Removal of Solidly Fixed Implants During Revision Hip and Knee Arthroplasty

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Abstract

The removal of solidly fixed implants during revision hip and knee arthroplasty is a technically challenging procedure with the potential for a large amount of bone loss during component removal. This bone loss may compromise the subsequent reconstruction. Careful preoperative planning is essential before undertaking removal of solidly fixed implants. The surgeon should determine the type and size of the implants and be familiar with any specialized removal equipment that may be available. For both the hip and knee, extensive exposure is often necessary. Removal of a well-fixed femoral component often requires an extended trochanteric osteotomy. The most difficult component to remove from the knee is a well-fixed cementless patellar component. The primary goal in removing well-fixed components is to minimize loss of surrounding bone, which requires effective planning and often access to specialized tools and techniques.

The Hip

Not all mechanisms of failure in total hip arthroplasty require revision of solidly fixed implants. For example, excessive polyethylene wear in a modular cementless acetabular component with satisfactory position and locking mechanism can be managed by simple liner exchange and bone grafting. However, some clinical situations dictate removal of well-fixed implants. These include chronic infection, instability, excessive polyethylene wear in an implant with proven poor durability, unsatisfactory component orientation, or severe osteolysis that cannot be dealt with adequately while retaining the shell. Other indications for removal of well-fixed implants are femoral stem revision necessitated by focal osteolysis, impending periprosthetic fracture, or prosthetic fracture requiring removal of the distal part of a solidly fixed femoral stem. In addition, removal is indicated during an intended isolated single-component revision when the component to be left in situ is inadvertently damaged (eg, trunnion damage, corrosion in a modular femoral stem, or scratching of the head in a nonmodular component).

The Acetabulum

Preoperative Planning

Preoperative planning is essential for successful removal of solidly fixed implants. The success of revision surgery depends in large part on the quality of host bone remaining after implant removal. When revising loose components, iatrogenic damage to the host bone can be kept to a minimum with careful technique; however, with solidly fixed components, avoiding further damage is more challenging. Success in this area of revision arthroplasty surgery requires a thorough understanding of the indications for removal of solidly fixed components, sound preoperative planning, selection of the appropriate surgical approach, and knowledge of the techniques available to remove these implants.

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acetabular components and often can be aided by Judet radiographic views of the acetabulum. The manufacturer, brand, and size of the component should be identified. One way to identify the correct information is to obtain copies of the implant labels from the initial surgical record. The operation of the locking mechanism in a cementless component should be understood before the procedure is begun so that the liner can be removed without undue damage to the locking mechanism or the shell. For cementless components, the appropriate screwdriver for screw removal should be obtained as well as any specialized tools available for removal of implant components. The approach to acetabular revision must be extensile, allowing enhanced exposure should complications occur.1

Removal of Cemented Acetabular Components

The general principle in removing solidly fixed cemented acetabular components is to loosen the cup from the underlying cement. The usual technique involves the use of curved osteotomes, which are carefully introduced and driven along the cement-implant interface so that the cup can be lifted out. The underlying cement is then carefully divided using cement-splitting osteotomes and removed piecemeal.

For all-polyethylene cups, another technique uses acetabular reamers to ream away much of the polyethylene component.2 Eventually, as the polyethylene becomes thinner and thus more flexible, it can simply be lifted out of the cement mantle. Alternatively, a threaded extractor may be inserted into the polyethylene through a drill hole to allow disimpaction and removal of the cup.

Removal of Solidly Fixed Cementless Acetabular Components

Severe damage to the host acetabulum and/or pelvis can easily occur during removal of a solidly fixed cementless acetabular shell, making this one of the most challenging areas in revision hip arthroplasty. The first step is liner removal. This must be done to remove any screws present and, in many cases, to clearly visualize the bone-implant interface. Many acetabular liners have locking mechanisms that may require specialized tools or techniques for removal. If such specialized removal instrumentation is not available, techniques exist for removing the liner. When the rim of the polyethylene protrudes beyond the shell, it may be possible to use a small lever behind the protruding rim to pry the liner out of place. Care must be taken not to lever against the wall of the host acetabulum and inadvertently cause a fracture. An alternative technique is to drill a hole into the polyethylene liner and advance a 6.5-mm screw into the hole; as the screw advances, the liner will be expelled from the shell.

