Inside Dentistry
August 2019
Volume 15, Issue 8

Reversal of Fortune

Advanced restorations can present greater challenges in the face of failure

Jason Mazda

Recent advancements in dental materials have led to treatments that offer greater long-term durability. However, the overwhelming acceptance and frequent placement of these materials has simultaneously resulted in an increase in incidences in which dentists face more difficult challenges removing restorations. Using the most durable material might not always be in the patient's best interest when the potential need for removal is considered, and even if it is, dentists should take proactive steps with that possibility in mind.

When the need for removal inevitably becomes a reality in some cases, several techniques can be utilized, including instrumentation ranging from burs to lasers.

"Not enough people are thinking, talking, or writing about this," says Edward A. McLaren, DDS, MDC, a recently retired professor at the UCLA School of Dentistry who directs the private teaching institute Art Oral America. "Potential removal should absolutely be a consideration when restoring teeth with today's materials."

Direct Composites

One of the simplest methods for treating dental prob-lems is the use of direct restoration, and although debonding and marginal leakage are among the most common reasons for failure and the development of secondary caries,[1,2] repairing these restorations-rather than replacing them-is increasingly being preferred as an option that is more conservative to tooth structure.[3,4] The material advances that pose the most significant challenges in direct restorative dentistry primarily involve esthetics, says Marcos A. Vargas, DDS, MS, a professor in the Department of Family Dentistry at the University of Iowa in Iowa City, Iowa. Discoloration over time is typically the most common reason to remove a direct restoration rather than to repair it.

"Ultimately, dentists usually remove some tooth structure when removing direct composites because of the difficulty in distinguishing between the tooth-colored material and the natural tooth structure," Vargas says. "There are multiple strategies that can be employed to address this problem, including the use of rubber points that remove composite but not enamel; acid etching, which can differentiate enamel from areas of composite; and the use of lasers."

Perhaps the most effective strategy for the removal of direct restorations is the use of lasers (ie, Er,Cr:YSGG or CO2 [9,300- to 9,600-nm wavelength]) to attack the composite but not the tooth structure. Research has indicated that CO2 lasers operating at high laser pulse repetition rates are ideally suited for the selective ablation of existing restorations, sealants, or residual composite adhesives.[5]

"With a handpiece, there is no question that the dentist will either remove some tooth structure or fail to remove 100% of the material," says Robert A. Convissar, DDS, FAGD, a practitioner of restorative and laser dentistry in New York City. "Conversely, because lasers work by absorption, the material absorbs the laser energy, and it is possible to remove that restoration completely without affecting the tooth structure."

Related Articles

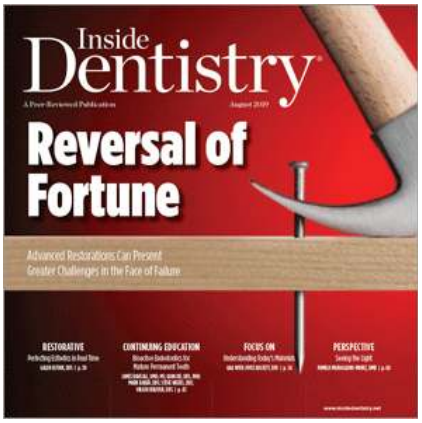
Airway Management in Restorative Dentistry
Inside Dentistry, June 2019

Esthetic Bonding: How to Avoid Catastrophe Before It Starts
Inside Dentistry, January 2017

Becoming a Super GP
Inside Dentistry, September 2015

The Restorative Horizon
Inside Dentistry, December 2017

Conservation Crisis
Inside Dentistry, September 2016



As effective as lasers can be, they are relatively expensive and extremely technique-sensitive. Vargas speculates that lasers may become more widely used for the removal of direct restorations in the future, but that time has not yet arrived.

"Using lasers to remove restorations requires irradiation of the entire restoration with the laser energy," Convissar says. "You cannot just do one corner here and one corner there. It is like light curing. It is not necessarily challenging, but it can be tedious and time-consuming."

