capitellum has a loose but nondisplaced fragment. A grade 5 OCD lesion of the capitellum has a displaced fragment that becomes one or more loose bodies.

The International Cartilage Repair Society (ICRS) also developed an arthroscopic classification system for capitellar OCD lesions. Stable OCD lesions of the capitellum that have a continuous but softened area covered by intact cartilage are classified as ICRS grade I. OCD lesions of the capitellum with partial discontinuity that are stable if probed are classified as ICRS grade II. OCD lesions of the capitellum with complete discontinuity that remain contained within the crater are classified as ICRS grade III. Empty defects or OCD lesions of the capitellum with a dislodged or a loose fragment are classified as ICRS grade IV.

Takahara et al reviewed a large series of patients and created a simple classification system for capitellar OCD lesions. OCD lesions of the capitellum were classified as stable (indicating a good prognosis after nonsurgical management) in patients who had an open capitellar physis, localized flattening or radiolucency of the subchondral bone, and near-normal elbow ROM. Capitellar OCD lesions in all other patients, including those who had a closed physis, fragmentation (Figure 1), or elbow ROM that was restricted more than 20°, were classified as unstable (indicating a worse prognosis after nonsurgical management).

### Alternative Treatments

The goals of treatment are to address a patient’s symptoms (pain, stiffness, or locking) and, ideally, allow the capitellar OCD lesion to heal. A healed, aligned fragment with a patient’s native articular cartilage is optimal. Management options for fragments deemed to have a poor chance of healing include débridement with stimulation of fibrocartilage and articular cartilage reconstruction.

### Stable Capitellar OCD Lesions

Arthroscopic techniques have become standard for the management of capitellar OCD. Arthroscopy can be used to assess, débride, and microfracture or drill OCD lesions. Advantages of arthroscopy include the capacity to assess the entire elbow joint, the ability to remove loose bodies, and the minimally invasive nature of the procedure.

Surgical options for patients who are unsatisfied after nonsurgical management of stable capitellar OCD lesions (that is, lesions unlikely to progress after nonsurgical management) include fluoroscopic-assisted drilling into the fragment to stimulate healing as well as fragment internal fixation (arthroscopic or open). Drilling can be accomplished from posterior to anterior through the intact humerus using Kirschner wires (K-wires) under arthroscopic or fluoroscopic guidance. Multiple passes are made with the K-wires to stimulate healing and create channels for blood flow. Internal fixation can be accomplished with small screws (Figure 2), bone spicules, sutures, or bioabsorbable tacks or darts. The anconeus muscle-splitting approach with the elbow in hyperflexion is used for open reduction and internal fixation (Figure 3).

### Unstable Capitellar OCD Lesions

Unstable capitellar OCD lesions can be reduced and fixed or excised. After excision, microfracture is intended to stimulate the growth of fibrocartilage; alternatively, these lesions can be reconstructed with osteochondral autograft. These techniques can be...
Indications

Complete tears of the triceps tendon and those tears comprising greater than 50% of the tendon are considered for surgical repair (Figure 1). However, treatment must be individualized to each patient. Patients who are debilitated may benefit from nonsurgical treatment of complete tears because the lateral expansion and anconeus are often intact, allowing active, albeit weak, elbow extension (Figure 2). Partial tears comprising greater than 50% of the tendon are often managed surgically in young, healthy patients.

Partial tears comprising less than 50% of the tendon are often managed nonsurgically. However, active individuals may require surgical intervention if nonsurgical treatment is unsuccessful. Symptoms of partial tears include pain and weakness. Partial and complete tears of the triceps muscle belly are generally managed nonsurgically.

Contraindications

Patients with severe medical comorbidities who are at risk for anesthetic or surgical complications should be treated nonsurgically. Patients with a history of infection or an active infection should not be treated surgically with allograft.

Alternative Treatments

Nonsurgical management often consists of immobilization in a splint or cast for up to 4 weeks with the elbow at approximately 30° of flexion. Depending on the size of the tear, immediate rehabilitation of small partial-thickness tears...
noted at 16 weeks in the two injection groups compared with the observation group.

