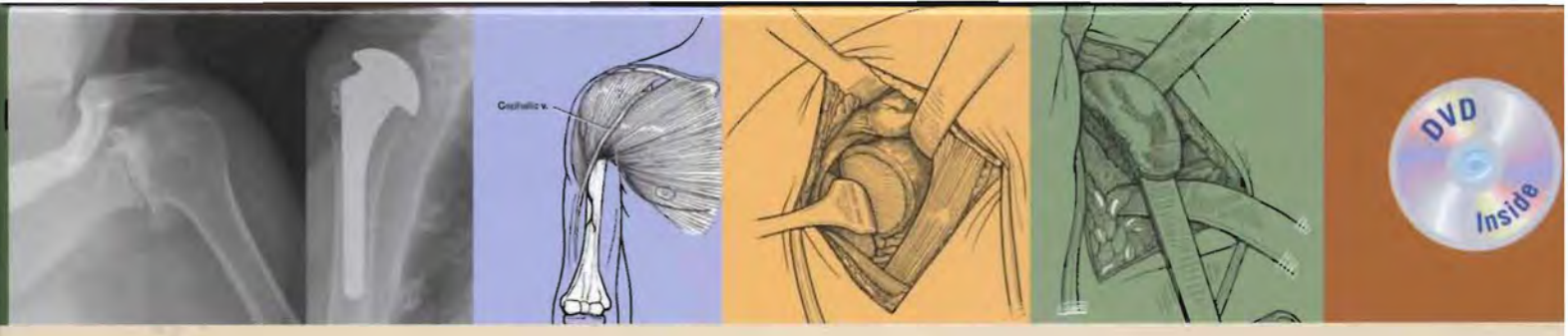
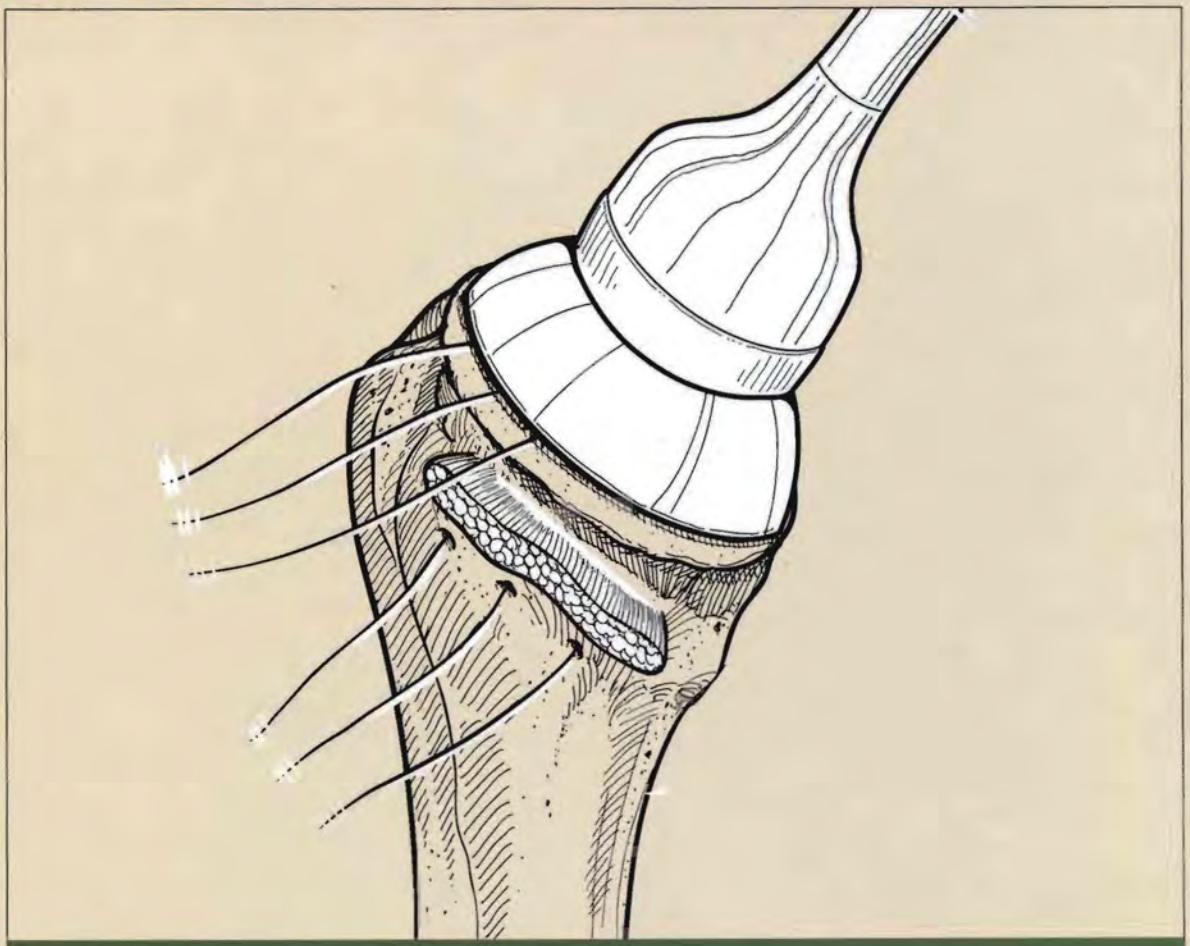


SHOULDER ARTHROPLASTY



GARTSMAN AND EDWARDS

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CHAPTER 38

Humeral Stem Removal and Glenoid Exposure

Humeral stem removal can be simple or one of the most difficult and time-consuming aspects of revision shoulder arthroplasty. Preoperative planning becomes very important in facilitating removal of the humeral stem during revision shoulder arthroplasty. Whereas relatively smooth press-fit humeral stems may be easy to remove, extensively porous-coated stems can be especially difficult to extract, particularly when they have been inserted with bone cement. Identification of the brand and type of implant used in the primary shoulder arthroplasty by radiographs or the primary arthroplasty operative report (or both) allows the surgeon to have an instrument set available to assist in extraction of the humeral implant (Fig. 38-1). Controlled extraction of the humeral implant, even if a humeral osteotomy is required, is certainly preferable to an intraoperative fracture of the proximal humerus caused by ill-fated attempts at extracting a well-fixated humeral stem without performing an osteotomy.

Once the humeral stem is removed, glenoid exposure proceeds in much the same manner as for primary shoulder arthroplasty (see Chapter 10). This chapter details our techniques for humeral stem removal and glenoid exposure during revision shoulder arthroplasty.

TECHNIQUE FOR HUMERAL STEM REMOVAL

Tenotomy of the subscapularis with subsequent release of the superior, middle, and inferior glenohumeral ligaments (see Chapters 9 and 37) is performed if the subscapularis is intact. If the subscapularis is absent, any subscapularis bursa is excised to expose the anterior aspect of the humeral head component (Fig. 38-2). A humeral head retractor is placed for retraction of the proximal humerus posteriorly (Fig. 38-3). If this provides sufficient visualization of the anterior glenoid and inferior capsule, inferior capsular release is performed, as described in the following section on glenoid exposure. Frequently, because of its size, however, the humeral implant sufficiently hinders glenoid visualization to prevent inferior capsular release. In these cases it is necessary to remove the humeral stem before proceeding with glenoid exposure.

The proximal humerus must be dislocated before attempts at removal of the humeral stem. The dislocation must be done with great care to avoid humeral injury. Frequently, capsular stiffness prevents dislocation by simple external rotation and extension of the arm. If this maneuver is not initially successful, a humeral-based inferior capsular release is performed (Fig. 38-4). Progressive release of the inferior medial capsule from the humerus with the needle tip electrocautery allows dislocation of the proximal humerus. Care must be taken to keep the electrocautery in contact with the humerus to avoid injury to the axillary nerve. Dislocation maneuvers must be done slowly and with great care in revision cases to prevent humeral fracture because the humerus is often osteopenic and compromised (Fig. 38-5).

Once the humerus has been dislocated, the humeral head portion of the arthroplasty is circumferentially exposed by removing any fibrous tissue at its margins with the needle tip electrocautery (Fig. 38-6). Nearly all implants currently encountered during revision surgery have a modular head fixed onto a stem via a Morse taper mechanism. It is important, however, for a surgeon unfamiliar with the type of implant being

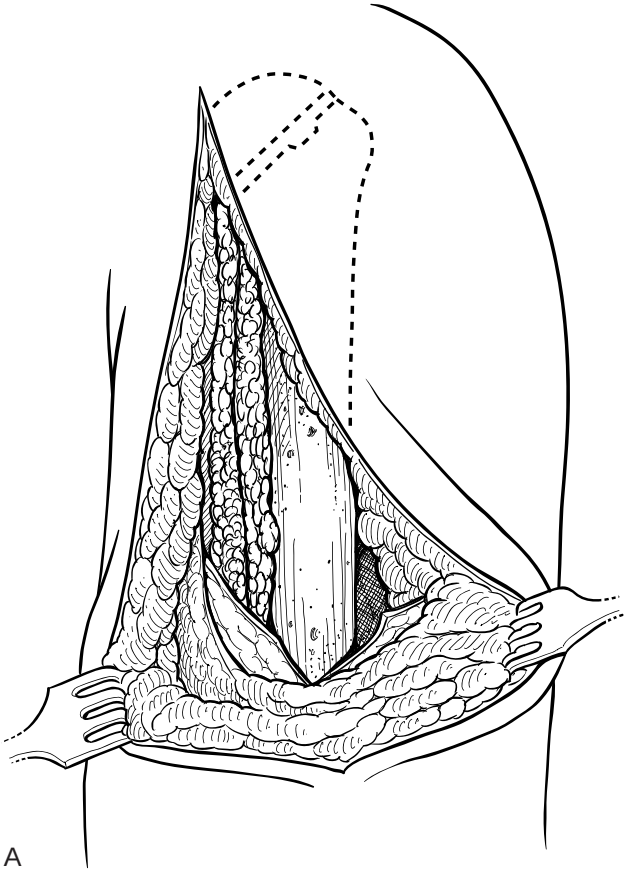


Figure 38-15 **A** and **B,** Exposure of the humerus in preparation for humeral osteotomy.