The second step is removal of the solidly fixed shell from the bone. Considerable caution must be exercised during this stage. The shell can be loosened using curved osteotomes (Fig. 1), although this method has the potential for bone loss. Other techniques have been devised in an attempt to minimize bone loss. One uses a pneumatic impact wrench; however, in the eight components tested with this technique, one pelvic fracture and one technical failure occurred.3 Another method uses an angled punch that was impacted against the acetabular component superiorly through a 3- to 4-mm keyhole made in the superior acetabulum. The punch applies tensile forces to the bone-implant interface, thus loosening the implant. Although no complications were encountered in the initial series of 35 cases, some host bone still must be removed to implement this technique.4 A reciprocating saw blade may be bent and used with power to loosen the shell without losing medial wall support; however, if this technique is used too aggressively, it could easily cause excessive bone destruction.5

Markovich et al6 described a technique using a separate stab incision over the high point of the ilium. A drill is introduced via this incision through the anterosuperior aspect of the acetabulum; then a punch is used to “pop out” the acetabular component with a few blows. In a series of 20 patients, acetabular component removal was accomplished within 10 minutes; one intraoperative fracture occurred.6 Another technique involves sectioning the acetabular shell with a metal cutting burr, then removing it piecemeal.7 This is time consuming and bears the theoretical risk of introducing metal filings into the hip joint, with the potential for increased polyethylene wear if any filings are left behind and make their way into the new joint.

Another technique uses short and long blades to loosen the shell’s interface with bone. A curved blade specific to the diameter of the shell is attached to a rotating handle device (eg, Explant Acetabular Removal System; Zimmer, Warsaw, IN) that is centered in the polyethylene liner by a head component of appropriate size (Fig. 2, A). If the shell is secured with screws, the liner and screws are removed and the liner is replaced. If
the liner is severely worn in an eccentric manner, a trial liner of the appropriate size is inserted to center the device. Two blades are used sequentially; the first is a truncated blade used to open the interface between the implant and the host bone. The second, a thin, full-radius blade, is used to completely release the implant from the host bone, minimizing acetabular bone loss (Fig. 2, B). In 31 procedures using this technique, time for removal of the shell did not exceed 5 minutes, and the median difference between the radius of implant removed and final reamer in the reconstruction was 4 mm. This reflects no more bone loss than the thickness of the blades. The uniform finding in all cases was removal of the acetabular shell devoid of any host bone.8

The Femur

Exposure

The key to successful removal of solidly fixed femoral components is wide exposure, thereby gaining free mobility of the proximal femur to achieve dislocation and component removal while avoiding intraoperative fracture. During preoperative planning, the surgeon must be alert to any varus remodeling that may have occurred in the proximal femur, although this is more common when the femoral component is loose. The presence of varus remodeling (Fig. 3) may add considerable difficulty to removal of a straight stem from the intact femur.

The position of the greater trochanter with respect to the femoral medullary canal also is important: if the greater trochanter overhangs the medullary canal, a predisposition to trochanteric fracture during implant removal exists. This can be avoided by carefully trimming the medial border of the trochanter with osteotomes or a high-speed burr or by performing a trochanteric osteotomy before implant removal. The shoulder of the femoral stem must be completely cleared of all soft tissue and bone before extraction is attempted.

The surgical approach for removal of a solidly fixed femoral stem must be extensile.1 Both the anterolateral and posterior approaches afford satisfactory exposure for straightforward procedures; depending on the surgeon’s experience, both can be extensile.

For removing well-fixed stems, the posterior extended trochanteric osteotomy is frequently the approach of choice.9 As well as enabling the surgeon to deal with femoral deformity, the extended trochanteric osteotomy allows the following procedures to be more easily performed: (1) cement extraction after removal of a polished tapered stem, or stem debonded from an intact cement mantle; (2) removal of roughened, precoated cemented or extensively coated cementless stems after osteotomy with the stem in situ;10 and (3) removal of broken stems.

Figure 2 A, Thin, size-specific hemispherical blades match the outside diameter of the cup to be removed. A truncated version of the blade (left) is used initially to loosen the periphery of the cup. Subsequently, the full-radius blade (right) is used to extract the cup with minimal bone loss. B, Typical appearance of the host bone following extraction of a solidly fixed cementless acetabular component using thin, size-specific hemispherical blades.