Surgical treatment should be reserved for patients in whom nonsurgical treatment has failed to achieve satisfactory results. In one study, researchers reported a 90% response rate with improvement in pain in select patients with a minimum of 6 months of previous failed nonsurgical treatment. Surgical management of lateral epicondylitis can include percutaneous or open release of the ECRB origin or open or arthroscopic débridement of pathologic tissue at the ECRB origin (Figure 2) with or without reattachment of the ECRB origin. Data on the surgical management of medial epicondylitis are limited. The authors of one study recommended débridement of the nidus of pathologic tissue in the medial conjoint tendon and attention to potential concomitant ulnar neuropathy (Figure 3).

**Contraindications**

Because evidence supports the time-limited nature of epicondylitis, nonsurgical treatment should be attempted before surgical treatment is considered. Additionally, if the patient’s symptoms are consistent with radial tunnel syndrome (compression of the posterior interosseous nerve in the proximal forearm), surgical treatment at the lateral epicondyle will not address this issue. In fact, many patients with so-called recalcitrant epicondylitis actually have radial tunnel syndrome. Caution is necessary when undertaking surgical treatment in patients with severe skin atrophy resulting from multiple corticosteroid injections. The local tissue may be hyperesthetic, and a surgical incision often worsens this problem.

**Table 1** Results of Nonsurgical and Surgical Management of Lateral and Medial Epicondylitis

<table>
<thead>
<tr>
<th>Authors (Year)</th>
<th>Number of Patients</th>
<th>Procedure or Approach</th>
<th>Mean Patient Age in Years (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dunn et al (2008)</td>
<td>83</td>
<td>Open Nirschl débridement</td>
<td>46 (23-70)</td>
</tr>
</tbody>
</table>
| Thanasas et al (2011) | 28                 | Injection of PRP or injection of autologous blood | PRP group, 35.9 (34-55)  
                                      Autologous blood group, 36.6 (29-52) |
| Coombes et al (2013) | 165                | Corticosteroid injection or physical therapy | 49.7 (NA)                       |
| Solheim et al (2013) | 295                | Open or arthroscopic tendon release | 46 (NA)                         |

NA = not available; PRP = platelet-rich plasma; quickDASH = quick Disabilities of the Arm, Shoulder and Hand.
facilitate exposure of the capitellum (Figure 5).

- The typical grade IV OCD lesion is carefully examined, and the margins of intact articular cartilage and the quality of the underlying subchondral bone are noted. Commercially available sizers should be available to quantify the diameter of the lesion, which typically measures 8 to 10 mm.

- The chisel appropriate for the recipient site is placed in the region overlying the OCD lesion. It is imperative that the chisel is oriented perpendicular to the articular surface.

- The chisel is impacted to a depth of 10 to 15 mm, and the abnormal bone from the OCD lesion is removed. The depth of the recipient site is carefully measured, and confirmation is made that no cortical breach has occurred. This completes preparation of the recipient site (Figure 6).

- Attention is then turned to the knee.

- After the limb is exsanguinated with an Esmarch bandage and the tourniquet on the proximal thigh is inflated to 250 mm Hg, a small lateral parapatellar incision is created just superior to the palpable joint line (Figure 7, A).

- Dissection is performed through the subcutaneous tissues and the deep fascia.

- A lateral parapatellar arthrotomy is created, leaving a cuff of tissue on the patella to facilitate subsequent closure.

- With the knee in full extension, the patella is gently retracted medially, and the non–weight-bearing anterior surface of the lateral condyle is visualized. The ideal location for donor graft harvest is above the sulcus terminalis but below the distal femoral physis (Figure 7, B).

- The chisel appropriate for the donor

---

**Figure 3**  
A, Arthroscopic image obtained from a proximal anteromedial viewing portal in a right elbow demonstrates removal of an osteochondral loose body through an anterolateral working portal.  
B, Appearance and size of the osteochondral loose body after excision. (Copyright Children’s Orthopaedic Surgery Foundation, Boston, MA.)