Indeed, whether using handpieces or lasers, time is almost always a consideration. For traditional restorative materials (eg, amalgam, composite, porcelain-fused-to-metal), McLaren recommends beginning with a newer carbide bur because of the speed with which they can cut, but then switching to a fine diamond bur at a low speed once closer to the composite-tooth interface.

"The carbide bur can cut through quickly and has the potential to take off a lot of tooth structure unintentionally," McLaren says.

Of course, the most effective way to ensure that patients do not experience problems related to the removal of restorations is to avoid those situations entirely.

"It is important to use sound techniques, very good shade selection, appropriate material manipulation, effective polymerization techniques, etc," Vargas says. "Patient education is important as well because the most common reasons for the need to replace direct composite restorations involve recurrent decay or fracture."

Endodontic Therapy

For teeth that require more intensive treatment than direct restorations, filling a root canal purely with cement might seem tempting. It is quick and easy for the dentist, and it is typically very strong. However, for cases that require endodontic re-treatment, the root-filling materials must be completely removed from the root canal system,[6] which is not possible when cement is the only material used. In those cases, the tooth must be removed. Allen Ali Nasseh, DDS, MMSc, a clinical instructor in the Department of Restorative Dentistry and Biomaterial Sciences at Harvard University School of Dental Medicine, frequently witnessed this firsthand during the 1990s.

"When the Soviet Union fell, we encountered a deluge of Russian patients who had been treated with all kinds of cements and pastes that were not re-treatable," Nasseh says. "These patients' root canals had been filled with materials that were expedient but that did not allow us access to revise the problems. These patients weren't given a chance to save those teeth in a reliable fashion."

Instead, Nasseh says, obturation techniques for root canal filling should include gutta-percha.

"The use of gutta-percha in a root canal filling is a practical approach that allows for revision," Nasseh says. "Even if you have an ideal material, you need to develop techniques that allow it to be revisable."

There are several techniques that can be employed for the removal of gutta-percha and other fillings, but no single method can completely remove obturating materials from endodontically-treated root canals.[6] When compared with hand instruments, rotary instruments have been shown to be better for removing gutta-percha from obturated root canals.[6]

"If gutta-percha has been used in addition to cement, the use of a solvent and ultrasonic technology or any of the modern 3-dimensional, rotary instruments is extremely helpful for revisions and re-treatments because they facilitate cleaning of the old root canal filling material without excessive removal of additional tooth structure," Nasseh says. "That makes re-treatment much more predictable."

It may be tempting to use today's advanced laser technology to remove gutta-percha, but Convissar cautions against doing that.

"The fact that you can remove something with a laser does not necessarily mean that you should," Convissar says. "When you need to re-treat a root canal, erbium lasers can remove gutta-percha, but potential problems can arise from their use, such as charring, overheating, or carbonization of the canal walls. Other methods, such as solutions, ultrasonics, and Gates Glidden burs, are currently more effective. Hopefully, laser manufacturers will eventually make more improvements, but at this stage, although obturating materials can be removed with a laser, the process is less than ideal."

Other factors that may make future revision challenging include the presence of any solid carrier-based obturation material that is difficult to remove or a post that is difficult to remove.

"We should always understand that some of our cases may fail in the future," Nasseh says, "and that the patient risks losing a tooth if we have not taken the proper precautions to allow for revision."

Crown and Bridge

In recent years, the most transformative material advancements in dentistry have perhaps come in the area of indirect restorations. Zirconia and lithium disilicate have become increasingly popular for crown-and-bridge work. Lithium disilicate typically offers approximately 500 MPa in flexural strength, whereas zirconia materials range from 600 MPa to 1,400 MPa. By contrast, traditional feldspathic porcelain ranges from 70 MPa to 90 MPa.[7]

"Lithium disilicate can be used in applications as thin as 0.5 mm with good flexural strength and fracture toughness, and it can be bonded to enamel, which increases the strength," says John F. Weston, DDS, FAACD, a cosmetic dentist who practices in La Jolla, California. "Currently, zirconia generally does not have great bond strength, so it is not ideal for veneers but is awesome for full-coverage restorations, especially in the back of the mouth where less space is available. You can go down to 0.8 mm and still retain good strength. There are also more translucent formulations, such as cubic zirconia, that can be cemented to premolars for an excellent balance of esthetics and strength. However, there will come a time 10 to 15 years from now when we may need to cut into some of these crowns, so clinicians should use materials that are strong enough to hold up well to occlusion without resorting to overkill. A bulletproof zirconia crown is not necessary."

