Techniques to Remove a Failed Integrated Implant

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LEARNING OBJECTIVES

- describe the proposed new decision tree for hopeless implant removal based on the literature and clinical experience of the authors
- understand less invasive techniques to remove implants when necessary
- identify techniques that are the most appropriate choices for specific situations

ABSTRACT

This literature and clinical review identifies and evaluates the various techniques for removing failed, fractured, or peri-implantitis-affected nonmobile implants. The article also discusses the limitations and complications that may arise with the various techniques during removal procedures. Based on specific clinical factors such as anatomical conditions, implant design, condition of implant connection, bone quality, and remaining amount of bone integrated to the implant body, a decision tree is proposed to help clinicians determine the most appropriate minimally invasive technique.
Implant failure can have a multifactorial etiology. Causes related to early failure include: overheating of the bone during osteotomy preparation; overpreparation of the osteotomy; implant contamination during surgery; poor bone quality; lack of primary stability; and macro-motion caused by overload or parafuntion. Implants with any of the aforementioned etiologies are usually mobile, and early removal is easily performed. Late failure is most often related to peri-implantitis, occlusal trauma, implant fracture, and/or implant overload; many late-failing implants remain partially integrated with no mobility. Implants that fail due to peri-implantitis show many clinical signs similar to those found around periodontally diseased teeth. These signs include bleeding on probing, suppuration, pain, increased probing depth, radiographic evidence of bone loss, presence of periopathogens bacteria, and site-specific infections.

Factors necessary for successful integration of dental implants have been proposed. Of these, a lack of mobility is a primary prerequisite. However, even when implants are nonmobile, indications for their removal may exist, such as fracture, malposition, infection, pain, and advanced peri-implantitis. Although several reviews of the literature cite various techniques to treat implants with peri-implantitis without removal, these techniques appear unpredictable. In cases of advanced peri-implantitis or implant fracture, removal of the affected implant is usually necessary. Many of these nonmobile implants require surgical intervention for their removal. Methods of implant removal include use of counter-torque ratchet, piezo tips, high-speed burs, elevators, forceps, and trephine burs. Oftentimes, these instruments are used alone or in combination depending on the clinical situation.

There is, however, a paucity of published literature on the subject of implant removal techniques, their indications, drawbacks, and possible complications.

The purpose of this literature and clinical review is to discuss the indications of various techniques to remove a failed, fractured, or peri-implantitis-affected nonmobile implant, and to delineate the limitations and complications that may arise with the various methods of removal. A decision tree is also proposed to guide the clinician in determining the least invasive method of implant removal.

**MATERIAL AND METHODS**

Clinical data in this study was obtained from the New York University College of Dentistry (NYUCD) Implant Database (ID). This data was extracted as de-identified information from the routine treatment of patients at the Ashman Department of Periodontology and Implant Dentistry at the NYUCD Kriner Dental Center or in private practices. The ID was certified by the Office of Quality Assurance at NYUCD. This use of the database was in compliance with the Health Insurance Portability and Accountability Act (HIPAA) requirements and approved by the University Committee on Activities Involving Human Subjects (UCAHIS).

A total of 2,333 articles from peer-reviewed journals published in English from January 1986 to August 2010 were collected from a search performed using MEDLINE at the Waldman Library at the NYUCD Kriner Dental Center. The keywords utilized identified 2,066 articles for “dental implant and failure,” 281 for “dental implant and fracture,” 31 for “hopeless and dental implant,” 114 for “displacement and dental implants,” and 54 for “remove and dental implant.” Inclusion criteria for this review included articles that discussed specific removal techniques for failed, fractured, or diseased implants and also included the following:

<table>
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<tr>
<th>TABLE 1</th>
<th>Published Literature of Implant Removal Techniques</th>
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<tr>
<td>AUTHOR</td>
<td>TECHNIQUE</td>
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<td>Esposito M., et al</td>
<td>Un-screw or trephine burs</td>
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<td>Plattelli A., et al</td>
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<th>TABLE 2</th>
<th>Comparison of Methods for Implant Removal Techniques</th>
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<tr>
<td>TECHNIQUE</td>
<td>INVASIVE</td>
</tr>
<tr>
<td>Counter-torque ratchet</td>
<td>-</td>
</tr>
<tr>
<td>Piezo tips</td>
<td>+</td>
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<tr>
<td>Forceps</td>
<td>+</td>
</tr>
<tr>
<td>High-speed burs</td>
<td>++</td>
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<tr>
<td>Trephine burs</td>
<td>+++</td>
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</tbody>
</table>

- = least; + = less; ++ = more; +++ = most
human clinical studies only; studies that discussed the advantages and disadvantages of various implant removal techniques; studies that included a discussion of complications associated with the removal modalities described.