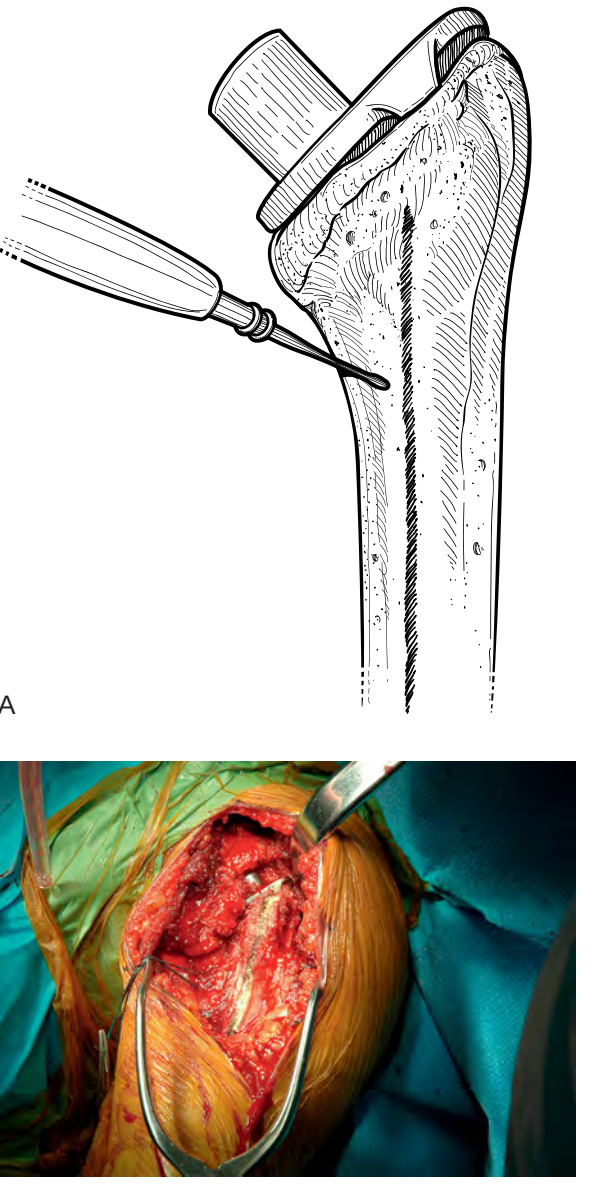
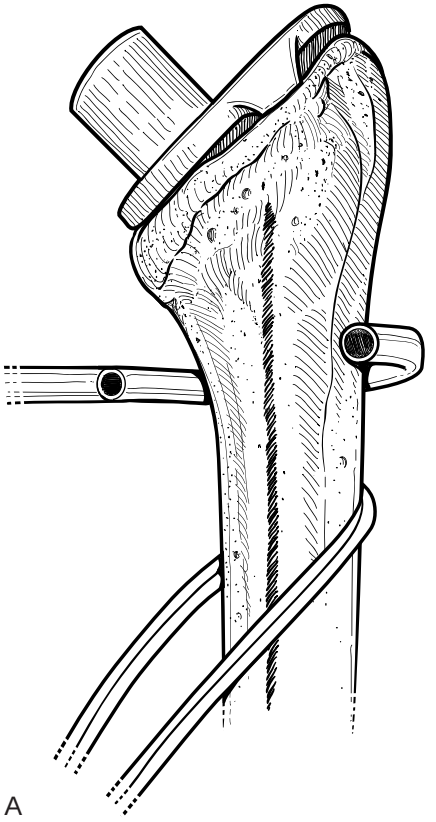


Figure 38-16 **A** and **B,** The planned osteotomy site is demarcated with a needle tip electrocautery.

Humeral Osteotomy

Once the necessity for humeral osteotomy is established, the surgical approach is extended distally, as detailed in Chapter 37. The humerus is exposed from its proximal aspect to the area distal to the pectoralis major insertion (Fig. 38-15). The planned osteotomy site is demarcated with the needle tip electrocautery and extended along the anterior humerus by starting just medial to the bicipital groove and continuing distally between the pectoralis major insertion and the deltoid insertion (Fig. 38-16). The distal extent of the osteotomy is determined by the length of the humeral stem to be removed.

Before performing the osteotomy, cerclage cables are placed for subsequent osteotomy fixation. Depending on the length of the osteotomy, we place two or three cables composed of a nylon monofilament core wrapped in braided ultrahigh-molecular-weight polyethylene (Kinamed Inc., Camarillo, CA). The cables are placed subperiosteally with the cable-passing instrumentation provided (Fig. 38-17). In cases in which the



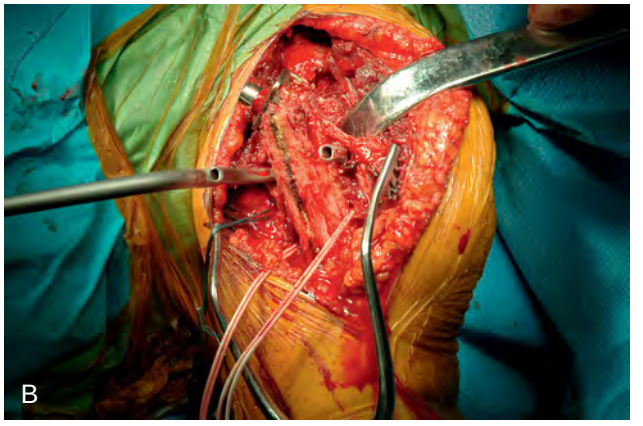
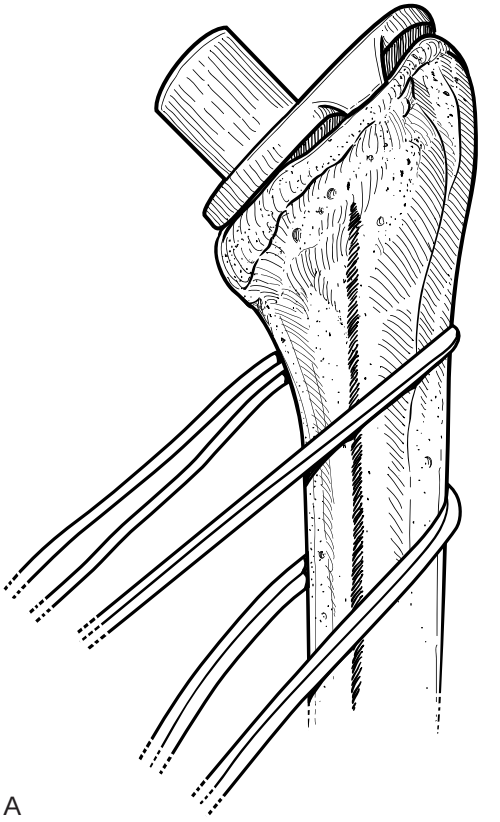


Figure 38-17 **A** and **B,** Placement of cables for later fixation of the humeral osteotomy.



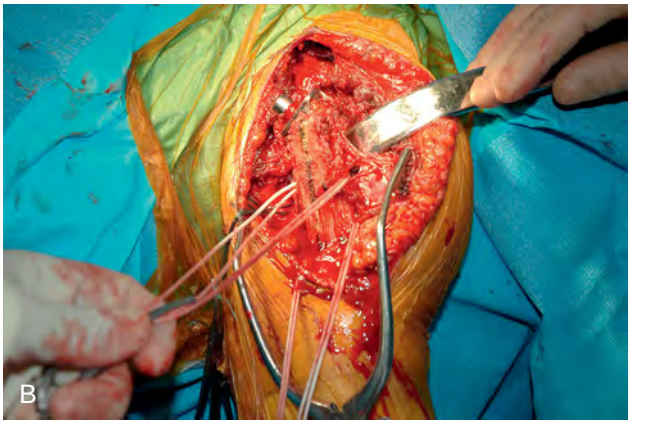
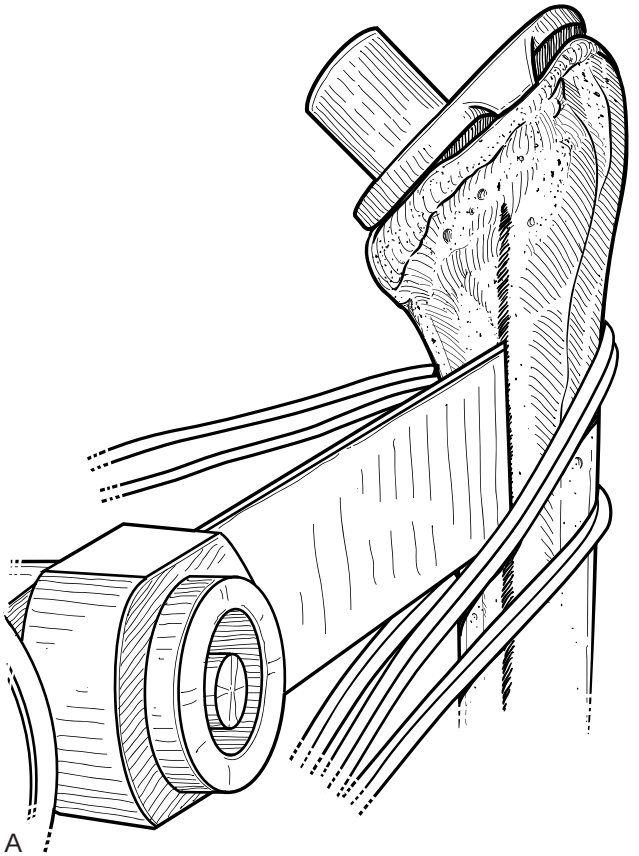


Figure 38-18 **A** and **B,** Final placement of the cables, which are held temporarily with Kocher clamps.

osteotomy extends beyond the junction of the proximal third and middle third of the humeral shaft, the radial nerve must be identified and protected before passing cables posterior to the humerus (see Chapter 37). Once the cables are passed, the free ends of each cable are clamped together with Kocher clamps (Fig. 38-18).

A unicortical humeral osteotomy is performed by penetration of the anterior cortex with a sagittal saw along the humerus at the demarcated osteotomy site down to the humeral implant (Fig. 38-19). A $1^1/_2$-inch straight osteotome is impacted into the osteotomy site proximally (Fig. 38-20). The osteotome is turned to open the osteotomy by plastically deforming the proximal humerus (Fig. 38-21). The humeral stem can then be removed with the extraction instrumentation provided or by disimpaction with a Cobb elevator, as described earlier (Fig. 38-22).