In some cases, the increased strength of a material (eg, non-precious metals) can complicate its removal.

"Zirconia and lithium disilicate are wonderful materials; however, with the constant evolution of the different types of zirconia and now, the development of zirconia-reinforced lithium silicates, little thought has been given to the situations that will arise in which they need to be removed," McLaren says. "They are harder to cut into than nonprecious metals."

That is not to say that they are impenetrable; however, cutting through these materials involves increased chairtime, bur wear, and risk of damaging the underlying tooth structure.

"Removal of zirconia crowns can be an issue because cutting the material is very difficult due to its hardness," Weston says. "If you make a lateral cut down the facial or lingual surface and onto the occlusal surface, you may be able to use a crown spreader and split the crown."

One question worth considering is whether a restoration needs to be bonded or whether it can instead be traditionally cemented. Some dentists, McLaren says, simply default to bonding. Although that option is preferred for a nonretentive preparation or when tooth structures are laminated together-such as porcelain to the tooth or composite to the tooth-cement is sufficient in most other normal crown situations.

"The easiest procedure is a traditionally cemented crown, which requires reasonable axial height and retention on the preparation, whether it is made from zirconia or lithium disilicate," Weston says.

Manufacturers have been working toward making bonded zirconia a more viable option, but that presents challenges in the removal process.

"Some new materials even allow dentists to etch the inside of zirconia," McLaren says, "but if you etch and/or chemically bond it, and you need to cut it off at some point in the future, which can inevitably happen, if it is well-bonded, you will need to cut off literally every molecule, just as you would have to with a bonded porcelain veneer, composite, etc. It will not just pop off. Alternatively, with a cemented crown, removal becomes simpler because you can cut up the side and use a crown spreader, much like with porcelain-fused-to-metal (PFM) restorations. If you attempt that on zirconia that is extremely well bonded, you could split the tooth in half."

In addition to the bonding versus cementation consideration, McLaren recommends evaluating pulp vitality and, if necessary, potentially placing an interim restoration with a bioactive material to stabilize the pulp before restoring with bonded zirconia.

Lithium disilicate, by contrast, ideally should be bonded to achieve high fracture resistance, especially in minimalistic restorations; however, manufacturers claim that these restorations can be conveniently cemented if they are at least 1.5-mm thick. Of course, a restoration on a bicuspid or lower incisor likely will not be that thick, and thus, cannot be prepared to those dimensions. McLaren recommends lithium disilicate for minimal preparation posterior restorations and sometimes for minimalistic anterior work. In these situations, he uses adhesive procedures for retention and stress distribution.

"I have had to cut off a few well-bonded lithium disilicate and zirconia restorations for reasons such as recurrent caries in a margin or insufficient pulp vitality," McLaren says. "It is a laborious procedure. Ten to 15 minutes might be required for one tooth. Although multiple tools are available to aid in that process, cutting with a specialized carbide bur can crack the restoration, which is worrisome if the goal is just to create an endodontic access opening, and specialized diamonds can be very expensive, so what I find works exceptionally well is using a regular red-stripe diamond bur. The cutting is high-speed, so a good handpiece is required along with water to ensure that it does not generate excessive heat or clog the bur. When done correctly, this process cuts these materials amazingly well. It is not easy, but nothing is easy with these materials."

Anterior restorations can cause additional problems. Many of today's anterior restorations are partial-coverage veneers because highly esthetic, minimally invasive options have become the treatments of choice for most patients.

"When lithium disilicate restorations are bonded properly, removing them can be problematic as well and is not as simple as cutting a line down the middle and spreading," Weston says. "You typically have to grind off all of the restorative material."