**Figure 4**  
Intraoperative photographs of a patient undergoing osteochondral grafting to manage osteochondritis dissecans.  
A, The planned surgical incision overlying the capitellum is marked on the right elbow, which is in hyperflexion.  
B, The fascia of the anconeus is split in line with the skin incision. (Copyright Children’s Orthopaedic Surgery Foundation, Boston, MA.)

**Figure 5**  
Intraoperative photograph shows removal of an unstable osteochondritis dissecans lesion with an anconeus-splitting approach. (Copyright Children’s Orthopaedic Surgery Foundation, Boston, MA.)

**Figure 6**  
Intraoperative photograph shows preparation of the recipient site in osteochondral autologous transplantation in a right elbow. (Copyright Children’s Orthopaedic Surgery Foundation, Boston, MA.)
the trochlea in which resection allows for preservation of the epicondyles and collateral ligaments.

In early studies, patients who had rheumatoid arthritis reported stiff, painful joints after DHH; however, this may not be the case for all patients. DHH may be of value in younger patients experiencing burnout or in low-demand patients being treated with disease-modifying antirheumatic drugs who have an eburnated but congruent joint. In the experience of the author of this chapter, the use of DHH for the management of primary osteoarthritis is unpredictable with regard to pain relief and ROM.

The condyles, coronoid process, and radial head must be intact or repairable to ensure elbow stability. The metaphyseal condyles and columns must be intact or repairable to ensure prosthesis stability. The medial collateral ligament and the lateral collateral ligament must be intact or repairable. Preoperative imaging should include AP and lateral radiographs of the elbow. Because it is often unclear whether a fracture is reconstructible or will require DHH, CT also should be considered to aid in the evaluation of articular column involvement. If reconstruction is not achievable, a radiograph of the contralateral elbow can aid in accurate templating (Figure 2). Prosthesis sizing is based on the direct correlation between the AP dimensions of the normal articular surface and the radii of the capitellum and trochlea. In addition, simultaneous alignment of the longitudinal axis of the radial neck with the center of the capitellum and of the prosthetic trochlea with the trochlea or sigmoid fossa should be confirmed on an AP radiograph.

Advances in the understanding of elbow anatomy and biomechanics have helped determine the correct shape and size of joint surfaces as well as the landmarks for appropriate implantation that will ensure good stability and function. A near-anatomic DHH spool...
Elbow Arthroplasty

Table 1 Results of Distal Humeral Hemiarthroplasty (DHH)