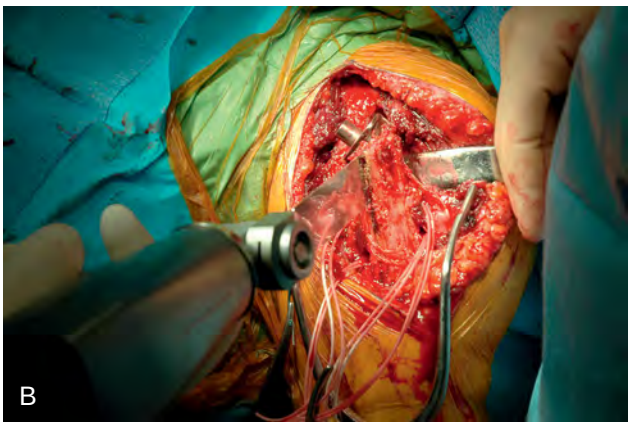
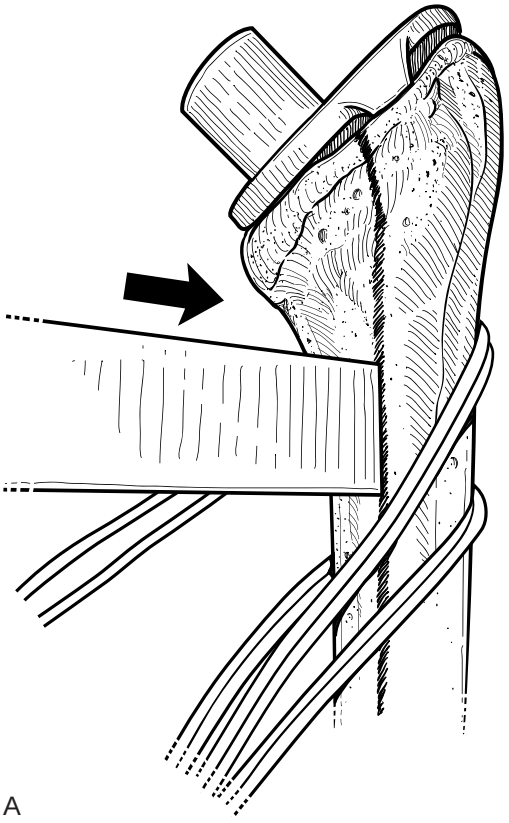


Figure 38-19 **A** and **B,** The osteotomy is performed with a saw along the anterior humerus.



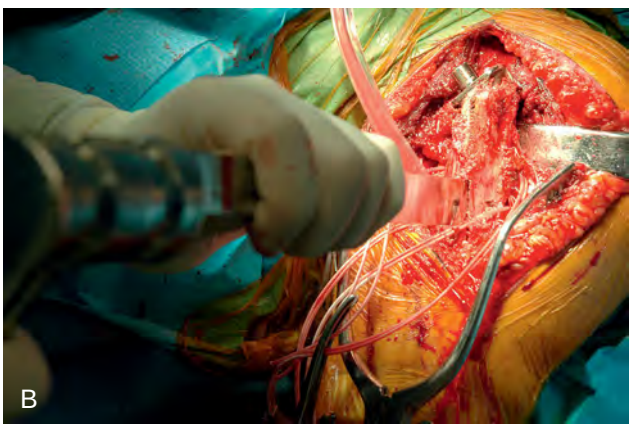


Figure 38-20 **A** and **B,** An osteotome is impacted into the osteotomy site proximally.

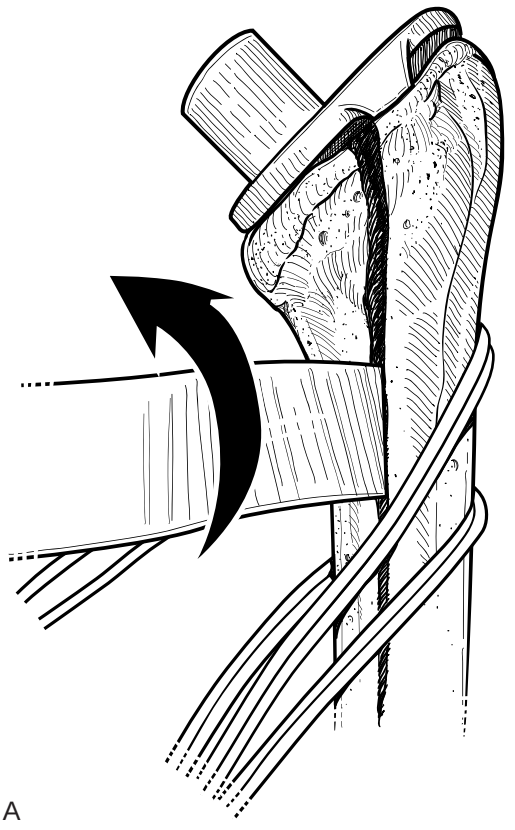


Figure 38-21 **A** and **B,** The osteotome is turned to open the osteotomy site by plastic deformation.

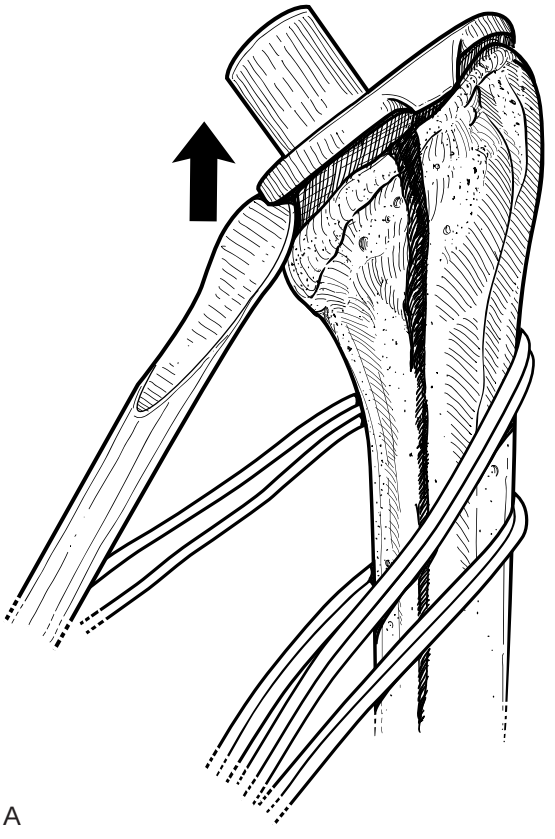


Figure 38-22 **A** and **B,** The humeral stem is removed.

After the humeral stem and any necessary cement (see later) are removed, the osteotomy must be fixated. This is performed by first preparing the proximal humerus for insertion of the revision humeral component with the instrumentation provided. The trial humeral stem is inserted and the cables are tightened with the tensioning device provided (Fig. 38-23). The cables are tightened in a distal-to-proximal direction. In cases in which the native humeral cortex is excessively thin, fresh frozen allograft cortical struts

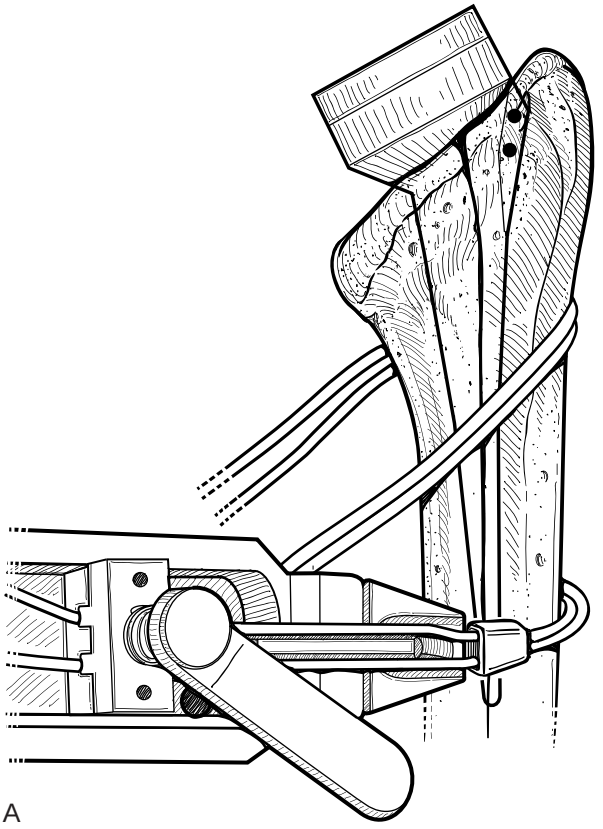


Figure 38-23 **A** and **B,** The cables are tightened over the trial stem.

are placed around the native humerus beneath the cables before tightening to provide additional support to the proximal humerus (Fig. 38-24).

Cement Removal

When removing a cemented humeral stem, residual cement is removed for two reasons—if it is loose within the humerus and if it prevents insertion of the revision humeral stem. Any residual cement that is well fixed within the humeral canal and does not interfere with insertion of the revision humeral stem is left in place. The revision humeral stem can be successfully fixated into a stable residual cement mantle.[1]

Loose cement within the humeral canal is easily removed with pituitary-type forceps (Fig. 38-25). Removing cement that is well fixed within the humeral canal to make room for the revision humeral component is more challenging. We use a set of specialized cement-removing osteotomes (Moreland osteotomes) that come in a variety of shapes and sizes (Fig. 38-26). A combination of curved and straight Moreland osteotomes is used to remove the proximal cement mantle (Fig. 38-27). Any cement fragments that fall into the humeral canal are removed with pituitary forceps. Only enough cement is removed to permit insertion of the revision humeral stem. The trial stem is inserted intermittently during the cement removal process to evaluate the sufficiency of cement removal.

Occasionally, it is necessary to remove a distal cement plug to permit insertion of the revision humeral stem. If this is the case, it will often be necessary to perform a humeral osteotomy to permit removal of the cement plug without perforating and damaging the humeral diaphysis. Once the humeral osteotomy is performed and extended distal to the cement plug, the osteotomy is plastically opened distally with an osteotome and the cement plug is removed from the humeral canal with pituitary forceps. If a cement restrictor is present, it is removed with the pituitary forceps.

