

SUBSPECIALTY PROCEDURES

TOTAL ELBOW ARTHROPLASTY: WHY AND HOW

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Introduction

Elbow arthroplasty is a relatively infrequent orthopaedic procedure that can be performed in multiple ways according to the type of prosthesis that is used and the needs of the individual patient. In 2016, the Dutch Arthroplasty Register included approximately 400 elbow arthroplasties compared with >28,000 hip arthroplasties and >27,000 knee arthroplasties¹.

Joint arthroplasty is performed in patients after other solutions to obtain pain relief and improve function, such as conservative treatment using physiotherapy and analgesics and operative treatment such as (arthroscopic) joint debridement, have been tried. In patients with slight to moderate joint osteoarthritis and in young patients, these options are preferable because a patient may outlive an elbow replacement and these approaches increase the time before a replacement is necessary.

The planned patient-specific approach includes decisions regarding which implant to use and how to handle the triceps muscle and tendon during the approach. First, the implant choices are made on the basis of stability and extensiveness; that is, whether unlinked implants, which have less intrinsic stability, or linked implants, which have more intrinsic stability, should be used, and whether ulnohumeral joint replacement should be done with or without radiocapitellar joint replacement. For example, in heavily deteriorated rheumatic elbows with insufficient ligamentous stability, a linked prosthesis is most often chosen. Second, to allow proper visualization, the triceps tendon can be split, reflected, or lifted using an ulnar osteotomy². After removal of the diseased cartilage and preparation of the ulna, humerus, and radius, the prostheses are implanted according to implant-specific guidelines. In the videos accompanying this article, the implantation of a Latitude total elbow prosthesis (Tornier) is shown.

As with all arthroplasties, rehabilitation is necessary. The elbow is prone to develop contractures, which are prevented by having the patient avoid long-standing inactivity and wearing a cast.

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Indications & Contraindications

Indications

- Elbow pain at rest or at night that is not controlled by analgesia, nonsteroidal anti-inflammatory drugs, or bracing
- Primary osteoarthritis
- Posttraumatic osteoarthritis
- Trauma (unreconstructible intra-articular distal humeral fractures)
- Posttraumatic conditions (nonunion of fractures or persistent dislocations in elderly patients)
- Inflammatory arthritis (rheumatoid or psoriatic)
- Tumor reconstruction

Contraindications

- Systemic infection
- Local infection
- Inability to participate in postoperative rehabilitation
- Neuropathic joint disease
- Poor soft-tissue envelope
- Poor surrounding muscle function or degenerative muscle disease
- High physical demands after arthroplasty and a biological age of <50 years, as results have shown a decreased 10-year survival rate in young, working patients compared with older patients and those with lower physical demands³.

Step 1: Preparation and Positioning of the Patient

Place the patient in the lateral decubitus position or in the supine position with the arm draped, allowing for easy manipulation of the elbow during the procedure.

- Place the patient in the lateral decubitus or supine position (Video 1). With the patient in the lateral decubitus position, the contralateral arm is placed in 90° of forward elevation with the elbow in 90° of flexion and the forearm pointing toward the head. With the patient in the supine position, the arm is placed in 90° of ante flexion with the elbow in 90° of flexion, in front of the head. In the supine position, more elbow flexion may be reached by abducting the arm^{4,5}. Secure solid positioning of the patient with the use of a beanbag or pelvic supports.
- Place the arm on a padded support in such a way that only the most proximal part of the arm is supported, leaving ample room for the elbow to be manipulated.
- Prevent the arm holder from pushing the neurovascular structures toward the operating field.
- After sterile draping of the arm, apply a silicone ring tourniquet, placing it as proximal as possible to allow for proximal extension of the posterior incision if required.

Video 1 Introduction to the surgical technique and demonstration of the method used to expose the joint for total elbow arthroplasty. (The patient-positioning illustration is reproduced from: de Vos MJ, Wagener ML, Verdonshot N, Eygendaal D. An extensive approach of the elbow with osteotomy of the medial epicondyle. *J Shoulder Elbow Surg.* 2014 Mar; 23(3):313-7. Copyright 2014; reproduced with permission from Elsevier. The anatomical illustration is reproduced, with modification, from Gray H. *Anatomy of the human body.* Philadelphia: Lea & Febiger; 1918.)

Step 2: Incision

Palpate and mark the local osseous landmarks, ulnar nerve, and incision, and then make a posterior incision to allow 360° access to the elbow joint as well as to allow decompression or transposition of the ulnar nerve.

- Mark the radial head, medial and lateral epicondyles, central band of the triceps muscle, and olecranon.
- Mark the incision, starting it at least 8 cm proximal to the elbow joint, making a slight curve just lateral to the olecranon tip, and extending it 8 cm distal to the elbow joint.
- Incise the skin as marked.
- Prevent the incision from running over the olecranon tip, as this might cause postoperative wound dehiscence and irritation of the scar.