RESULTS

A review of the published literature on the subject of implant removal techniques showed only seven articles that satisfied the inclusion criteria (Table 1). These included the use of high/low-speed burs, elevators, trephines, and piezo surgical techniques. Based on these articles and clinical data from the Implant Database, an evaluation of the advantages and disadvantages of using each of these implant removal techniques was made (Table 2). In addition, examples are presented depicting the various techniques used for implant removal (Figure 1 through Figure 13).

DISCUSSION

The use of dental implants in the treatment of total or partial edentulism has demonstrated a high degree of success, with documented survival rates of 90% to 97%.[14-17] Although osseointegrated implants have high survival rates, failures do occur. The first-year failure rate for dental implants ranges from 3% to 8%.[14] The global failure rate for dental implants has been reported to be between 2% and 9%.[14-17] An annual loss of 1% after the first year in function was also reported.[18] An estimated 200,000 to 250,000 implants are likely to fail annually worldwide.[19]

Mobility is a recognized sign of implant failure, whereby partial or complete loss of bone to implant contact is evident. In cases of implant failure where the implant demonstrates frank mobility, all parts of the implant should be immediately removed to prevent progressive destruction of the surrounding tissue. Implant removal may also be indicated if implants are nonmobile but are fractured, malpositioned, or have infections or advanced peri-implantitis. In these situations, the implant might remain partially or fully osseointegrated. Therefore, any nonmobile implants deemed hopeless require surgical intervention for their removal. Considerations for implant removal are as follows:

1. **Mobile implant**—complete loss of bone-to-implant contact. A mobile implant may easily be removed by rotating it counterclockwise using a driver, counter-torque ratchet, or forceps. Rotating with minimum luxation allows reduced trauma and damage to the surrounding bone and soft tissue.

2. **Immobile implant**—partially or fully osseointegrated. Methods of immobile implant removal include: use of counter-torque ratchets, screw removal devices, piezo tips, high-speed burs, elevators, forceps, and trephine burs.

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Fig 1. Periapical radiograph of a failed implant with peri-implantitis. Bleeding on probing and pus from the mesial pocket was present. **Fig 2.** Following crown and abutment removal, the implant platform was exposed. **Fig 3.** The implant was explanted by using a counter-torque ratchet. **Fig 4.** The site following atraumatic implant removal. **Fig 5.** A screw removal device.
The advantages and disadvantages of the various instruments and removal techniques are described in the following section and vary from the least to most invasive in terms of collateral damage to surrounding soft tissue, bone, and teeth (Table 2).

**REMOVAL INSTRUMENTS, INDICATIONS, AND TECHNIQUES**

**Counter-Torque Ratchet Technique (CTRT)**

Displayed in Figure 1 through Figure 4, the CTRT is the least invasive technique for removing an implant without damaging surrounding structures. Cases amenable to removal with a counter-torque ratchet depend on an intact implant connection (external hex, internal hex), implant diameter, implant geometry, implant location (bone quality), and the amount of osseointegration remaining. The use of a counter-torque ratchet should be considered the option of choice if the implant is able to be engaged and reverse-torqued until mobile.

Care must be taken with narrow-diameter implants that are <4 mm in dense cortical bone to avoid implant fracture.

The reverse screw technique (RST) is another less invasive method that uses a screw removal device. RST is indicated in the removal of a fractured implant when the connection is damaged or in the removal of an external connection implant when the ratchet cannot be engaged to use the CTRT (Figure 5).

**Bone Removal Techniques (BRTs)**

**Piezo Tips**

Piezo tips (Figure 6) allow for better intraoperative control than high-speed burs during bone-cutting because they prevent damage to the surrounding soft tissue. Typically, a diamond tip for extraction (eg, EX1, EX2, EX3, Piezosurgery, Inc, www.piezosurgery.com; BT1, BT3, ST1, ST2, ST3, ST4, LT1, Extraction Kit Tips, Vista Dental, www.vista-dental.com; BS1, BS2L,

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**Fig 6.** Piezo tip used to remove bone for implant removal. **Fig 7.** High-speed bur used to remove sufficient bone to reverse-torque the malpositioned implant. **Fig 8.** Trephine bur used to remove bone around the implant. **Fig 9.** Sufficient bone has been removed (left implant) by using the trephine bur; implant platform (middle implant) is to be cut. **Fig 10.** Implant removed with forceps. **Fig 11.** Remaining implant after cutting implant platform to allow for use of the smallest diameter trephine. **Fig 12.** Trephine bur used to remove bone around the failed implant guided by the implant mount. **Fig 13.** Combination technique with the counter-torque ratchet used following bone removal with the trephine bur.
BS2R, BS4, BS5, BS6, Satelec Extraction Kit Tips, Acteon North America, www.us.ateongroup.com) is preferred. Furthermore, the bone healing response following piezoelectric surgery seems to be more favorable than osteotomies performed with burs.22 However, when deep cuts into bone are necessary, the device is less efficient,23 and when the cutting speed is decreased the tip’s temperature rises. Therefore, it is necessary to pause several times during the removal procedure to let the tip cool down; also, the use of copious irrigation with cold saline is recommended.