Similar to direct composite restorations, indirect restorations can also be removed with lasers. In particular, Er,Cr:YSGG lasers have been found to be able to safely and conservatively remove lithium disilicate restorations at settings of 3.5 W and 4 W.[8] However, those procedures are not without risks.

"A laser can fairly easily remove a material that is bonded to dentin, but it is not as easy when the material is bonded to enamel," Weston says. "The heat of the laser breaks down the bond, but you need to be careful about overheating the pulp."

Convissar notes, however, that lasers are so tightly regulated by the US Food and Drug Administration that the risk is minimal if the dentist is properly trained.

"You need to be trained and certified by a bona fide organization, and most importantly, you need to know how the laser works," he says.

Of course, any removal of indirect restorations comes with risks, even when using traditional instrumentation. Heat generation is a primary concern, particularly with zirconia, which concentrates heat rather than dissipating it, making it possible to overheat the tooth and potentially kill the pulp. In addition, it is not always known whether the dentist who initially treated the case bonded or cemented the restoration. If the crown has been bonded, cutting up the facial surface of the crown, as would be done with a PFM restoration, could split the tooth in half. Furthermore, the mere fact that zirconia and lithium disilicate are harder than natural tooth

structure poses its own challenges.

"Ideally, the restoration needs to be removed without any tooth structure being removed, but the dentist is pushing fairly hard because of the strength of the materials," McLaren says. "Sometimes, when you hit the tooth interface, your hand will jump because of the difference in hardness, and the tooth can be damaged. For this reason, in addition to being very careful as I approach the interface, I prefer to cut into an area of the tooth where I know I have a good amount of tooth structure between the pulp and dentin in case some tooth structure is unintentionally removed."

Removal is not the only potential challenge posed by the use of stronger materials in crown and bridge work. In some cases, endodontic treatment may become necessary, such as when the margins of the crown are inadequately sealed. Drilling through zirconia and even modern cements can be very difficult.

"A thick zirconia crown may require the dentist to go through several diamond burs to cut through it," Weston says.

In highly questionable cases, Nasseh suggests that dentists consider pre-prosthetic root canal therapy prior to placement of a zirconia crown as well as ensuring that the crown margins are well validated prior to final cementation.

"The 360° seal around the tooth is more important than the esthetics," Nasseh says, "but that often gets lost with the emphasis placed on esthetics."

Implants

Many of today's modern ceramic crowns are placed on top of implants, which can pose another set of challenges. Occlusal overload due to bruxism, inappropriate or inadequate occlusion, or a combination of these factors can cause restoration failure and/or implant body fracture, particularly with single crowns.[9] The most common causes of complications and failure for implant-supported single crowns, fixed partial dentures, and splinted restorations have been identified as screw loosening, lateral screw loosening, de-cementation, esthetics, veneer chipping or fracture, and food packing/contact point issues.[10]

"Patients today are getting implants in their 20s, and hopefully, they are living into their 80s, so deconstruction will become an inevitable reality of implant restorations," says Todd R. Schoenbaum, DDS, FACD, director of continuing dental education at the UCLA School of Dentistry.

Just as the preservation of tooth structure is a primary consideration when removing direct restorations and crown-and-bridge work, the integrity of an implant is a concern when removing an implant-retained crown.

"Most cement-retained implant crowns cannot be retrieved simply," Schoenbaum says. "Some dentists use temporary cement, believing that it will allow the crown to be easily removed with forceps, but anecdotal experience has indicated that this is rarely a predictable protocol. The biggest factor is probably position in the mouth. In the anterior segment, the buccal-palatal angulation is difficult to assess with 2-dimensional radiography. We can estimate the mesial-distal angulation, but defining the buccal-palatal angulation remains difficult. When removal is required in the posterior, access can be estimated from the radiograph and is usually achieved through the occlusal table. Secondary to position in the mouth would be the type of implant that is used. A tissue-level implant with an older solid abutment can be problematic to retrieve because there is no screw, just a crown to dissect and deconstruct and then an abutment to retrieve."