TECHNIQUE FOR GLENOID EXPOSURE

After the humeral component is removed, attention is turned to glenoid exposure. In cases in which no glenoid component has previously been implanted, any remaining labrum is excised from the base of the coracoid process extending inferiorly to the 5 o'clock position in a right shoulder (7 o'clock in a left shoulder) with the needle tip electrocautery. This allows identification of the osseous anterior margin of the glenoid. In nearly all cases, proper exposure of the glenoid requires release of the inferior capsule. The tip of the electrocautery is used to release the inferior capsule directly off the rim of the glenoid bone, just as in primary total shoulder arthroplasty. To help prevent injury to the axillary nerve, the tip of the electrocautery should be kept in contact with glenoid bone. This release is extended sufficiently medially to completely transect the capsule and expose the muscular fibers of the triceps inserting on the inferior osseous glenoid. The amount of posterior subluxation present on preoperative secondary imaging studies

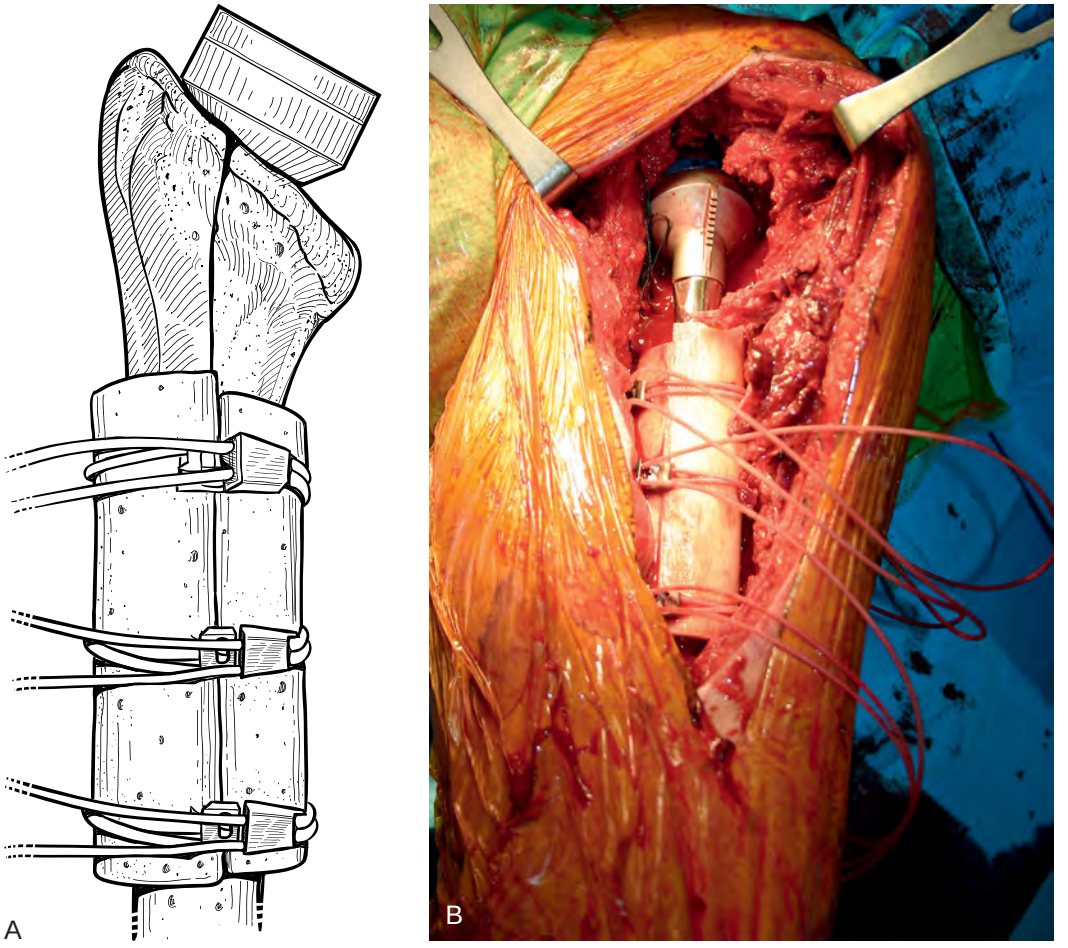


Figure 38-24 **A** and **B,** Cortical allograft struts can be used to reinforce the proximal humerus in patients with severe osteopenia.

(computed tomography, magnetic resonance imaging) determines the posterior extent of release. In shoulders without posterior subluxation, the release continues posteriorly to the 8 o'clock position for right shoulders (4 o'clock position for left shoulders). In shoulders that have preexisting posterior subluxation, either with or without posterior glenoid erosion, the release continues initially to only the 6 o'clock position. These patients often have a distended posterior capsule, so no more release is performed than is absolutely necessary to avoid compromising these posterior structures further. If release to only the 6 o'clock position proves inadequate later in the procedure during glenoid reaming, the release can be extended at that time. A Cobb elevator can be used to check the release for completeness.

If a glenoid component has previously been placed, removal is usually simple because most of these components are loose in the revision scenario. After the humeral component has been removed, the proximal humerus is retracted posteriorly with a humeral head retractor. Soft tissue is removed circumferentially from around the glenoid component with the needle tip electrocautery (Fig. 38-28). The inferior capsule is released just as in cases in which no glenoid component has previously been placed. Once the periphery of the glenoid component has been cleared of soft tissue, a half-inch curved osteotome is used to lever

CHAPTER 39

Humeral Component

Reconstruction of the proximal humerus can be a very difficult aspect of revision shoulder arthroplasty. During extraction of the previous humeral stem, every effort should be made to preserve as much native proximal humeral bone as possible (see Chapter 38). The overall condition of the proximal humerus and rotator cuff plays a significant role in determining the type of implant to be used in revision surgery (unconstrained versus semiconstrained). In cases in which the rotator cuff is largely functional, preservation of the greater and lesser tuberosities helps dictate which type of revision implant to use during revision surgery. Once the type of revision implant to be used is selected, preparation of the proximal humerus and implantation of the humeral component proceed just as for primary arthroplasty. This chapter details our techniques for reconstruction and preparation of the proximal humerus and implantation of the humeral component in revision shoulder arthroplasty.

TECHNIQUE FOR PREPARATION OF THE PROXIMAL HUMERUS

Preparation of the proximal humerus is largely dependent on the residual osseous anatomy of the proximal humerus after the previously placed humeral stem has been extracted. In cases in which extraction of the previous humeral stem was relatively uncomplicated, with minimal compromise of the proximal humeral metaphysis and tuberosities, preparation of the proximal humerus can be straightforward and similar to proximal humeral preparation for primary shoulder arthroplasty. In cases in which the proximal humeral osseous anatomy has been compromised either before or during extraction of the humeral stem, preparation of the proximal humerus becomes substantially more complicated.

When proximal humeral osseous anatomy is well preserved, proximal humeral preparation for either an unconstrained stem or a reverse stem is performed similar to cases of primary arthroplasty.

Unconstrained Humeral Stem

In cases in which we are going to implant an unconstrained proximal humeral stem, we prefer to implant a stem with geometry designed originally for use in proximal humeral fractures. This cemented stem design allows a good fit into the humeral metaphysis and comes in a variety of lengths. This allows the surgeon to treat periprosthetic fractures or bypass the distal aspect of a humeral diaphyseal osteotomy used for extraction of the humeral stem (Fig. 39-1).

For this revision stem, no metaphyseal broaching is necessary. The diaphysis is progressively reamed with the hand reamers provided (Fig. 39-2). Frequently, after removing an uncemented humeral stem, a small pedestal of bone exists in the intramedullary canal at the level just distal to the tip of the original humeral stem (Fig. 39-3). It is easy to tap the smallest diaphyseal reamer through this osseous pedestal. Subsequent reamers pass through this area without difficulty.

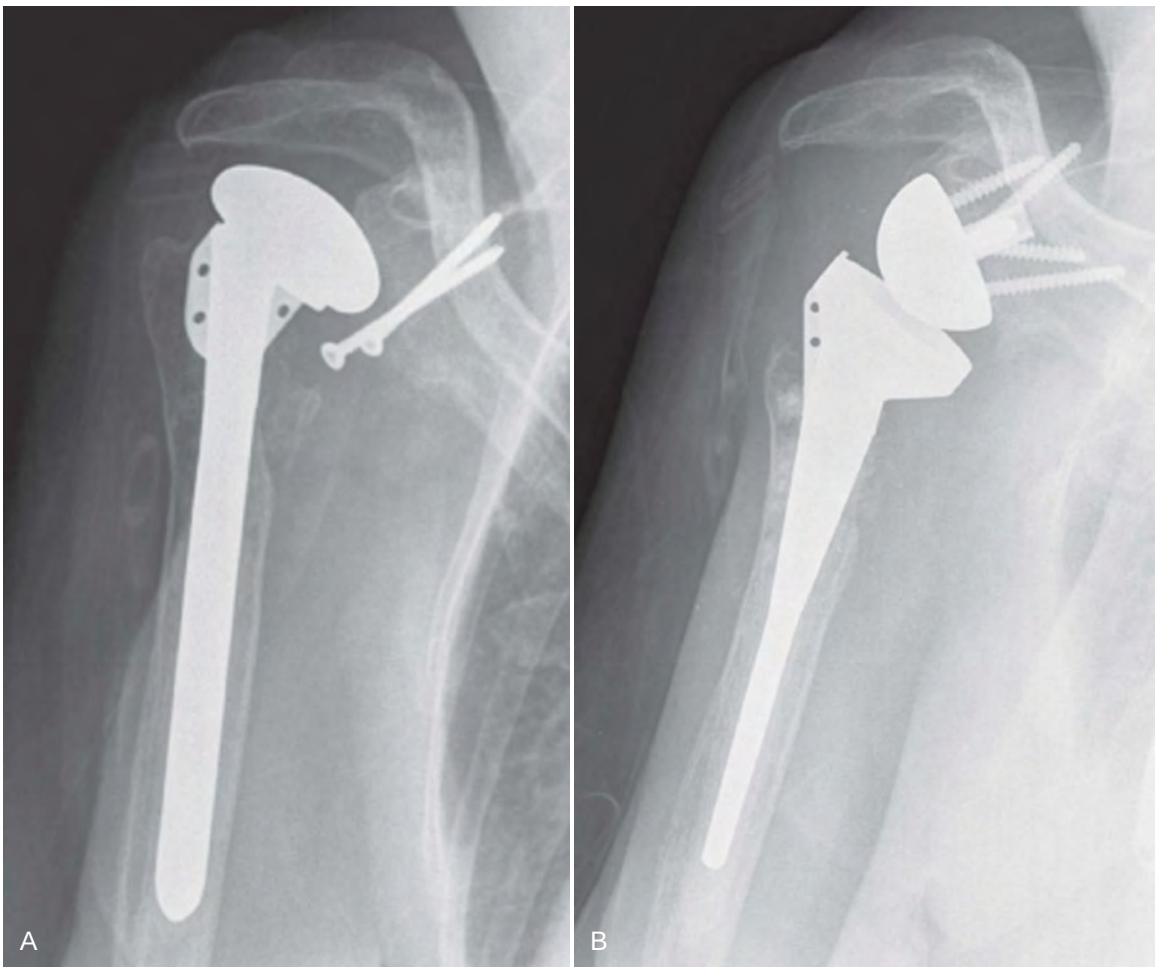


Figure 39-16 Patient with proximal humeral bone loss that did not require proximal humeral bone graft reconstruction before (**A**) and after (**B**) revision arthroplasty with a reverse prosthesis.