<table>
<thead>
<tr>
<th>Authors (Year)</th>
<th>Number of Prostheses</th>
<th>Prosthesis</th>
<th>Mean Patient Age in Years (Range)</th>
<th>Mean Follow-up in Months (Range)</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mellen and Phalen (1947)</td>
<td>4</td>
<td>Acrylic custom</td>
<td>22.5 (19-28)</td>
<td>(9-18)</td>
<td>Good pain relief</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Follow-up time noted for only 3 patients</td>
</tr>
<tr>
<td>Street and Stevens (1974)</td>
<td>10</td>
<td>Anatomic metal spool</td>
<td>NA (16-64)</td>
<td>NA (12-84)</td>
<td>4 of 5 elbows with posttraumatic lesions were pain free</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Poor ROM in the 3 elbows with rheumatoid arthritis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The other 2 elbows were managed for ankylosis secondary to hemophilia</td>
</tr>
<tr>
<td>Shifrin and Johnson (1990)</td>
<td>1</td>
<td>Custom</td>
<td>19</td>
<td>252</td>
<td>Good pain relief</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>and ROM</td>
</tr>
<tr>
<td>Swoboda and Scott (1999)</td>
<td>7</td>
<td>Capitellocondylar</td>
<td>38 (20-50)</td>
<td>NA (25-109)</td>
<td>1 prosthesis was removed due to infection</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4 patients were pain free and 2 experienced minimal pain</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean 27° increase in flexion arc</td>
</tr>
<tr>
<td>Parsons et al (2005)</td>
<td>8</td>
<td>Sorbie-Questor (Wright Medical Technology)</td>
<td>61 (46-83)</td>
<td>24 (NA)</td>
<td>Mean ASES score, 80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean extension, 22°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean flexion, 126°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Patients with acute fractures had better outcomes compared with those with chronic fractures</td>
</tr>
<tr>
<td>Adolfsson and Hammer</td>
<td>4</td>
<td>Kudo (Biomet)</td>
<td>80 (79-89)</td>
<td>10 (3-14)</td>
<td>MEPS: 3 excellent outcomes and 1 good outcome</td>
</tr>
<tr>
<td>(2006)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean extension, 20°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean flexion, 126°</td>
</tr>
<tr>
<td>Burkhart et al (2011)</td>
<td>10</td>
<td>Latitude Total Elbow Prosthesis (Tornier)</td>
<td>75.2 (NA)</td>
<td>12.1 (NA)</td>
<td>MEPS: 9 good to excellent outcomes and 1 fair outcome</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean extension, 17.5°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean flexion, 124.5°</td>
</tr>
<tr>
<td>Adolfsson and Nestorson</td>
<td>8</td>
<td>Kudo</td>
<td>79 (71-89)</td>
<td>48 (30-72)</td>
<td>Mean MEPS, 89</td>
</tr>
<tr>
<td>(2012)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean extension, 31°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean flexion, 126°</td>
</tr>
<tr>
<td>Argintar et al (2012)</td>
<td>10</td>
<td>Latitude Total Elbow Prosthesis</td>
<td>73.4 (56-77)</td>
<td>12 (NA)</td>
<td>Mean MEPS, 77.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean DASH score, 35.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean extension, 22°</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mean flexion, 121°</td>
</tr>
</tbody>
</table>

ASES = American Shoulder and Elbow Surgeons; DASH = Disabilities of the Arm, Shoulder and Hand; EQ-5D = EuroQol EQ-5D Health Questionnaire; MEPS = Mayo Elbow Performance Score; NA = not available; ROM = range of motion.

TEA has gained acceptance as a primary treatment for comminuted intraarticular distal humerus fractures in infirm, low-demand, elderly patients who have osteoporotic bone. However, the application of TEA in healthy, active patients increases the risk of early prosthesis failure.

**Results**

The longest follow-up of DHH with a custom prosthesis is 20 years; the results of that study included good pain relief and functional ROM. The literature on DHH is limited to a few small case series (Table 1). One study involved 10 elbows that were managed with distal humeral anatomic spools without stems. Poor ROM and unstable implants were reported in five elbows with rheumatoid arthritis. Four of five elbows with posttraumatic lesions were pain free and had good functional ROM. A study on the use of capitellocondylar humeral
ACUTE PATHOLOGY

- The triceps is reflected, and the articular segment is wrapped in saline-soaked gauze to protect the articular cartilage.
- The fracture is assessed, and if DHH is planned, the humerus is broached in preparation for stem insertion.
- If ORIF of a supracondylar column is required, a trial component or broach is left in situ to preserve the intramedullary canal for the prosthesis.
- Freehand bone cuts often are necessary to allow for appropriate placement of the prosthesis.
- Reconstruction of the bony columns and the collateral ligament origins is required when performing a DHH.
- Care is taken to maintain the joint axis. Periarticular plate systems may aid in maintaining the joint axis; however, the complexity of DHH increases substantially with each additional column reconstruction.
As with comminuted supracondylar humerus fractures, some shortening may aid in obtaining stable fixation.

- The correct depth and rotation of implant insertion is determined by aligning the axis of the component with the origins of the medial collateral ligament (anteroinferior border of the medial epicondyle) and the humeral insertion points of the lateral collateral ligament (center of the lateral epicondyle).
- Varus-valgus alignment is determined by centering the prosthetic stem in the humeral canal with the aforementioned alignments correct. The correct depth, rotation, and valgus-varus orientation can be accurately restored in this manner.
- Preoperative templating helps determine implant selection. The Latitude EV Total Elbow Prosthesis does not allow for using large stems with small spools; therefore, a best fit is most likely determined by spool selection.
- Spool selection is verified intraoperatively by positioning the spool on the anterior sigmoid fossa and radial head, confirming that the center of the radial head aligns with the center of the capitellum and that there is good trochlear congruency (Figure 5, E).

