medullary canal, a cannulated reamer is used to widen the distal part of the ulnar medullary canal under fluoroscopic guidance.

Fig. 5

The guidewire and cannulated reamer are used on the humeral side in the same manner as on the ulnar side under fluoroscopic guidance.

Fig. 6

Morselized allograft is tightly packed into the area of bone loss.

Fig. 7-A

Illustration demonstrating the correct position of the ulnar stem in the medullary canal, which is confirmed with fluoroscopy.

Fig. 7-B

Intraoperative lateral radiograph demonstrating the correct position of the ulnar stem in the medullary canal, which is confirmed with fluoroscopy.

Fig. 8

The humeral stem is inserted into the right position under fluoroscopic guidance.

Fig. 1-A

Fig. 1-B

Fig. 2-A

Fig. 2-B

Fig. 3-A

Fig. 3-B

Fig. 3-C

Fig. 4

Fig. 5

Fig. 6

Fig. 7-A

Fig. 7-B

Fig. 8