Revision cases with proximal humeral insufficiency may require proximal humeral osseous reconstruction with a bone graft. In general, in any case in which the rotator cuff insertion is compromised and glenoid bone stock allows, we will use a reverse prosthesis for revision arthroplasty. In cases of proximal humeral insufficiency limited to the proximal humeral metaphysis, no bone graft is indicated because the reverse prosthesis can be implanted into the intact humeral diaphysis (Fig. 39-16). In cases in which proximal humeral bone loss extends distally and compromises the proximal humeral diaphysis, bone graft reconstruction of the proximal humeral diaphysis is indicated (Fig. 39-17). In many cases, only a portion of the proximal humeral diaphysis is deficient (anterior or posterior). For this reason we prefer to reconstruct only the portion that is deficient and leave any native bone intact. Fresh frozen cortical strips of allograft tibia are used for the reconstruction (Fig. 39-18). The residual diaphysis is reamed with the hand reamers.

Depending on the length of the humeral defect, we place two or three cables composed of a nylon monofilament core wrapped in a braided ultrahigh-molecular-weight polyethylene (Kinamed, Inc., Camarillo, CA) subperiosteally around the residual native humerus with the cable-passing instrumentation provided (Fig. 39-19). One or two allograft strips are trimmed to fit the diaphyseal defect and placed in the defect. The trial humeral stem is placed in the humeral diaphysis, and the allograft is placed in the diaphyseal defect (Fig. 39-20). The cables are tightened in a distal-to-proximal direction with the tensioning device (Fig. 39-21). The humeral stem is removed while leaving the reconstructed proximal humerus, and attention is turned to the glenoid, if indicated (Fig. 39-22).

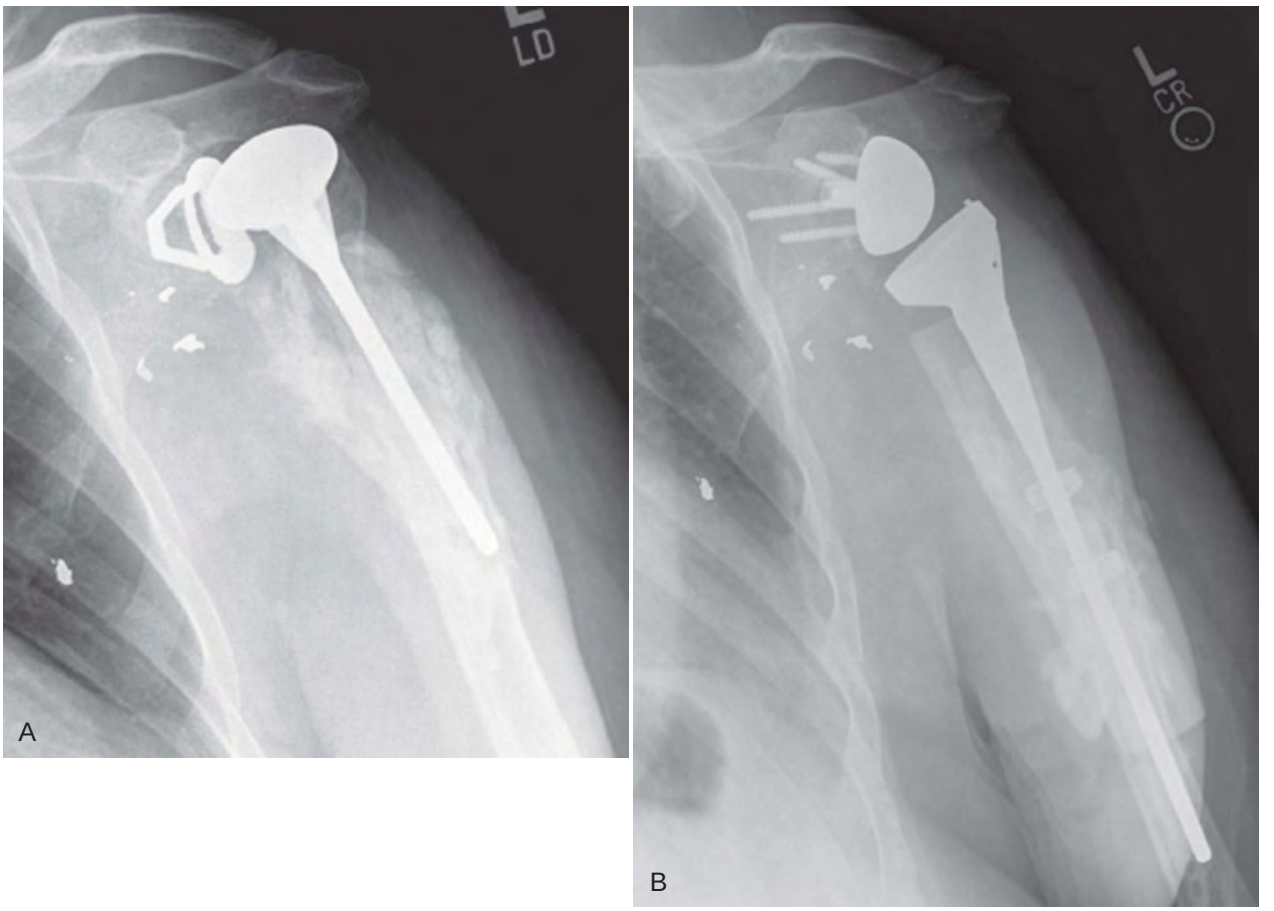


Figure 39-17 Patient with severe proximal humeral bone loss that required proximal humeral bone graft reconstruction before (**A**) and after (**B**) revision arthroplasty with a reverse prosthesis.

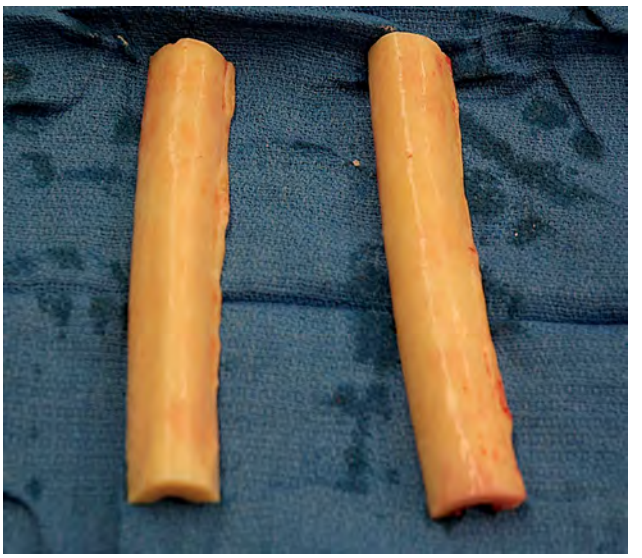
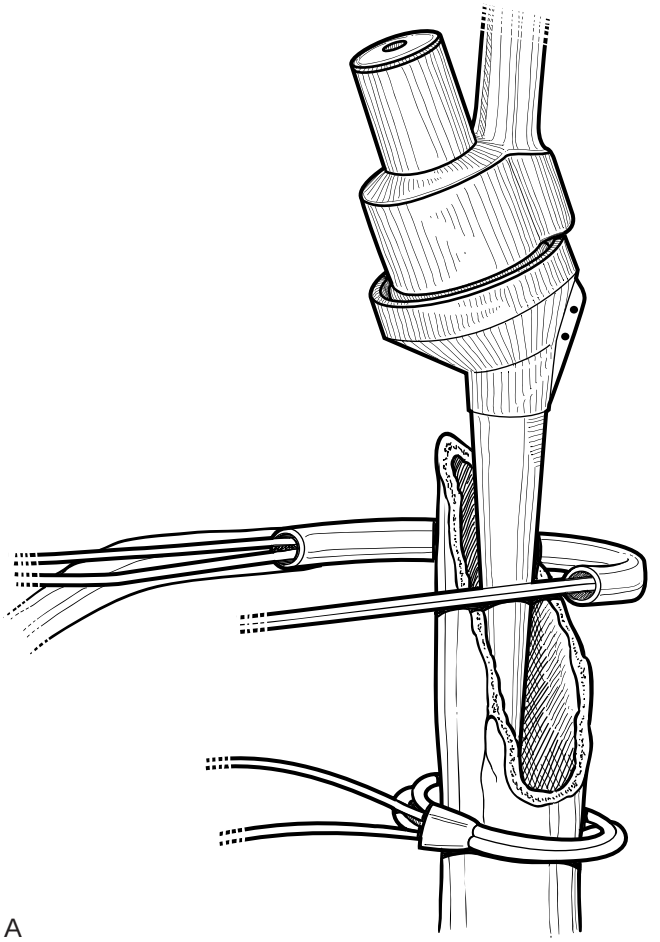


Figure 39-18 Fresh frozen allograft tibial strips used in proximal humeral reconstruction.