The most severe mechanical complication associated with the removal of implant-supported restorations is the fracture of the osseointegrated dental implants themselves,[11] but avoiding that, Schoenbaum says, is 100% dependent on the clinician's caution, skill, and understanding of the implant system. If proper steps are taken, there should be little to no risk, he says.

"If you do not fully understand the implant system, then it is probably not a good case for you to deconstruct," Schoenbaum says. "You might not appreciate where the abutment ends and the implant begins, how deep the screw is, or how the abutment is designed. Generally, the risk of damage to the implant is low, but the quantification of that risk is entirely dependent on the operator."

Conversely, abutments can be more vulnerable, especially today's increasingly popular hybrid zirconia abutments. Given that they are composed of two pieces bonded together-a titanium insert that goes into the implant and a zirconia interface-care must be taken when the goal is to remove a crown but keep the abutment intact.

"The crown might be cemented, so it is important to avoid generating too much vibration and causing a problem with the seal between the zirconia and the titanium insert," McLaren says. "I prefer to avoid using a carbide bur for that reason. Like with a bonded zirconia crown, I use a red-stripe diamond bur and lots of water."

In somewhat rare cases, the implant itself might need to be removed from the bone.

"The foremost reason that an implant would need to be removed is failure of integration, when the implant becomes loose and there is no way for it to recover," says David A. Gelb, DDS, DABP, a practitioner of periodontics and implant surgery in West Hartford, Connecticut. "The second reason would be the development of peri-implantitis to the extent that the implant is compromised and/or is compromising the adjacent teeth or implants. In that case, the implant could be removed, a bone graft could be placed, and the site could be reestablished."

Gelb describes removal of a failing implant as "generally a nonevent," even if it is still partially integrated.

"Today, we have instrumentation that actually reverse torques from inside of the implant," Gelb says. "It is screwed into the top of the implant, and as you turn it in reverse, the tool adequately engages the internal aspect of the implant so you can remove it atraumatically without violating the dimensions of the site. That is really the new approach to implant removal."

Still, Gelb says that implant failure is generally avoidable if the clinician understands the key elements of implant surgery, including proper site selection, appropriate implant size, careful site preparation, and placement with favorable torque and stabilization that is deep enough to account for normal crestal remodeling and avoid subsequent exposure of the crestal implant threads to sulcular fluid and the oral environment. He cites a 96% success rate over the course of placing more than 16,000 implants at his practice.

Proactive steps during the initial treatment are not only crucial to avoiding failures, but they are also perhaps some of the most important factors contributing to the successful removal of implant restorations if that becomes necessary. For example, Schoenbaum suggests that patients should receive a record of their implants at the time of placement, indicating the brand of implant, the materials used, and the design of the restoration, so other clinicians can have access to that information in the future.

"More directly, the dentist can block the screw access channel with something that is relatively inert and easily retrievable instead of cotton. Currently, it seems that the best choice is probably polytetrafluoroethylene (PTFE) tape," Schoenbaum says. "Gutta-percha is sometimes used, and it is fairly troublesome to remove without endodontic instrumentation."

Another strategy is to mark the restoration with a cue where the drill access hole is located.

"The dentist can instruct the laboratory to leave a fairly identifiable mark on the surface where the hole would need to be drilled to get to the screw access channel, such as an opaque white or dark spot that is easily identifiable by clinicians but not esthetically troublesome to patients," Schoenbaum says. "The problem is that the place where we need this information the most is in the anterior region where angulation is an issue, and we generally cannot put spots on the facial surfaces of anterior teeth."

Digitally designed and manufactured custom abutments can help prevent the need for removal, and more precise margins make peri-implantitis and other complications less likely.

"When a custom implant abutment is digitally designed, the margin is in the right spot with respect to the gingival tissue; therefore, the dentist can carefully place a cemented crown using minimal cement with complete control of where that interface is and have the ability to see it and clean off any excess cement," Weston says.

Following manufacturers' instructions is of paramount importance as well. "Most manufacturers require that the abutment screw be torqued into the implant to a prescribed value in order to properly stabilize the abutment," Gelb says. "That creates a preload that will be relatively stable, but failure to properly torque is probably one of the most common technique errors committed by clinicians. Without proper torqueing, the abutment can become loose and the crown may need to be removed and remade."