Step 3: Approach—The Superficial Layer

Perform the superficial approach, including a decompression of the ulnar nerve, and properly visualize the triceps tendon attachment on the proximal part of the ulna and both epicondyles.

- Develop an ulnar flap separating the subcutaneous layer from the fascial and muscular layer deep to it. The medial epicondyle is then in view.
- Locate the ulnar nerve and decompress it. Then prepare the nerve as for an anterior transposition. A vessel loop can be used as a visual aid to keep the nerve from harm during the remainder of the procedure.
- Use a stay suture to keep the ulnar flap to the ulnar side.
- Develop the radial flap in a similar fashion, keeping it as thick as possible, revealing the lateral epicondyle, and secure the flap temporarily with another stay suture.

Step 4: Approach—The Deep Layer

Mobilize the triceps to allow visualization of the articular surfaces of the ulna, humerus, and radius, while taking care to protect the ulnar nerve.

- For a so-called triceps-on approach, when the distal triceps tendon is not lifted from the ulna, multiple options are possible. First, make a chevron osteotomy of the ulna on the proximal part of the ulna, distal to the attachment of the triceps muscle. This allows the triceps to be lifted off and the articular surfaces to be visualized. When this approach is used, we advise “pointing” the chevron osteotomy distally, to maximize bone stock of the central band of the triceps tendon. Second, the triceps can be reflected medially or laterally according to what is needed during surgery. This approach has a relatively high rate of failure because of nonunion of the ulnar osteotomy². We advise refixation of the osteotomy, when performed, with both a screw and Kirschner wires in a figure-8 configuration.
- For a triceps-splitting approach, perform dissection lateral to the triceps muscle, which allows room for dislocation of the elbow joint. This approach does not interfere with the triceps muscle fiber integrity, yet care must be taken not to cause traction on the ulnar nerve².
- For a so-called triceps-off approach, palpate the central band of the triceps. Perform an incision around the central band to create a triceps flap and sharply dissect the tendon to divide the tendon off the muscle⁶. Then, incise the triceps muscle to allow visualization of the articular surfaces. Ensure that the lateral side of the triceps, to which the intermuscular septum is attached, remains untouched.
- To allow movement between the humerus, radius, and ulna, perform osteotomies to release the ligamentous structures. An osteotomy of the supinator attachment on the tuberosity of the ulna, to which the lateral collateral ligament and annular ligament are attached, allows a disarticulation of the elbow and direct visualization of all joint surfaces.
- To allow even better visualization, release the medial collateral ligament. We advise the use of an osteotome to create a humeral bone block with the insertion of the medial collateral ligament, which can be reattached during closure with transosseous sutures or bone anchors.
- Note that these osteotomies lead to more patient morbidity and should be performed only when necessary.

Step 5: Preparation of the Osseous Structures

Prepare the humerus and ulna in conformance with the technique that is described for the prosthesis and take care to restore the anatomical flexion-extension axis of the elbow.

- When an implant that also allows placement of a radial head component is chosen, perform standard preparation of the radius (Video 2).
- To determine the axis of the bones and joint surfaces, insert a guide pin into the medullary canal of the humerus and ulna. Perform meticulous assessment, as improper alignment may result in excessive wear of the prosthesis⁷.
- Replace the guide pin with reamers to open the cortex, prepare the medullary canal, and determine implant sizes.
- Note that the axis of the distal end of the humerus passes through the midpoint of the lateral condyle and the anterior and inferior part of the medial condyle with 5° of internal rotation.
- Insert the trial components.

Video 2 Resection and preparation of osseous structures.

Step 6: Placement of the Prosthesis

When all trial components are in place, reduce the joint to test the stability of the elbow.

- Reduce the joint with the trial prosthesis and test the function and stability of the elbow, using varus and valgus stress in 30° of elbow flexion. Perform this maneuver cautiously as it is prone to causing iatrogenic fractures.
- When a convertible prosthesis is implanted, link the trial component to assess the influence on the stability of the elbow.
- Remove the trial prosthesis. When a cemented prosthesis is used, insert the cement plugs to the proper depth into the ulnar and/or humeral shaft.
- Perform excessive lavage of the ulnar and humeral shafts and, when indicated, of the radial shaft. This will lead to the best cement fixation possible.
- Depending on the type of the prosthesis, assemble the definitive components.
- Cement all components of the elbow prosthesis at the same time or separately, depending on the type of the prosthesis and the surgeon's preference. During cementation, take care to maintain the proper depth and rotation of the components. It is useful to extend the elbow at this time so that longitudinal pressure over the arm can be given.
- Depending on the stability of the elbow during trial reduction and after reduction of the definitive prosthesis, link a convertible prosthesis at this time.
- Document the preoperative range of motion in order to evaluate rehabilitation success during recovery.