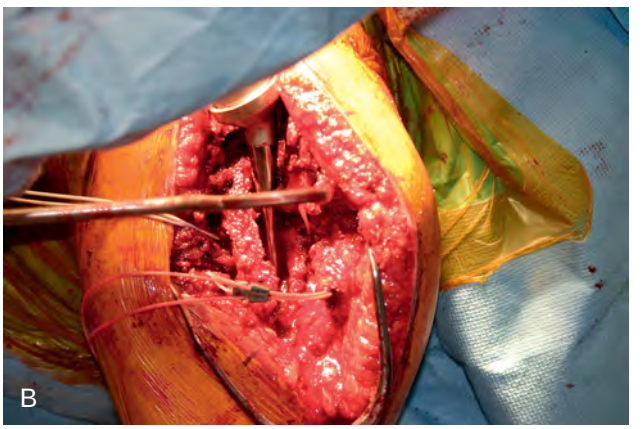


Figure 39-19 **A** and **B,** Passage of fixation cables to secure the allograft during proximal humeral reconstruction.

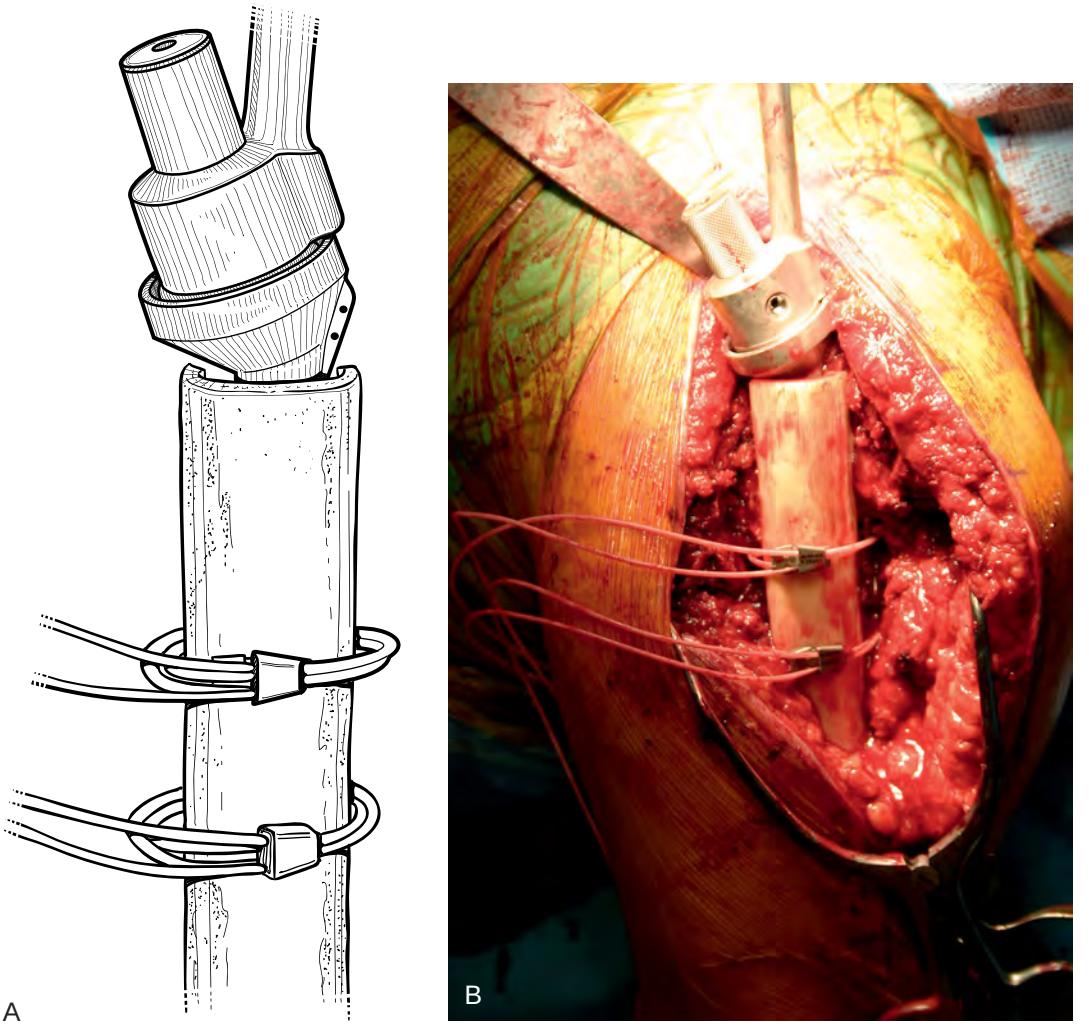


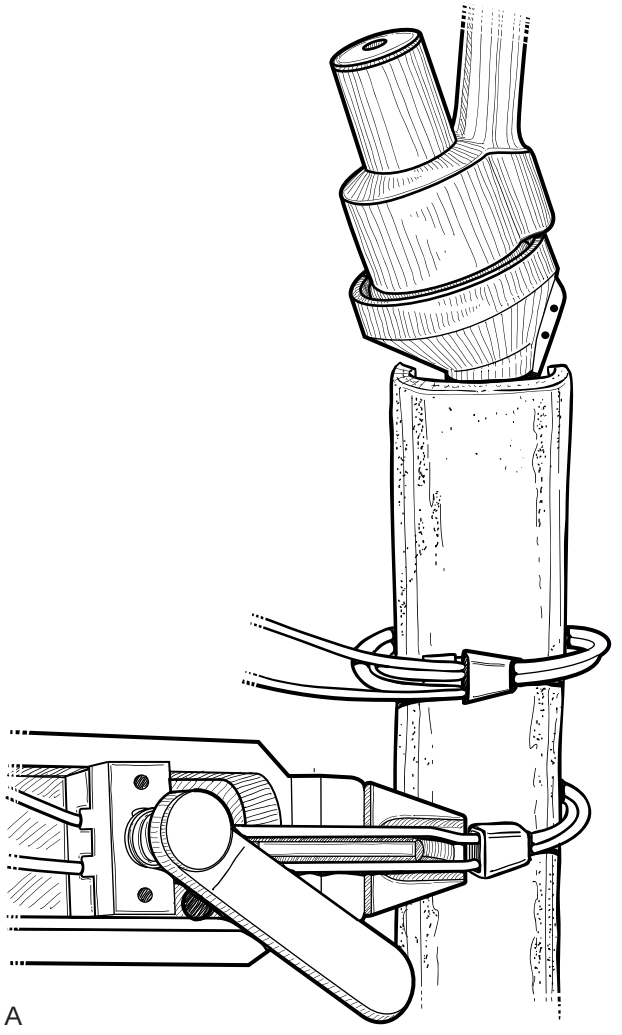
Figure 39-20 **A** and **B,** Placement of the allograft strip over the diaphyseal defect during proximal humeral reconstruction.

In cases in which a proximal humeral osteotomy has been performed for removal of the humeral stem, the cerclage cables are secured before removal of the trial humeral stem (see Chapter 38). In cases in which the native humeral cortex is excessively thin, fresh frozen allograft cortical struts are placed around the native humerus beneath the cables before tightening them to provide additional support for the proximal humerus, as shown in Chapter 38. The trial humeral stem is removed and attention is turned to the glenoid, if indicated.

TECHNIQUE FOR INSERTION OF A REVISION HUMERAL STEM

Once any glenoid pathology has been addressed, the humeral stem may be implanted. We cement the humeral stem in nearly all revision cases. In cases in which an unconstrained shoulder arthroplasty is to be implanted, the trial stem is replaced after any glenoid procedure is completed and glenohumeral stability is evaluated. With the arm externally rotated approximately 30 degrees, force is applied in a posterior direction to the proximal humerus, as with primary unconstrained shoulder arthroplasty. The prosthetic humeral head should subluxate posteriorly approximately 30% to 50% of its diameter and spontaneously reduce on release of the posteriorly directed force. If spontaneous reduction does not occur, posterior capsulorrhaphy may be necessary, as described in Chapter 13. Conversely, if posterior translation of at least 30% of the diameter of the humeral head is not possible, posterior capsular release may be necessary.

Once the shoulder is properly balanced, the humeral implant is cemented into place. Before insertion of the humeral stem, a cement restrictor is placed 1 cm distal



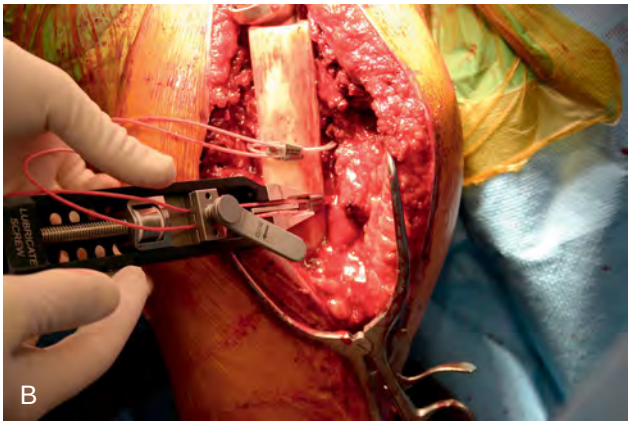
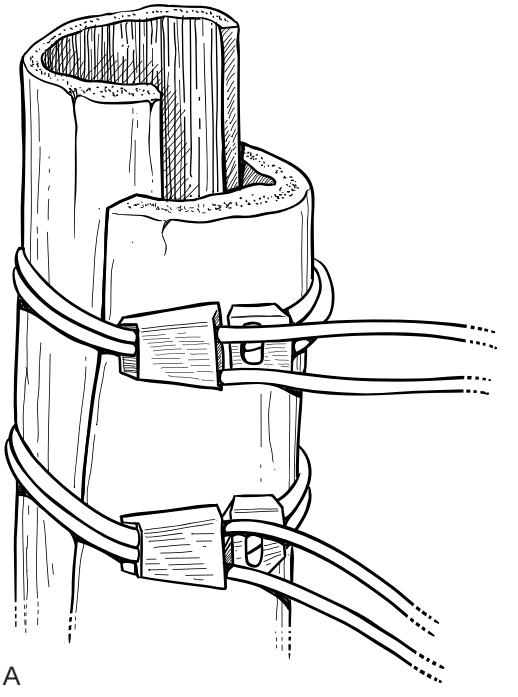


Figure 39-21 **A** and **B,** Tensioning of fixation cables during proximal humeral reconstruction.