Another consideration is occlusion. If the restoration is too high in occlusion, the screw may sustain metal fatigue that can result in screw loosening or fracture and/or intrusion of the opposing natural dentition, Gelb says.

"If a patient who is a clencher or a grinder intrudes all of his or her natural dentition," he says, "and there is slight highness to the implant restoration, suddenly, the implant restoration will receive a masticatory load that is unrealistic, which can break the preload and result in either loosening of the crown or of the abutment."

Conclusion

A dentist's primary concern should be ensuring that any endodontic, restorative, or implant treatment is performed well enough to minimize the potential for future failure and the need for removal.

"Doing it right the first time will typically ensure longevity," Vargas says.

Today's material advancements can help with that; however, achieving a 100% success rate is nearly impossible in the unpredictable oral environment. As such, the potential need for removal in the future should be a primary consideration.

"We always want to do what is best for patients in terms of the materials, techniques, and methodologies involved in their treatment," Nasseh says. "We also must understand that some modes of failure may be outside of our control. Therefore, at the time of the initial treatment, we should always attempt to maintain the ability to revise teeth in the future so that we can give the patient a second chance for keeping them. Performing any procedure that is irreversible and nonrevisable is essentially risking the patient's tooth, and this is not fair."

That does not necessarily mean avoiding today's high-strength materials. They offer many benefits. It simply means taking precautions, both during the initial treatment and at the time of removal, when necessary.

"I can appreciate that needing to spend an extra half-hour to cut through a crown could be problematic in a busy private practice," Schoenbaum says. "However, if the material provides the best chance of long-term success for the patient, then those extra decades of service are worth the time."

References

1. Pinna R, Usai P, Filigheddu E, et al. The role of adhesive materials and oral biofilm in the failure of adhesive resin restorations. *Am J Dent*. 2017;30(5):285-292.

2. Gordan VV, Riley JL 3rd, Geraldeli S, et al. Repair or replacement of defective restorations by dentists in The Dental Practice-Based Research Network. *J Am Dent Assoc*. 2012;143(6):593-601.

3. Sharif MO, Catleugh M, Merry A, et al. Replacement versus repair of defective restorations in adults: resin composite. *Cochrane Database Syst Rev*. 2014;(2):CD005971. doi: 10.1002/14651858.CD005971.pub3.

4. Blum IR, Jagger DC, Wilson NH. Defective dental restorations: to repair or not to repair? Part 1: direct composite restorations. *Dent Update*. 2011;38(2):78-80, 82-84.

5. Chan KH, Fried D. Selective removal of dental composite using a rapidly scanned carbon dioxide laser. *Proc SPIE Int Soc Opt Eng*. 2011;7884:78840R1-78840R5.

6. Patil A, Mali S, Hegde D, et al. Efficacy of rotary and hand instrument in removing gutta-percha and sealer from root canals of endodontically treated teeth. *J Contemp Dent Pract*. 2018;19(8):964-968.

7. McLaren EA, LeSage B. Feldspathic veneers: what are their Indications? *Compend Contin Educ Dent*. 2011;32(3):44-49.

8. Gurney ML, Sharples SD, Phillips WB, et al. Using an Er,Cr:YSGG laser to remove lithium disilicate restorations: a pilot study. *J Prosthet Dent*. 2016;115(1):90-94.

9. Stoichkov B, Kirov D. Analysis of the causes of dental implant fracture: a retrospective clinical study. *Quintessence Int*. 2018;49(4):279-286.

10. Wang JH, Judge R, Bailey D. A 5-year retrospective assay of implant treatments and complications in private practice: the restorative complications of single and short-span implant-supported fixed prostheses. *Int J Prosthodont*. 2016;29(5):435-444.

11. Schoenbaum TR, McLaren EA. Retrieval of a defective cement-retained implant prosthesis. *Compend Contin Educ Dent*. 2013;34(9):692-696.