SOLUTIONS IN REMOVAL OF BROKEN IMPLANTS IN
ORTHOPEDIC SURGERY

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Abstract – The decision to remove hardware has significant economic implications, including the costs of the procedure as well as possible work time lost for postoperative recovery. The clinical indications for implant removal are not well established. There are few definitive data to guide whether implant removal is appropriate. Implant removal may be challenging and lead to complications, such as neurovascular injury, refracture, or recurrence of deformity. When implants are removed for pain relief alone, the results are unpredictable and depend on both the implant type and its anatomic location. Current literature does not support the routine removal of implants to protect against allergy, carcinogenesis, or metal detection. Surgeons and patients should be aware of appropriate indications and have realistic expectations of the risks and benefits of implant removal. Despite advances in metallurgy, fatigue failure of hardware is common when a fracture fails to heal. Revision procedures can be difficult, usually requiring removal of intact or broken hardware. Several different methods may need to be attempted to successfully remove intact or broken hardware. Broken intramedullary nail cross-locking screws may be advanced out by impacting with a Steinmann pin. Broken open-section (Küntscher type) intramedullary nails may be removed using a hook. Closed-section cannulated intramedullary nails require additional techniques, such as the use of guidewires or commercially available extraction tools. Removal of broken solid nails requires use of a commercial ratchet grip extractor or a bone window to directly impact the broken segment. Screw extractors, trephines, and extraction bolts are useful for removing stripped or broken screws. Cold-welded screws and plates can complicate removal of locked implants and require the use of carbide drills or high-speed metal cutting tools. Hardware removal can be a time-consuming process, and no single technique is uniformly successful. Although hardware removal is commonly done, it should not be considered a routine procedure.

Keywords - orthopedic surgery, implants

Hardware removal can pose an unpredictable level of surgical difficulty in elective or revision surgery. 1 Broken hardware often can be identified on preoperative radiographs, but it also may be encountered unexpectedly during surgery. Overlapping hardware may obscure visualization of broken screws on preoperative radiographs. Screws also can be broken during removal when the screw head is sheared off a well-fixed shaft. Screwdriver tips can break during attempted screw removal, and the tip may remain incarcerated in the screw head. Stripped screws, stripped intramedullary (IM) nail extraction threads, and cold-welded screws and/or plates may be discovered intraoperatively. The difficulty of removing broken or stripped hardware can markedly increase surgical time and complexity. Although broken hardware may be encountered unexpectedly during routine hardware removal, this commonly occurs in the presence of nonunion or delayed union of a fracture following trauma. Broken hardware also may occur following tumor resection and reconstruction when the bone does not heal. Implants placed for prophylactic stabilization of impending pathologic fracture may fail as a result of improved patient survival (eg, with advances in chemotherapy and radiation therapy). In the presence of infection, removal of broken hardware is indicated to minimize bacteria colonization. When IM nailing is performed, any broken screw that impinges on the IM nail path will need to be removed. Overall, no single technique is uniformly successful, and several different methods may need to be attempted to remove intact or broken hardware. Additionally, commercially available tools are useful for hardware removal (Table 1).

1. Broken Intramedullary nail Interlocking screws

Because of their narrow diameter, interlocking screws are far more prone to fatigue failure than IM nails. Fatigue failure of the screw often occurs near the edge of the nail, and implant migration may lead to angulation of the broken screw. Advancement of the screw fragment may be necessary to permit removal of the IM nail. Interlocking screws are often
positioned in a metaphyseal location where the cortical bone is relatively thin. This allows the broken screw fragment to be advanced with relative ease. A stout, smooth Steinmann pin or similar device of the appropriate diameter is commonly used to impact the broken screw segment. 