Figure 3 Anteroposterior radiograph showing a stem that has failed with severe osteolysis. The femur, however, has remodeled to the extent that removal of the stem and further reconstruction will be difficult without accessing the femoral medullary canal with an extended osteotomy. The line shows the degree of varus remodeling.
Removal of Solidly Fixed Cemented Femoral Components

Cemented stems can have different degrees of bonding to the cement mantle. Smooth stems, or stems with only slight texture, can be extracted easily using any of several available stem extractors. However, very rough or precoated stems may be impossible to remove with an extractor alone. In either situation, the basic principles are similar: initial stem removal followed by cement mantle extraction.

If a cemented stem cannot be removed with extraction devices, the preferred removal method is to loosen the stem from the cement using a combination of thin/flexible osteotomes, cement-removing instruments, and very narrow high-speed burrs. The extended femoral osteotomy is an excellent technique to afford safe exposure of the stem-cement interface. When using this technique, the surgeon must know whether there is precoating or roughening of the tip of the stem besides that of the metaphyseal portion. If only the metaphyseal portion is precoated or roughened, then the osteotomy needs to extend to a point just below that region. The stem can be loosened with a narrow pencil-tip burr to remove cement from the cement-stem interface; then the stem can be tapped out of the remaining cement mantle. Once this is done, small cement osteotomes can be used to create fractures in the inaccessible cement mantle. The stem is then removed by tapping it out or by using a stem extractor. However, if there is precoating or roughening at the tip of the stem, the extended osteotomy must be lengthened to just below the tip of the stem so that the same procedure can be taken more distally until the tip of the stem is freed. Once the stem has been removed, the well-bonded cement may be removed.

Several techniques have been adopted to simplify the process of removing well-bonded cement from the femur. The most common method of cement removal involves the use of long, thin osteotomes, reverse cutting hooks, and drills and taps designed specifically for cement removal (Fig. 4). With great care and patience, all of the cement usually can be removed from the intact femur with these instruments, causing minimal damage to the host bone. Gray described a modified technique that employs modular manual tools and cannulated reaming instruments to maximize the safety and efficiency of cement removal. Gray described a technique using a high-powered drill equipped with a centralizer to aid distal cement plug removal while avoiding cortical perforation (Fig. 5). We favor an extended trochanteric osteotomy, which reduces the time for cement removal and ensures removal of the distal cement plug without perforating the femur. After an extended trochanteric osteotomy, the cement is removed using a combination of osteotomes, drills and taps, and high-speed burrs.

Other methods to improve visualization of the distal cement include...
making windows in the femur\textsuperscript{14-18} and using endoscopic instruments.\textsuperscript{19,20} One windowing technique (controlled femoral perforation) uses small perforations that aid in cement removal, preventing the stress riser effect of larger windows.\textsuperscript{14}

Other methods of cement removal include the use of high-energy ultrasound delivered directly to the cement mantle; this heats and softens the polymethylmethacrylate (PMMA), thus allowing less troublesome removal.\textsuperscript{21,22} The advantage of high-energy ultrasound is that it usually creates little damage to cortical bone.\textsuperscript{23-25} A variety of modular probes designed for cement perforation and scraping are available for these ultrasound devices. Fletcher et al\textsuperscript{26} found ultrasoundic cement removal to be very helpful during revision of cemented femoral components. It facilitated shorter extended trochanteric osteotomies and the subsequent implantation of shorter prostheses.

Another technique involves insertion of fresh PMMA cement into the carefully prepared existing cement mantle inside the femur. Before the cement has cured, an extraction rod with nuts is inserted into the new cement. Using a series of further extraction rods, the cement is then segmentally extracted based on the assumption that the PMMA-PMMA bond is stronger than the bone-cement interface.\textsuperscript{27,28} Lithotripsy and laser also have been used to weaken the bone-cement interface and allow straightforward cement removal, but neither technique is commonly employed.

**Removal of Proximally Coated Cementless Femoral Components**

The design principle of proximally coated cementless stems is to achieve primary stability by press-fit, then facilitate metaphyseal bone ingrowth or ongrowth through a porous or hydroxyapatite proximal coating. Although these stems are not designed for diaphyseal ingrowth, some designs include roughening of the distal portion of the stem, which may lead to bone ongrowth. Removal of such a stem requires techniques similar to those used for removal of extensively porous-coated stems.