- With the trial implant in situ, the elbow is moved through full elbow flexion and extension to ensure that the joint is not overstuffed as a result of an oversized spool or too-distal placement of the joint axis. If the joint demonstrates any tendency toward instability or translocation, the prosthesis is likely misaligned relative to the ligament attachments. The prosthesis is realigned accordingly, and the tracking of the articulation is rechecked (Table 2). A cement restrictor and antibiotic-impregnated cement are used to cement the component.

### Table 2 Complications of Distal Humeral Hemiarthroplasty

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative flexion contracture</td>
<td>Oversized spool Prosthetic axis distal to ligament axis Capsular contracture</td>
<td>Check the preoperative template Place the trial spool directly onto the radial head and coronoid Insert the implant deeper Release the anterior capsule</td>
</tr>
<tr>
<td>Joint translocation</td>
<td>Undertensioned collateral ligament repair Overtensioned collateral ligament repair</td>
<td>Reassess ligament repair</td>
</tr>
<tr>
<td>Rotatory instability</td>
<td>Component malrotation Incomplete restoration of columnar length Failed LCL repair</td>
<td>Perform radiographic EUA Address identifiable causes</td>
</tr>
<tr>
<td>Radiocapitellar mismatch</td>
<td>Incorrect spool size PLRI</td>
<td>Revise the spool Assess for instability</td>
</tr>
<tr>
<td>Olecranon osteotomy nonunion</td>
<td>Inadequate fixation Inadequate biology</td>
<td>Ensure accurate reduction Ensure rigid ORIF Bone graft all osteotomies</td>
</tr>
<tr>
<td>Ulnar neuritis</td>
<td>Traumatic neurapraxia Increased neural tension Ulnar instability</td>
<td>Assess for neurolysis Assess for transposition Check depth of implant insertion and ulnar transposition</td>
</tr>
<tr>
<td>Painful joint</td>
<td>Overstuffed joint Arthrolysis Sepsis (Staphylococcus epidermidis or Propionibacterium acnes) Loose prosthesis Nonunion (condyle/osteotomy)</td>
<td>Downsize the spool Revise to TEA Obtain serology/aspirate/perform staged TEA Obtain serology/aspirate/perform TEA Obtain serology/perform ORIF with or without bone graft</td>
</tr>
<tr>
<td>Stiff elbow</td>
<td>Overstuffed joint Arthrofibrosis Heterotopic ossification</td>
<td>Downsize spool Assess whether position of joint axis needs to be revised Perform surgical release of the contracture at 6 months post-operatively</td>
</tr>
</tbody>
</table>

EUA = examination under anesthesia, LCL = lateral collateral ligament, ORIF = open reduction and internal fixation, PLRI = posterolateral rotatory instability, TEA = total elbow arthroplasty.
Table 1 Results of Radiocapitellar Prosthetic Arthroplasty