<table>
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<tr>
<th>Indication</th>
<th>Device</th>
<th>Equipment/Comments</th>
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<tr>
<td>Broken or stripped screws</td>
<td>Screw removal instrument system (DePuy, Warsaw, IN)</td>
<td>Hex screwdrivers, screw extractors, trephines, extraction bolts, and easy-out extractors</td>
</tr>
<tr>
<td></td>
<td>Universal screw removal instrument system (Innomed, Savannah, GA)</td>
<td>Screw extractors, trephines, and various screwdrivers</td>
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<tr>
<td></td>
<td>Implant extraction set (Stryker, Mahwah, NJ)</td>
<td>Screwdrivers, screw-removal bits for stripped screws, conical extraction bits, trephines, and intramedullary nail extraction tools</td>
</tr>
<tr>
<td></td>
<td>Screw Removal System (Synthes USA, Paoli, PA)</td>
<td>Screwdrivers, screw-removal forceps, conical extraction screws, hollow reamers, extraction bolts, and carbide drill bits</td>
</tr>
<tr>
<td></td>
<td>Xtract-All universal broken screw removal system (S.S. White Medical, Piscataway, NJ)</td>
<td>Thirteen sizes of extractor shafts with ratcheting T-handle</td>
</tr>
<tr>
<td></td>
<td>Xtract-All stripped bone screw removal system (S.S. White Medical)</td>
<td>Eight sizes of twisted screw extractors (1.5 to 5.0 mm), ratcheting T-handle, parallel jaw pliers, and mallet</td>
</tr>
<tr>
<td>Broken intramedullary nails</td>
<td>Nail extractor hook (Biomet, Warsaw, IN)</td>
<td>When used for other nail brands, confirm that extraction hook fits through nail opening</td>
</tr>
<tr>
<td></td>
<td>Nail extractor hook (Smith and Nephew, Memphis, TN)</td>
<td>When used for other nail brands, confirm that extraction hook fits through nail opening</td>
</tr>
<tr>
<td></td>
<td>Nail extractor hook (Stryker)</td>
<td>Small and large sizes are available in implant-extraction set, along with various intramedullary nail extraction tools</td>
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<tr>
<td></td>
<td>Extraction hook for titanium cannulated nails (Synthes USA)</td>
<td>When used for other nail brands, confirm that extraction hook fits through nail opening</td>
</tr>
<tr>
<td></td>
<td>Intramedullary Nail Extractor (Innomed)</td>
<td>Includes three-eighths inch and one-half inch conical extraction bolts for removal of both fluted and nonfluted cannulated nails</td>
</tr>
<tr>
<td></td>
<td>Offset punches (Innomed)</td>
<td>Used to push cut broken solid nail segments</td>
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<tr>
<td></td>
<td>Solid nail extraction system (Synthes USA)</td>
<td>Various sizes of trephines and extractor heads for solid 8, 9, 10, 11, and 12-mm intramedullary nails</td>
</tr>
<tr>
<td></td>
<td>Intramedullary nail extraction set (Zimmer, Warsaw, IN)</td>
<td>Includes various diameters of smooth and beaded guidewires, corkscrew extractors, and extractor bolts</td>
</tr>
<tr>
<td>Cold-welded plates</td>
<td>Carbide drill bits (Synthes USA)</td>
<td>Part of the Synthes Screw Removal System</td>
</tr>
<tr>
<td>General</td>
<td>OrthoVise (Innomed)</td>
<td>Vise-grip pliers with attached slap hammer</td>
</tr>
</tbody>
</table>

Table 1

The diameter selected depends on the diameter of the interlocking screw. Using a mallet, the blunt end of the Steinmann pin is passed through the nail hole and impacted against the fragment (Figure 1). Depending on the location and fragment size, a counter-incision may be necessary to retrieve the broken interlocking screw fragment. Otherwise, the fragment may be allowed to remain in the adjacent soft tissues. Alternatively, the screw fragment alone may be partially advanced to clear the nail pathway, leaving most of the fragment in the metaphyseal bone.

Figure 1: A Steinmann pin is used to impact a broken interlocking screw. The diameter of the Steinmann pin selected should be as stout as possible while still able to fit through the intramedullary nail hole.
2. Broken intramedullary nails

Removal of broken IM nails may be particularly challenging and sometimes is difficult. When removing an IM nail, it is helpful to identify the brand and diameter of the nail. This will help in obtaining the correct instrumentation for nail removal. When a nail is broken, it is also useful to obtain a sample nail of the same brand and size. Knowing the brand and size of the nail will help to determine the size of the extraction devices (eg, hooks, ball-tip guidewires) that will fit through the distal nail outlet.

Problems with IM nail removal can be encountered even in the absence of a broken nail. Challenging nail removal may occur when the extraction threads are stripped or when the correct extraction device is unavailable. Several commercial IM nail extraction sets provide corkscrew extractors that can be cross-threaded into the IM nail and attached to an extraction slap hammer. The use of an extraction hook, use of the interference-fit ball-tip technique, or other methods for broken IM nail removal may be required.4-6 Numerous technical tips for the removal of broken solid and cannulated IM nails are available. Regardless of the technique used to remove the broken nail segment, it is often helpful to ream the IM canal after removing the threaded end of the nail. Providing a larger pathway may ease the removal of the broken nail segment. Initial methods to remove broken cannulated IM nails required the use of a custom-made hook fabricated from a reverse biting-hook osteotome.4

Extraction hooks also have been hand-made from a 0.25-inch Luque rod and a 3-mm smooth guidewire.7,8 Similar hooks are now commercially available for this purpose from several vendors (Biomet, Warsaw, IN; Smith and Nephew, Memphis, TN; Stryker, Mahwah, NJ; Synthes USA, Paoli, PA). As noted, the hook must be small enough to fit through the distal end of the nail and engage the tip of the broken fragment. Reverse extraction is used to remove the broken nail segment (Figure 2). Serial stacking of smooth guidewires into the nail lumen has been described to help align broken segmental pieces.5 This technique provides pressure against the hook to maintain its proper position. A plastic exchange tube also can be used to center the broken distal nail segment.7 In addition to keeping the hook engaged against the nail, these techniques will prevent a short distal segment from angulating obliquely and becoming jammed during extraction. Open-section nails (Kuntscher type) are best removed using a hook. Winquist developed a similar technique for removal of closed-section cannulated nails.9 A pointed guidewire is first passed or impacted through the distal nail hole to remove any adherent bone or fibrous tissue (Figure 3). Once an adequate working area has been developed, a ball-tipped guidewire is passed through the tip of the broken nail fragment.