**High-Speed Burs**
The use of high-speed burs (Figure 7) under copious irrigation is an efficient method to remove a failed implant. However, air from the high-speed handpiece can be forced into a surgical wound or a laceration in the mouth causing an air embolism.24 The crown and abutment should be removed prior to using the burs to gain better access to the implants. Usually a long, thin diamond bur (e.g., 5863, 5850, Brasseler USA, www.brasselerusa.com; 757, Kerr Corporation, www.kerrdental.com; 166/016, Shofu Dental Corp., www.shofu.com) is preferred over a carbide bur, because the diamond bur is easier to control and produces a more efficient, thinner cut. Cuts should be made using high-speed burs and copious irrigation on the mesial and distal aspects of the implant to prevent damage to the buccal plate of bone. Oftentimes this is sufficient to loosen the implant and remove it with the CTRT or RST. When using high-speed burs, the residual apical part of the implant should be carefully approached in order to prevent damage to anatomical structures such as the sinus floor, inferior alveolar nerve, and mental foramen. Moreover, particles of the implant surface may enter the healing wound and should be removed as part of the procedures. When the implant is in close proximity to a vital structure before using the burs, accurate radiographs and a computer axial tomographic (CAT) or cone beam (CB) scan is recommended to locate anatomical structures.

**Trephine Burs**
There are several sizes of trephines available that correspond to various implant diameters (Figure 8 through Figure 11). The smallest effective size trephine should be selected to avoid collateral damage to the neighboring bone, teeth, and/or implants. The internal diameter of the trephine needs to be slightly larger than the implant to avoid engaging the implant body. The preferred speed to use a trephine is 1,200 rpm to 1,500 rpm with copious irrigation. This technique is one of the most invasive options for

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**Fig 14.**
Clinical decision for removal of implants.

CTRRT = counter-torque ratchet technique
RST = reverse screw technique
BRT = bone removal techniques
Implant removal. Fatigue fracture of the mandible after the use of a trephine bur has been reported.\textsuperscript{23} Osteomyelitis is another complication that may occur following explantation with a trephine bur, particularly if bone is overheated.\textsuperscript{24} Thus, trephine burs are only indicated when absolutely necessary, and the retrieval procedure should be carefully planned and performed under copious irrigation with cooled saline.\textsuperscript{25} As previously stated, if the crown and abutments are present, it is essential that they are cut off and/or removed prior to trephine use. This allows for use of the smallest diameter trephine (Figure 9 and Figure 11). Oftentimes only the coronal half of bone around the implant needs to be removed to loosen the implant, at which point elevators, forceps, and, where possible, torque drivers may be employed as part of a combination technique, as described in the following section.

Combination Techniques
When an integrated implant cannot be removed with less invasive methods, the piezo tips and/or drill are used to remove sufficient supporting bone around the coronal parts of the implant, and the counter-torque ratchet or forceps are then employed to remove the implant to reduce damage to the surrounding bone. To assure implant removal without fracture, the reverse-torque technique with a counter-torque ratchet is recommended at the lowest torque values first. If there is no movement, a bur or trephine can be used to cut through the surrounding cortical bone and into the trabecular bone. The reverse-torque technique is then attempted again. The goal is to preserve the remaining bone as much as possible. Alternating between the counter-torque ratchet and the elevator and occasionally drilling with the bur or trephine can then be used in combination to remove the implant (Figure 12 and Figure 13).

The technique selected depends on the specific clinical situation. A decision tree for implant removal is presented in Figure 14.