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>No. of Patients</th>
<th>Procedure or Approach</th>
<th>Mean Patient Age in Years (Range)</th>
<th>Mean Follow-up in Months (Range)</th>
<th>Success Rate (%)</th>
<th>Results</th>
</tr>
</thead>
</table>
| Pooley (2007)      | 43 (44 elbows) | 22 hemi-LRE arthroplasty (capitellar resurfacing only); 22 total LRE arthroplasty      | 52 (40-75)                       | 9 (9-18)                        | 95              | Results only reported for 10 patients  
MEPS: 6 excellent results, 3 good results, and 1 fair result  
2 patients had complications necessitating revision surgery: 1 deep infection leading to removal of components, 1 triceps muscle dehiscence requiring repair |
| Heijink et al (2008)| 3              | Custom radiocapitellar hemiarthroplasty (Stryker) with metallic capitellar resurfacing component and metal-backed polyethylene radial head prosthesis | 43 (37-50)                       | 87 (25-173)                     | 100             | MEPS: 2 excellent results and 1 good result  
No further revision surgery procedures                                                                                                                   |
| Giannicola et al  (2012)| 24\(^b\) | 17 total LRE arthroplasty; 3 hemi-LRE arthroplasty (capitellum only)                    | 55 (31-73)                       | 23 (6-47)                       | 80              | 19 patients had good to excellent results, with significant improvement of MEPS, modified ASES scores, QuickDASH scores, and arc of motion  
(P = 0.001 for each measure)  
16 patients were satisfied with their outcome, and 4 patients were unsatisfied with their outcome (3 with recurrent elbow stiffness and 1 with worsening of ulnar neuropathy)  
3 patients underwent revision surgery (1 open elbow arthrolysis with HO excision, 1 soft-tissue release with HO excision, and 1 débridement with ulnar nerve neurolysis)  
1 patient with Parkinson disease had a chronically dislocated prosthesis but refused further treatment                                                                 |
| Heijink et al  (2014)| 6              | UNI-Elbow Radio Capitellum arthroplasty (Stryker)                                      | 52 (40-69)                       | 50 (30-64)                      | 100             | All patients had substantial improvement in MEPS (3 excellent results and 3 good results)  
No implant failures  
All patients were satisfied with their outcome at final follow-up                                                                                     |

ASES = American Shoulder and Elbow Surgeons elbow assessment; HO = heterotopic ossification; LRE = Lateral Resurfacing Elbow (Biomet); MEPS = Mayo Elbow Performance Score; QuickDASH = Quick Disabilities of the Arm, Shoulder and Hand.

\(^a\) All studies are level IV evidence.

\(^b\) 20 patients were available for follow-up.
straight posteriorly until it exits the lateral distal humerus, or a posterior longitudinal counter-cut can be made in the coronal plane posterior to the origin of the LCL complex (Figure 3, B).

- Alternatively, the LCL can be taken down from its origin at the lateral epicondyle and repaired later through bone tunnels or with the use of suture anchors. A lateral epicondyle osteotomy may help provide more reliable tensioning and better healing of the repaired LCL.

- The center of rotation of the capitellum is established by placing a Kirschner wire (K-wire) through the capitellum, which can be done with the aid of a capitellar centering guide (Figure 4). The medial targeting arm of the capitellar centering guide is placed over the medial epicondyle, and the lateral part of the capitellar centering guide is placed on the lateral aspect of the capitellum and positioned to mirror its curvature. The geometry of the nondiseased capitellum must be taken into consideration when placing the capitellar centering guide because advanced degenerative changes can substantially distort the geometry of the capitellum.

- A K-wire is placed through the capitellar centering guide. Placement of the K-wire in the center of rotation of the distal humerus is confirmed via multiplanar fluoroscopic imaging.

Figure 3  A, Photograph of the distal humerus of a bone model shows the site for a lateral epicondyle osteotomy. B, Intraoperative photograph of the elbow of a cadaver model shows a lateral epicondyle osteotomy, which results in wide exposure of both the anterior and posterior aspects of the radiocapitellar joint.

Figure 4  Intraoperative photograph of the elbow of a cadaver model shows correct placement of a capitellar centering guide. The drill guide is tightened in place after the capitellar centering guide is situated in the correct position and a guidewire has been driven through the lateral aspect of the capitellum at its center of rotation but not through the medial cortex of the distal humerus.
sensitivity. Only if the findings of all of these tests are normal or, in the case of patients with inflammatory arthritis, consistent with a patient’s baseline results, does the author of this chapter confirm that a patient has aseptic loosening. Performing a single-stage revision TEA in patients with a low-grade infection is associated with a high risk for recurrent loosening caused by infection. Both the ulnar and radial nerves are at risk during revision TEA. The ulnar nerve must always be identified, superficially decompressed, and protected throughout revision TEA. Whether the ulnar nerve is routinely anteriorly transposed at the end of the procedure usually depends on the surgeon’s preference; however, there is one situation in which transposition of the ulnar nerve is essential. The ulnar nerve must be transposed if it appears to be stretched during passive flexion of the elbow after insertion of the revision prosthesis. The radial nerve is at risk if a long-stemmed humeral component is being revised or if a long tail of cement has to be removed before insertion of the revision prosthesis. In these patients, the radial nerve should be exposed and protected throughout the revision TEA.