The amount of bone fixation observed with proximally coated cementless stems can be remarkable, and the difficulty of removal should not be underestimated. The preferred method of removal is with very sharp, flexible osteotomes (Fig. 6) or thin, high-speed burrs to break down the metaphyseal bone growth. Using a stem extractor,\textsuperscript{27} repeated attempts are made to remove the stem. This averts unnecessary damage to the femur that can occur with prolonged use of the osteotomes and burrs. The surgeon should ensure that a stem extractor with proper fit is available and that it will obtain good purchase on the specific type of stem to be removed.

**Removal of Fully Coated Cementless Femoral Components**

Removal of a solidly fixed, fully coated stem by techniques such as those described is time consuming and may well lead to extensive femoral

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**Figure 5** Instruments used to remove the cement plug from within the femur. A well-fixed stem is initially removed using a stem extractor. In the case of a monoblock stem, the extractor (K) can be assembled on a handle (C) using the assembly tools (E and H). The slap hammer (A) is then used to extract the stem. Once the more proximal cement has been removed, a drill guide (I and J) is connected to centralizers (B) that match the diameter of the femoral canal. The drills (F and G) are then used to drill the cement plug. A variety of taps (D) can then be used to grasp the plug, which is then tapped out in a retrograde manner.

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damage. Multiple instruments should be available for this procedure, including broad osteotomes; flexible osteotomes; Gigli saws; high-speed, metal-cutting burrs; and multiple trephines with diameters 0.5 mm larger than the stem to be removed. An extended trochanteric osteotomy is performed with the stem in situ. The level of the osteotomy depends on the length of the stem in situ and the length of the revision stem available. If the stem to be removed is relatively short and a revision stem can be used that will provide satisfactory fixation below the level of the existing stem tip, then the osteotomy is made at the level of the stem tip. Using a combination of Gigli saws and flexible osteotomes, the osteotomy fragment is lifted off the stem and mobilized in the standard manner. Using the same instruments, the stem is then loosened from the underlying femur and lifted out.

When removing a long primary stem or a revision stem, the extended trochanteric osteotomy cannot be made at the level of the stem tip because doing so may seriously compromise the fixation of the subsequent implant. In this situation, the osteotomy is made at a level that is planned to facilitate satisfactory reconstruction after implant removal. The osteotomy fragment is then mobilized as described to expose the underlying stem, and the stem is sectioned using high-speed, metal-cutting burrs. This can be time consuming, requiring several new burr tips, particularly when sectioning a cobalt-chrome stem. Once the stem is sectioned, the proximal fragment is loosened from the femur and lifted out. The distal segment is loosened using trephines (Fig. 7, A). The exact dimensions of the stem should be known at the planning stage of the procedure. If the stem is not straight, the osteotomy and subsequent sectioning should be made at the apex of any angle in the stem. If the stem is tapered, trephines of progressively reduced diameter may be used to avoid unnecessary removal of host bone.

Removal of Broken Femoral Stems

The broken cementless femoral stem is invariably solidly fixed distally. Removal of this implant is achieved with the same techniques as described for the long, fully coated stem. The extended trochanteric osteotomy is made at the level of the fracture in the stem, and the well-fixed distal portion is removed using trephines (Fig. 7, B). A broken cemented stem may be removed using similar techniques, but the osteotomy may have to extend distal to the fracture so that the cement may be removed once the broken stem is removed. The cement around the stem may be removed using a high-speed pencil-tip burr. A small divot is then made in the stem using a metal-cutting burr, and a carbide punch is used to tap the broken stem out of the femur. A similar technique may be applied without an extended osteotomy, using the controlled perforation technique. The divot in the stem can be made through a small anterior perforation in the femur. The carbide punch then can be used to extract the stem.

The Knee

Indications for the removal of solidly fixed knee implants include chronic infection around both cemented and cementless prostheses (which requires implant removal to eradicate the infection), component malposition (causing mechanical problems), instabili-
ty, or osteolysis (not amenable to treatment with component retention). Additional indications include polyethylene wear associated with modular components that have a poor locking mechanism, poor durability, or metal damage; and inability to retain an in situ component when a single-component revision would suffice (eg, a component is damaged, a compatible revision component is not available, there is size mismatch, or balancing the knee satisfactorily is not possible).