**TABLE 3**

<table>
<thead>
<tr>
<th>Implant Connection</th>
<th>Ease of Removal</th>
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<tbody>
<tr>
<td>External hex</td>
<td>-</td>
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<tr>
<td>External spline</td>
<td></td>
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<tr>
<td>Internal trilobe</td>
<td>-</td>
</tr>
<tr>
<td>Internal conical seal</td>
<td>-</td>
</tr>
<tr>
<td>Internal octa</td>
<td>+</td>
</tr>
<tr>
<td>Internal square</td>
<td>++</td>
</tr>
<tr>
<td>Internal hex</td>
<td>++</td>
</tr>
</tbody>
</table>

- = difficult to remove; + = moderately difficult to remove; ++ = easy to remove

Whereas an internal connection engages within the implant body, an external hex implant requires an adapter when removing the implant via the counter-torque technique. Removal is easier when the implant driver connects directly to the internal connector. Therefore, an internal connection implant is much easier to remove than one with an external hex implant because the connection is more rigid (Table 3). However, complications may occur when removing an implant with an internal trilobe connection using the counter-torque ratchet. The neck portion of this type of implant, especially those with smaller diameters (i.e., 3.5 mm), has been observed to fracture during removal procedure if the reverse torque is more than 45 Ncm (Fig 15).

**Implant Diameter**
When the outer diameter of an implant increases 0.1 mm and the inner diameter remains unchanged, the moment of inertia increases to 30% in strength.\textsuperscript{26} When the outer diameter remains unchanged and the inner diameter decreases 0.1 mm, there is an increase of 16% in strength.\textsuperscript{27} Therefore, an increase in the outer diameter has a more significant effect on body wall strength even though the metal thickness is similar in both scenarios. When a narrow-diameter implant (< 4 mm) is removed, an excessive torque force must be avoided in order to prevent complications such as implant fracture. If fracture occurs, any of the aforementioned instruments except the counter-torque ratchet may be used to remove the implant section.
Implant Geometry: Thread Shape and Depth
The thread shape is an important characteristic of implant design. Thread shapes in dental implants include buttress, square, V-shape, and reverse buttress. The V-shaped and reverse buttress threads have similar bone-to-implant contact (BIC) as well as reverse-torque values. The square thread design has a higher BIC and greater reverse-torque test value. Therefore, a square design may be significantly more difficult to remove by the reverse-torque technique and may require high values with a counter-torque ratchet; it may also be an indication for a combination removal technique.

Thread depth, which is the distance between the outer diameter and the implant body, is another characteristic of overall implant geometry. A tapered implant with the same platform diameter as a straight-walled implant has a decreasing outer diameter because of the taper. Thus, the thread depth decreases toward the apical region. The tapered, threaded implant has less implant-to-bone contact in the apical region and is, therefore, easier to remove with a more conservative technique.

Some implant systems have an anti-rotational feature, which is usually incorporated into the implant body in the apical region. The most common design employs a hole or vent. In theory, bone can grow through the apical hole and resist rotational loads applied to the implant. These implants may require use of a trephine or burr to cut to the apex to sever the bone attachment and remove the implant if the implant is not rotated with the CTRT or RST.

Implant Location (Bone Quality)
Functional surface area plays a major role in addressing the variable initial BIC zones related to bone density upon initial loading. The densest bone (D1 bone) found in the jaws has the stiffest modulus of elasticity and the highest initial BIC (approximately 80%). There are progressively decreasing percentages of bone at the initial implant interfaces with D2, D3, and D4 bone. The latter (D4) demonstrates an approximate 25% interface contact at the initial healing of a machined implant. As a result, bone density and the implant geometric body design are related to functional surface area. The weakest biomechanical strength and the lowest BIC area to dissipate the load at the implant–bone interface are found with D4 bone. In many cases of D4 bone, removing the bone circumferentially in order to get enough implant exposure for the rongeur placement is sufficient to enable unscrewing of the implant. When dealing with a narrow-diameter immobile implant in dense bone (D1 or D2), the clinician should be careful when using the reverse-torque technique to avoid exceeding the recommended insertion torque and prevent the fracture of the implant connection. In the anterior maxillary esthetic zone, an immobile implant should be removed by using a reverse-torque technique whenever possible in order to preserve soft and hard tissues.

After removing a failed implant, the placement of an immediate replacement implant is often dependent on the amount of residual bone. Several authors have stated that guided bone regeneration (GBR) procedures are unnecessary for four-wall socket sites with no fenestrations or dehiscences and a gap distance < 2 mm between implant surface and surrounding bone walls. However, if the implant socket site contains less than three walls, use of the GBR procedure as well as knowledge of the classification of the extraction socket type is helpful in treatment-planning the augmentation of the bony defect. In any event, preservation of the bone during removal of the implant can help avoid or reduce the necessity of augmentation procedures to promote implant placement. This is essential because the literature suggests that replanted implants may have a decreased survival rate.

CONCLUSION
Several techniques are available for implant removal. The choice of technique should be based on the specific clinical factors present such as patency of the implant connection, remaining amount of bone–implant contact, anatomical conditions at the implant site, and bone quality. However, more research is needed to compare the removal techniques available and to document the survival of implants placed at the sites where previous implants were removed.

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