Step 7: Closure of the Elbow

When all of the definitive components of the total elbow arthroplasty are in place, close the surgical wound in layers as the anatomy is restored.

- After placement of the prosthesis, thoroughly rinse the elbow with saline solution to wash out any debris and prevent heterotopic ossification (Video 3).
- If the ulnar and radial collateral ligaments have been released during the approach, perform refixation to provide additional stability to the total elbow replacement.
- If the triceps has been released from the olecranon (e.g., to create a triceps flap), perform refixation of the triceps with Vicryl sutures (Ethicon). A thick suture is recommended, as the triceps muscle provides large pulling forces at this point during extension and proper fixation is necessary.
- Leaving a drain in the surgery site is an option, yet it might pose a possible source of infection. Therefore, we suggest leaving a drain only when a patient uses therapeutic anticoagulants or has excessive blood loss during surgery.
- Remove the vessel loop from the ulnar nerve and either transpose the nerve or replace the nerve into the sulcus. Preoperative ulnar nerve symptoms might guide the decision to transpose.
- Close the subcutaneous layers with Vicryl sutures and the skin with transcutaneous sutures or staples. A continuous intracutaneous suture is not recommended because, if there is an infection, the entire wound would need to be opened.

Video 3 Closure of the elbow.

Step 8: Postoperative Care

After surgery, a wound dressing is applied and physical rehabilitation is started to maximize the functional outcome.

- After surgery, but before the tourniquet is removed, apply a compressive wound dressing. According to local standards, the dressing is left on for 24 to 72 hours.
- As there is no clear scientific evidence regarding when to start physical rehabilitation—immediately after surgery or after several days of rest—or on the use of continuous passive motion, these choices are made according to the preference of the surgeon.
- Adequate pain relief is mandatory in the first weeks during exercises and may include an interscalene block for the first 2 to 3 days. Physical therapy should be used to prevent limitation of range of motion.

Results

In our study of the mid-term results of a convertible total elbow arthroplasty, based on 58 elbow arthroplasties, patients had significant improvement in range of movement, function, and pain at 6 months postoperatively⁸. The patients were followed for a mean of 43 months, and the improvement either continued or reached a plateau. However, as for all practical interventions, preparation and rehearsal of the procedure are paramount. We do not recommend one specific approach, yet we do advise that the surgeon be aware of different methods and that he or she choose the most fitting one for the individual patient. The success of total elbow arthroplasty is demonstrated by the substantial improvement experienced by the patient, which is measured objectively with an increased range of motion and subjectively with pain reduction. In general, total elbow arthroplasty has a 10-year survival rate of approximately 85% to 90%^{3,9,10}. However, the complication rate for the procedure remains high. Therefore, elbow arthroplasties should be performed in specialized centers^{3,11,12}.

Pitfalls & Challenges

- Do not incise the skin over the olecranon tip. This might lead to more wound problems as patients apply more pressure on this point of the elbow and less soft tissue is present.
- When incising the deeper layers, take care with respect to the ulnar nerve. In a fair number of patients (10%), the ulnar nerve shifts out of the sulcus during flexion and extension. This is best assessed before incision by palpating the ulnar nerve in the sulcus.
- The central band of the triceps tendon provides the most force transmission to the ulna and should be left untouched as much as possible. A proximal transverse incision provides the most traction resistance, in our opinion, and is therefore recommended.
- During elbow disarticulation for articular exposure, remain aware of the neurovascular structures on the ventral side of the elbow joint and do not force the disarticulation.
- For the prevention of intraoperative fractures, we advise the use of cannulated reamers instead of noncannulated broaches following preinsertion of a Kirschner wire.
- Preoperative sizing of the implant is possible, yet most implants come in a limited number of sizes, which makes preoperative implant sizing less useful than it is in hip surgery, for example.
- We do not recommend oversizing of the prosthesis, as this might lead to intraoperative fractures as well. Therefore, we try a larger component only when trial components are apparently undersized.
- To prevent an inaccurate approach and a faux route during surgery, we first introduce a Kirschner wire in the ulnar and humeral medullary canals, which we prepare by drilling over the wire with cannulated reamers.

- In our opinion, the use of a drain is controversial, since the integrity of the skin is compromised and therefore it might be more prone to infections; however, the prevention of hemarthrosis might be beneficial in postoperative rehabilitation.
- Regarding postoperative instructions to physiotherapists and patients, the exact amounts of force allowed to be exerted on the elbow after arthroplasty are not clear. Empirically, the avoidance of high impacts and forces is recommended, and a 2-kg weight restriction is advised; however, to our knowledge no scientific evidence is available.
- The postoperative use of a brace is controversial, as immediate postoperative exercise might lead to better functional outcomes (i.e., better range of motion and muscle strength) but may lead to iatrogenic fractures because of overuse. We recommend that the patient start with continuous passive motion and physiotherapist-supervised exercises before he or she is discharged.

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