Preoperative Planning

The crucial elements of removing any solidly fixed component include wide exposure of the component while preventing intraoperative fracture and damage to the extensor mechanism of the knee. Several specialized exposure techniques have been described to lessen the risk of this serious complication.1

Careful preoperative planning is critical to minimize problems during implant removal. One factor is whether the component to be removed is posterior cruciate ligament retaining or posterior stabilized. If the closed box of a posterior stabilized component is associated with a large amount of cement, then implant removal can be hazardous. The intercondylar part of the femoral component may have to be removed with a high-speed burr to access cement in this region.30 The manufacturer of the component to be removed should be identified by obtaining the implant labels when possible, so that any specialized removal instrumentation can be available at the time of surgery. Femoral deformity and any areas of focal osteolysis should be noted because these predispose to intraoperative fracture.

Femoral Components

Removal of Primary Femoral Components

The principle of removing cemented primary femoral components is to fully loosen the implant from the underlying cement, remove the implant, and then remove the cement from the femur.31 In the cementless femur, the interface between implant and bone must be accessed to disrupt the bone ingrowth. Excess cement or overgrown bone may be removed using osteotomes to visualize the interface. The implant-cement interface can be broken down using specialized thin osteotomes (Fig. 8). Alternatively, a narrow oscillating, reciprocating saw blade or an ultrasound device may be passed between the cement and the implant to loosen the implant. The guiding principle is to keep the instruments working at the implant-cement interface and not to drift into and damage the host bone. Osteotomes always should be angled slightly toward the implant. Osteotomes are available that are specifically designed for areas that are particularly difficult to access (ie, the medial aspect of the lateral femoral condyle, the lateral aspect of the medial femoral condyle, and the areas of the posterior chamfers and posterior cuts) (Fig. 8).

Once the femoral component has been loosened to the extent that slight motion is visible, then either an extraction device or direct blows with a punch, parallel to the long axis of the femur, may remove the femoral component with little damage to the host bone. If the femoral component does not advance as expected, then, rather than simply hitting the component harder, all the surfaces of the implant-cement interface should be reinspected. Once the implant is removed, the cement can be removed piecemeal using osteotomes, rongeurs, drills, and, if necessary, high-speed burrs for the lug holes.

Removal of the cementless femoral component can be accomplished in a comparable manner using osteotomes or thin saws to disrupt the implant-bone interface. Alternatively, a Gigli saw can be used to disrupt as much as possible of the interface between the component and bone. The Gigli saw is passed underneath the most proximal aspect of the anterior femoral flange and is then advanced distally until the proximal portion of the intercondylar notch is encountered. At this stage, the Gigli saw usually breaks and is easily removed. Caution must be exercised to prevent the Gigli saw from drifting into the stress-shielded and osteopenic bone underneath the anterior femoral flange. This can be accomplished...
by guiding the saw away from the bone and pulling it toward the implant. The rest of the interfaces can be approached in a manner similar to the cemented femoral component.

**Removal of Femoral Revision Implants With Press-Fit Stems**

These components achieve fixation through cement on the resurfacing part of the implant and stems that achieve stability through press-fit. Generally, these stems are not designed for bone ongrowth or ingrowth; thus, removal is directly analogous to removal of the cemented primary femoral component. Once the implant-cement interface has been loosened, the implant can be removed with no further difficulty imposed by the stem. If a large amount of cement is in the intercondylar notch region of the implant, it may be bonded to the stem. Failure to debond this cement from the stem as the implant is removed may lead to an intercondylar fracture.

**Removal of Femoral Revision Components With Cemented Stems**

Removal of implants with cemented stems can be challenging because it is not possible to know how well bonded the stem is to the cement mantle in the femur and, similarly, how well bonded the cement is to the host bone. The resurfacing part of the implant must be debonded from the cement in the usual manner. Using either a punch or an extraction device, removal of the femoral component should then be attempted. This effort will yield one of three results.

1. The stem will debond from the cement, and the implant can be removed, leaving the cement behind. The residual cement is then removed using osteotomes, drills and taps, reverse cutting hooks and, if necessary, high-speed burrs.

2. The second possibility is that the implant-cement construct will debond from the bone and begin to advance as a single unit. If this happens, the surgeon should not continue in the same manner because the cement may wedge in the femur and, with repeated blows, lead to an intraoperative fracture. Instead, the surgeon should use the enhanced exposure to the stem and cement to attempt to debond the stem with osteotomes, or at least carefully debulk the cement as it is seen emerging from the femur. With this method, either the implant is removed, leaving the cement behind, or the cement is removed at the same time as the implant, yet leaving the femur intact.