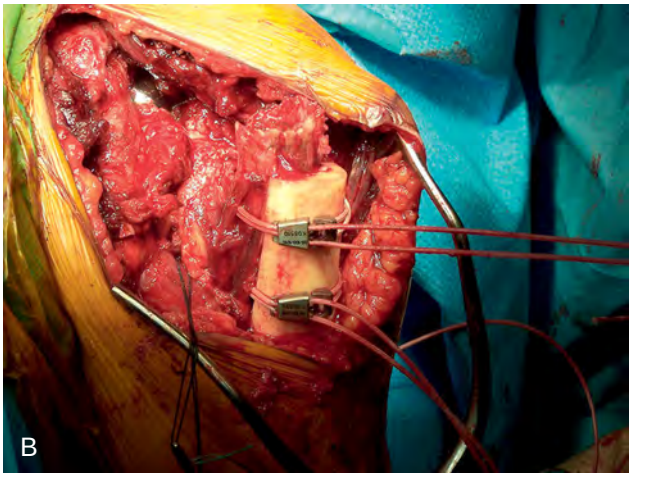


Figure 39-22 **A** and **B,** The trial humeral stem is removed while leaving the reconstructed proximal humerus.

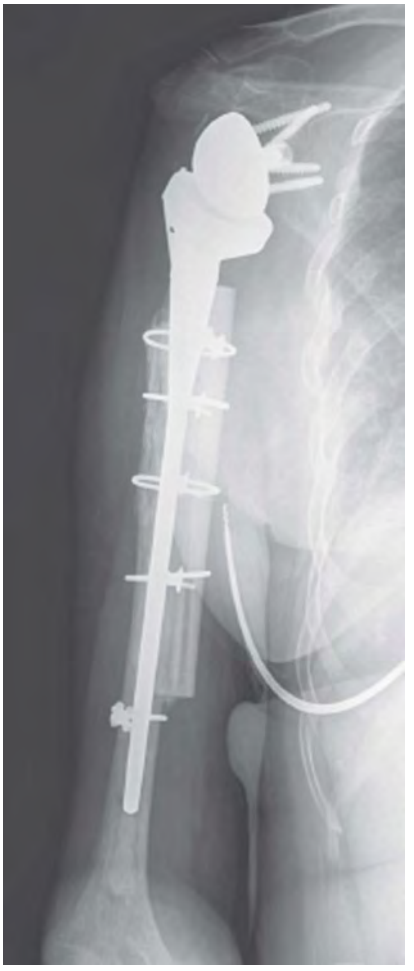
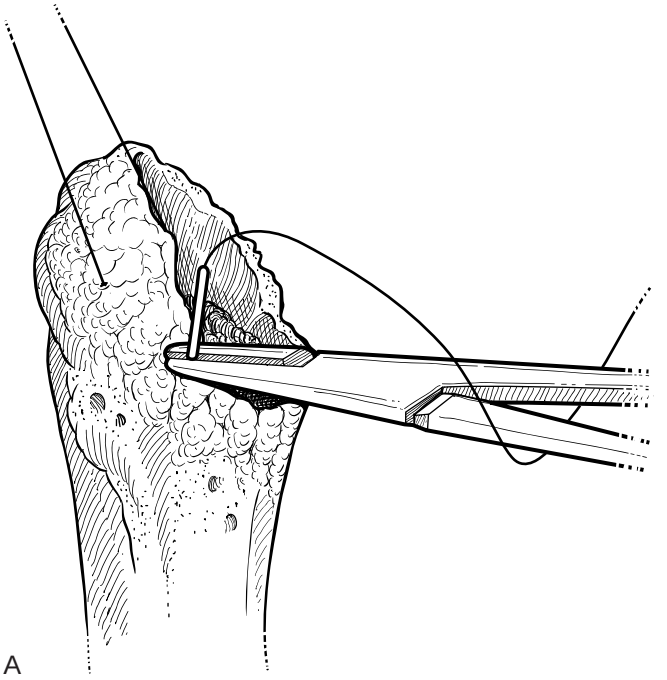


Figure 39-23 Case not requiring the use of a cement restrictor.

to the distal-most extent of the stem with an insertion device, except in cases in which a long-stem humeral implant that extends distally to the humeral isthmus is used, in which case no cement restrictor is placed (Fig. 39-23). Three no. 2 nonabsorbable braided sutures are placed first through the humeral stump of the subscapularis tendon, into the lesser tuberosity, and out through the intramedullary canal of the humerus for later use in reattachment of the subscapularis, as in cases of primary unconstrained shoulder arthroplasty (Fig. 39-24). These sutures are tagged with three different types of hemostats to identify the sutures as superior, middle, and inferior (we use a curved Kelly hemostat superiorly, a mosquito hemostat on the middle suture, and a regular hemostat inferiorly). The humeral canal is irrigated with sterile saline and dried with suction and gauze sponges. Two packages of bone cement (we prefer to use DePuy 2 bone cement [DePuy, Inc., Warsaw, IN] because of its accelerated curing time of less than 8 minutes) impregnated with 4 g of vancomycin powder (or 4.8 g of tobramycin powder in



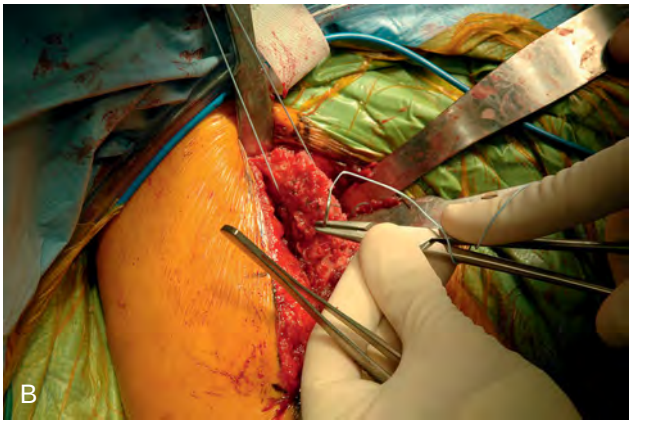


Figure 39-24 **A** and **B,** Transosseous sutures placed before insertion of the humeral stem for later use in reattachment of the subscapularis.

patients with vancomycin allergy) are introduced with a modified catheter tip syringe (Fig. 39-25). The canal is filled with cement and the assembled humeral stem is seated with an impactor while making sure to lateralize the humeral stem (Fig. 39-26). It is not necessary to pressurize the cement. Excess cement is removed with a Freer elevator. The cement is allowed to cure before reducing the glenohumeral joint. The subscapularis is repaired with the previously placed transosseous sutures, as in cases of primary shoulder arthroplasty.

When implanting a reverse prosthesis during revision shoulder arthroplasty, we reinsert the trial humeral stem with the 6-mm polyethylene insert after complet-

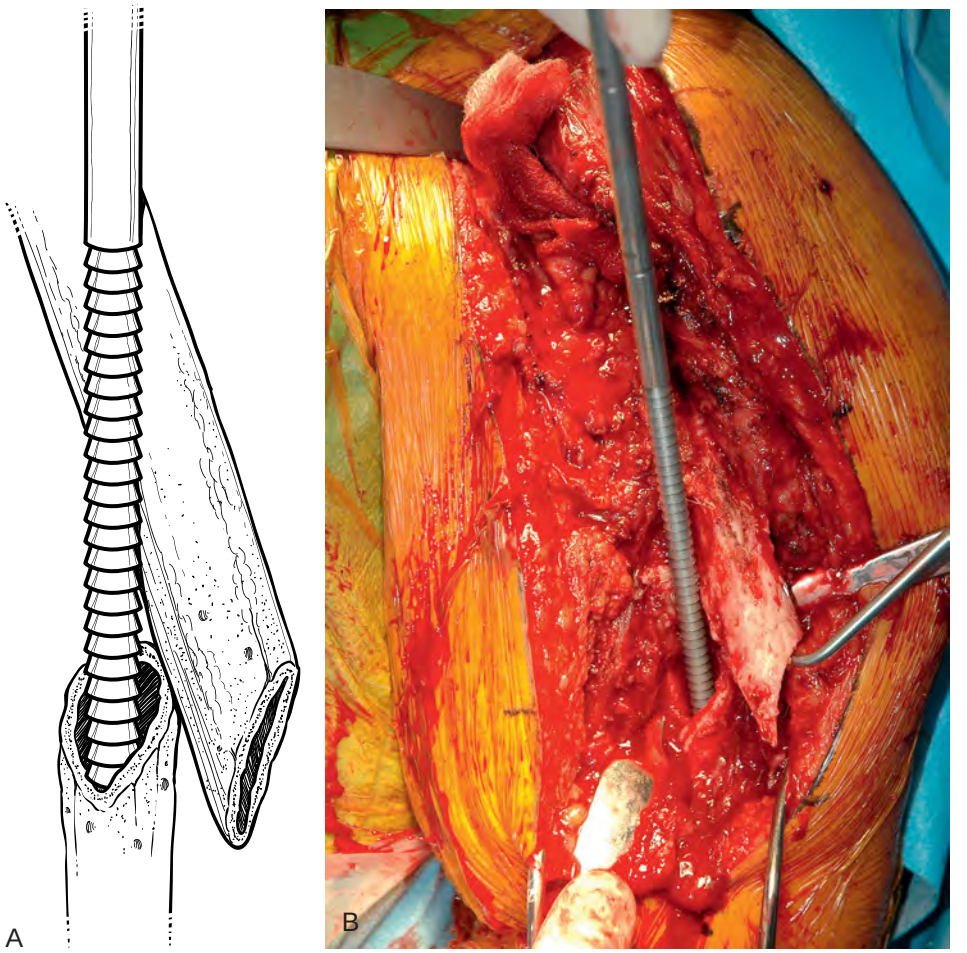
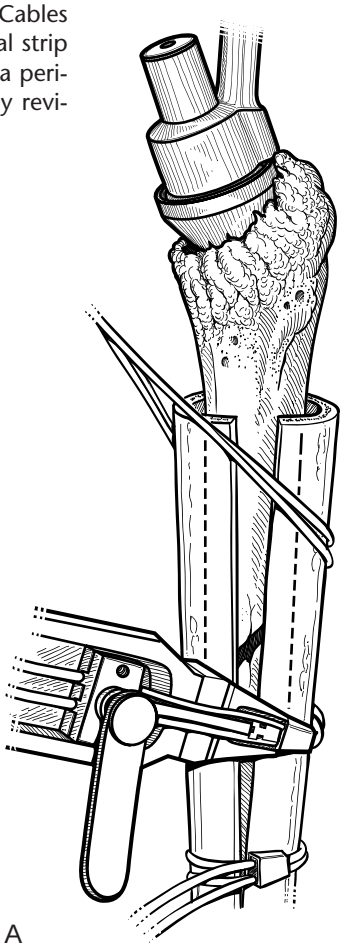


Figure 39-30 **A** and **B,** The humerus distal to the fracture site is reamed with diaphyseal reamers introduced at the fracture site.

radial nerve) are exposed as detailed in Chapter 37. The humerus distal to the fracture site is reamed with the diaphyseal reamers introduced at the fracture site (Fig. 39-30). The humerus proximal to the fracture site is prepared with the instrumentation provided for the selected humeral stem. It is often helpful to stabilize the proximal humeral fragment with a bone clamp during preparation of the proximal humerus (Fig. 39-31).