The removal of partially loose total elbow implants can be surprisingly difficult and may be associated with iatrogenic fractures and bone perforations. To minimize the risk for iatrogenic fractures and bone perforations, a wide range of appropriately sized revision instruments must be available. The risk of iatrogenic fracture also can be reduced by creating a bone window to facilitate implant removal. Replacing and maintaining the bone window in a satisfactory position before insertion of the revision prosthesis may be difficult but can be aided with the use of absorbable sutures (Figure 6).

Postoperative periprosthetic fractures are more likely to occur if the tip of either the humeral or the ulnar implant ends at the level of a bone window or perforation. To reduce the risk for postoperative periprosthetic fractures, the tip of the prosthesis should extend twice the medullary canal diameter beyond any bone window or perforation.

The anatomic axis of flexion and extension of the elbow should be determined as accurately as possible during revision TEA. If the anatomic axis of flexion and extension of the elbow is not achieved, the forces across the elbow during functional movement will result in early loosening of the prosthesis. Identification of the anatomic axis is often difficult, however, particularly in patients who have structural bone loss. The technique the author of this chapter uses involves passive flexion and extension of the elbow with the trial implants in place. If either the humeral or ulnar

---

**Figure 8** Radiographs of the right elbow of a patient who underwent four previous total elbow arthroplasties (TEAs) to manage aseptic loosening. A, Lateral view demonstrates loss of distal humeral bone, antibiotic beads, and an ulnar fracture. AP (B) and lateral (C) views obtained immediately after revision TEA. The absent distal humerus was reconstructed with the use of a proximal humeral allograft. The surgeon identified the appropriate length of proximal humeral allograft necessary for distal humerus reconstruction, and the proximal humeral allograft was inverted, which allowed the bone to be inserted such that it overlapped the patient’s humeral shaft, providing rigid fixation between host and allograft bone. A strut graft was used to reinforce the ulnar reconstruction.

---

© 2016 American Academy of Orthopaedic Surgeons
inserted immediately after irrigation and debridement.

- In the second stage of a two-stage exchange, the antibiotic cement spacer is removed and the new implants are inserted after intramedullary reaming.
- Insertion of new implants is performed using the principles of revision TEA, a description of which is beyond the scope of this chapter.
- The authors of this chapter prefer a tongue approach to take down and repair the extensor mechanism. The tendon is repaired first at the apex with a figure-of-8 No. 2 braided nonabsorbable composite stitch, which also allows the length of the triceps tendon to be adjusted and set. To complete the repair, the suture is run from proximal to distal and then from distal to proximal to create a double, baseball-style stitch.

**Figure 3** Postoperative AP (A) and lateral (B) radiographs from a 68-year-old woman with advanced rheumatoid arthritis in whom a chronic periprosthetic infection and proximal ulna nonunion developed after primary total elbow arthroplasty. During revision surgery to manage the infection and proximal ulna nonunion, the loose humeral implant was easily removed. However, the ulnar implant was well fixed, which required cutting the ulna along its medial and lateral borders as well as anteriorly at the level of the distal stem tip to create a cortical window to extract the implant and cement. This step resulted in iatrogenic completion of the fracture at the distal end of the cortical window. C, Intraoperative lateral radiograph demonstrates the ulnar corticotomy stabilized with cerclage wires and a long Steinmann pin incorporated into the antibiotic-impregnated cement spacer. AP (D) and lateral (E) immediate postoperative radiographs obtained after second-stage revision arthroplasty demonstrate implant position and fixation as well as strut allograft augmentation of the proximal ulna. The patient was pleased with her elbow function despite a fibrous union of the proximal ulna.