3. The final possibility is that the femoral component cannot be moved, requiring a femoral osteotomy to expose the cement mantle. This can be either a window at the tip of the stem to debond the cement in a retrograde manner or a window over the whole length of the stem. A revision stem must be available that extends beyond the uppermost extension of the window by at least two cortical diameters of the femur. The femur also may be reinforced by an onlay cortical strut allograft.

**Tibial Components**

**Removal of Primary Tibial Components**

The strategy for removing a cemented primary tibial component is to loosen the implant from the cement on the tibial plateau; the strategy with a cementless implant is to break the bone ingrowth bond. Even if there is cement around the keel, the implant can be removed from the tibia using a punch and mallet or an extraction device. Either fine, narrow osteotomes or a saw can be used to carefully cut against the undersurface of the implant to debond it from the underlying cement. Although it is difficult to advance a saw beyond the keel of the implant, narrow osteotomes usually can be passed to loosen the implant completely. If the implant is extracted before its posterior aspect is completely loosened, a coronal fracture of the tibia may occur when the tibia is being extracted. To aid the removal of a loosened tibial component, specialized tibial extractors are available that have limbs passed from anterior to posterior on either side of the keel. The extractor is connected to a slap hammer. The use of this extractor al-
allows a vector of extraction force more nearly parallel with the long axis of the tibia (Fig. 9). Once the tibial component is taken out, the residual cement is removed piecemeal using a combination of osteotomes, rongeurs, drills, and reverse cutting hooks.

At this stage, the surgeon must be particularly careful to avoid inadvertent fracture of the tibial plateau or perforation of the tibial metaphyseal cortex, which is relatively thin. All-polyethylene tibial components may be removed by using a saw to cut through the keel and completely loosen the implant. Once the articular portion of the implant is removed, the keel portion may be removed by breaking the cement mantle around it, then using a drill and tapping the keel with a slap hammer to remove it.

Removal of Tibial Components With Press-Fit Stems

These components obtain stability through cement fixation to the tibial plateau and press-fit into the tibial diaphysis. The stems are not designed for bone ongrowth; thus, removal is again comparable to removal of a cemented primary tibial component. Once the implant-cement interface has been debonded, the implant can be removed with no greater difficulty imposed because of the stem. The presence of cement in the metaphyseal region of the stem does not usually cause a problem during implant removal.

Removal of Tibial Components With Cemented Stems

For tibial components with cemented stems, the preferred extensile exposure is a tibial tubercle osteotomy (TTO). Typically this exposure would not be selected initially because it may not be necessary for implant removal. However, if extensile exposure is required before removal can be attempted, then a TTO is preferable to a rectus snip. If the tibial plateau is satisfactorily exposed without the need for a TTO, then the plateau part of the component is loosened in the usual fashion. Once the implant is taken out, the cement can be removed from within the medullary canal. If the implant cannot be removed, a TTO is done.

Patellar Components

Removal of Cemented Patellar Components

For patellar button removal, a saw can be used to divide the polyethylene pegs of an all-polyethylene component, leaving them in situ with the cement. The remaining cement on the surface of the patella is removed with either osteotomes or a saw (using it like a plane). The pegs and cement in the peg-hole are then drilled out. A high-speed burr with a fine tip also may be used.

Removal of Cementless Patellar Components

Removal of a well-fixed, cementless patellar component is particularly challenging. A saw may be used all the way around the patellar component until the fixation pegs are encountered. It may then be possible to lift out the implant, leaving an intact patella. If this is not the case, then a fine-tipped high-speed burr or wheel is used to section the pegs, enabling removal of the patellar button. The residual pegs are then “cored out” with the same type of burr. However, unless revising for infection, the pegs usually can be left in situ and still provide fixation of a further revision component if desired.

Summary

Removal of solidly fixed components during revision hip or knee arthroplasty is necessary in a wide range of clinical situations. Removal of these implants can easily result in significant damage to the host bone, compromising the success of subsequent reconstruction. Different approaches and techniques must be adopted when dealing with the various types of implants that may be encountered. Careful preoperative planning, wide/extensile exposure, the ability to perform multiple techniques, and the availability of specialized instrumentation are fundamental to success in this area of revision surgery.

References

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