Once the proximal humerus has been prepared, the fracture is reduced and the trial humeral stem is placed. A humeral stem that bypasses the distal extent of the fracture by a minimum of two cortical diameters is selected (Fig. 39-32).[1] The position of the humeral stem within the humerus is noted after trial reduction and stability testing, as previously described. Fresh frozen cortical strips of allograft tibia are used on each side of the humerus and centered at the fracture site. We place two or four cables composed of a nylon monofilament core wrapped in a braided ultrahigh-molecular-weight polyethylene (Kinamed Inc., Camarillo, CA) subperiosteally around the residual native humerus with the cable-passing instrumentation provided while taking care to avoid the radial nerve posteriorly (Fig. 39-33). The cables are tightened with the tensioning device, the humeral stem is removed, and the periprosthetic fracture is left reduced (Fig. 39-34). The humeral canal is irrigated with sterile saline and dried with suction and gauze sponges. The final humeral implant is cemented into place with antibiotic-impregnated cement via the technique previously described in this chapter (Fig. 39-35). The cement is allowed to cure before reducing the glenohumeral joint.

Figure 39-33 **A** and **B,** Cables placed for fixation of a cortical strip allograft during treatment of a periprosthetic humeral fracture by revision arthroplasty.



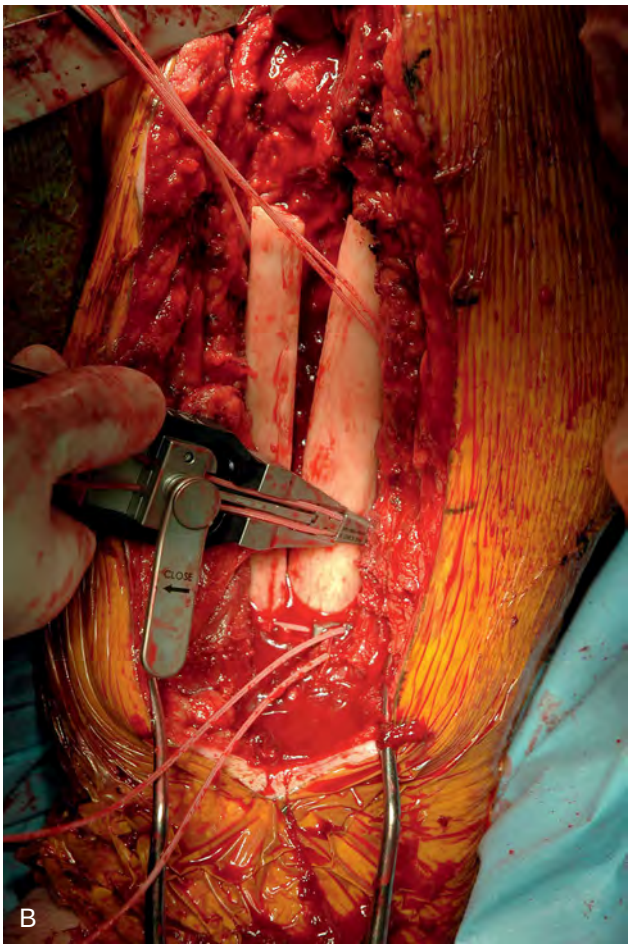
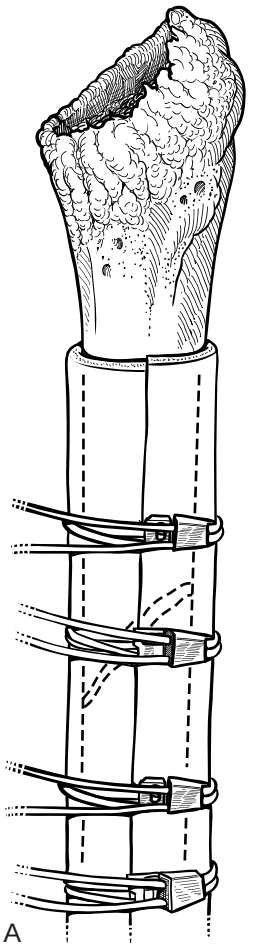
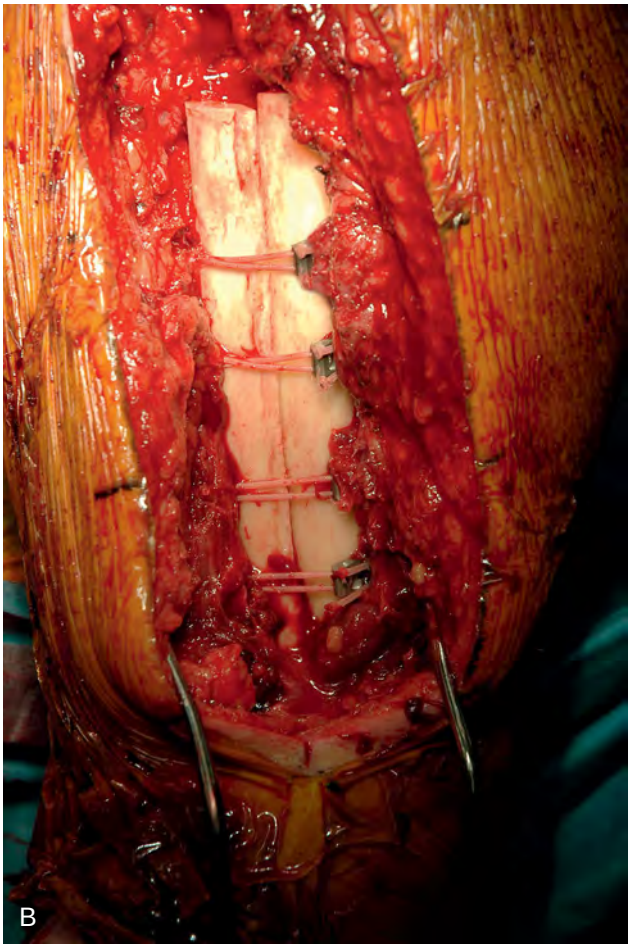


Figure 39-34 **A** and **B,** The humeral stem is removed, leaving the periprosthetic fracture reduced.





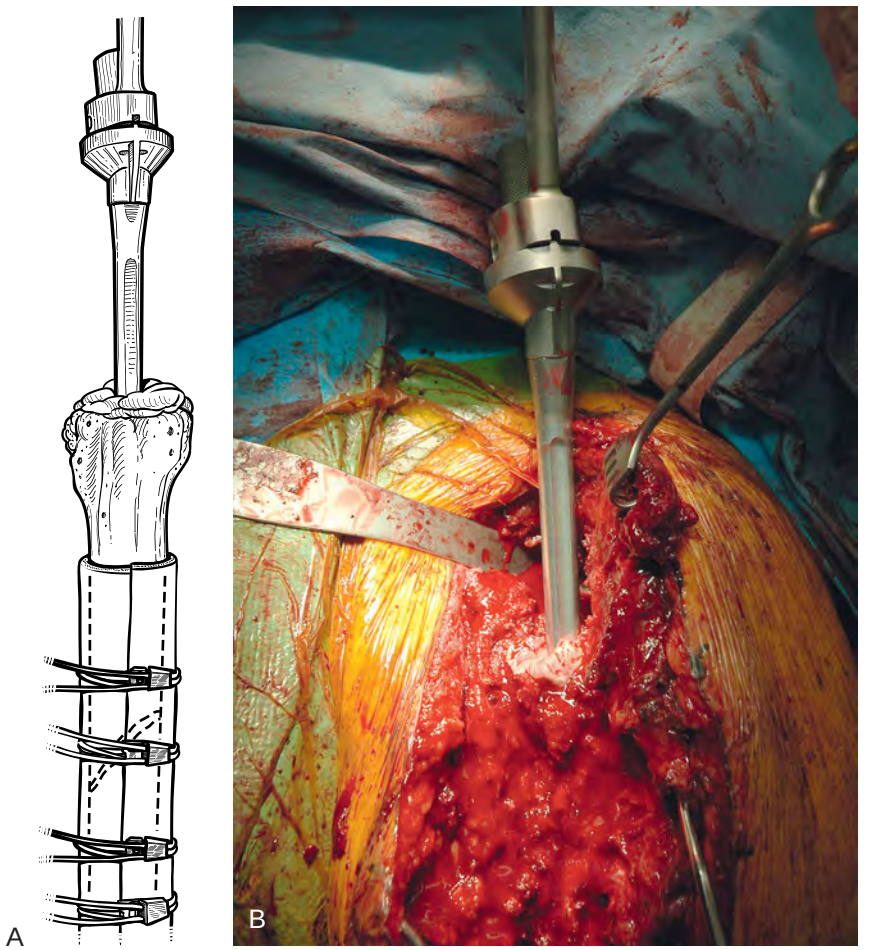


Figure 39-35 **A** and **B,** The final humeral implant is cemented into place with antibiotic-impregnated cement.

REFERENCE

1. Johansson JE, McBroom R, Barrington TW, Hunter GA: Fractures of the ipsilateral femur in patients with total hip replacement. J Bone Joint Surg Am 1981;61:1435-1442.