Figure 2: Removal of a broken cannulated nail. A hook is passed through the broken distal nail segment (dashed rectangle), and the segment is removed with gentle reverse extraction.

Figure 3: Removal of a closed-section cannulated nail. Interference fit against a beaded guidewire is obtained by insertion of smooth guidewires, thereby allowing removal of a broken distal nail segment.

Figure 4: Removal of a solid intramedullary nail. A, A large cylindrical hole is drilled in the metaphysis, and the broken distal segment is levered proximally with a Steinmann pin. B, A narrow Hohmann-type retractor is placed beneath the tip of the nail, and the broken segment is pushed out with a narrow-diameter nail inserted from above.
3. Broken solid screws following plate fixation

Following screw breakage, the screw head portion is often loose (as a result of motion) and is easy to remove. Depending on the circumstance, the removal of the distal screw tip portion may not be required.

When fracture nonunion is complicated by infection, removal of the distal screw tip may be warranted to eliminate a potential infection nidus. Removal of the distal screw tip also may be required when converting to IM stabilization, depending on the location of the fatigue break.

A centering pin is placed through the near cortex hole, and multiplanar fluoroscopy is used to obtain the correct trajectory to the remaining screw tip. An appropriately sized hollow reamer is implemented to enlarge the hole in the near cortex and to clear tissue surrounding the screw (Figure 6). Hollow reamers have reverse cutting teeth and are turned counterclockwise with a T-handle or power drill in reverse.

The extraction bolts have reverse threads and are threaded onto the screw by turning counterclockwise while applying axial pressure. Occasionally, the distal screw tip may become incarcerated in the hollow reamer and the screw is then extracted by turning the hollow reamer counterclockwise. It is recommended that the hollow reamer be advanced to expose approximately 1 cm of the broken screw shaft. To avoid further cortical bone loss, an extraction bolt with reverse threads should be placed over the broken screw shaft and turned by hand in reverse while applying pressure in the direction of the screw axis (Figure 7). When it is not possible to create purchase on the remaining screw tip, it may be necessary to use a hollow reamer to drill across the far cortex.

Figure 5 and 6: A commercial ratchet grip extractor designed for removal of solid intramedullary nails. A hollow reamer is used to remove bone and tissue surrounding the remaining shaft of a broken screw.

Figure 7, 8 and 9: Removal of a distal screw tip after enlarging the cortical hole with a hollow reamer. A reverse-threaded extraction bolt is threaded onto the screw shaft while axial pressure is applied. Removal of a broken cannulated screw by a conical extraction device thread into the hollow screw. Removal of a stripped screw using a conical extraction device.

4. Removal of cold-welded screws

The development of locking plate technology has led to problems with the cold welding of screws to plates, especially in softer titanium implants. Occasionally, screwdriver tips will break and remain embedded in the screw head. The use of a carbide drill bit or diamond-impregnated metal cutting disk will be required to remove a cold-welded screw.

The cold-welded screw head is then drilled out through the use of the carbide drill (Figure 10). Techniques described previously for broken screws may be used to remove the remaining screw shaft. Alternatively, the plate can be cut directly at the screw hole with a diamond cutting wheel, thereby releasing the plate from the screw (Figure 11). The screw then can be removed with a screwdriver or
vise grip–style pliers when the screw head is stripped or damaged. The plate also can be cut adjacent to the screw, and the remaining plate and screw twisted counterclockwise with pliers, thus removing the coldwelded screw from the bone (Figure 12). Adequate clearance of the plate from the bone will be necessary for the cut plate segments to be used as a T-handle to turn the screw. When using metal-cutting tools, soft tissues should be protected with saline-soaked gauze to prevent excessive accumulation of metal debris. Irrigation and suction should be used simultaneously to cool the field and remove any metal debris.

5. Summary

Removal of broken hardware can be technically challenging and necessary in surgical management. Preoperative planning is recommended to have the proper removal equipment available. Surgeons should be aware of available equipment for broken hardware removal onsite in the operating room as well as where other equipment that may be needed can be obtained. Anticipating the unexpected may prevent failure that may occur when necessary equipment is not available. Because no single removal technique is universally successful, the operating surgeon should be familiar with several different techniques to remove broken or bent IM nails, broken or stripped screws, and cold-welded screws and plates.

6. References:


[6] Giannoudis PV, Matthews SJ, Smith RM: Removal of the retained fragment of broken solid nails by the


Solutions in Removal of Broken Implants in Orthopedic Surgery


