Overcoming clinical failures in dentistry

Advice from Gordon J. Christensen, DDS, PhD, MSD

Have you experienced challenges—even failures—in your clinical techniques? You're not alone. Take zirconia—it's a developing technology; there are inherent obstacles to surmount. There are many ways dental implants can fail, but extra attention to occlusion, bone density, and prosthodontic design can make all the difference. Have you noticed crowns coming off and recurrent caries? Much of the problem appears to be related to cementing. Sealants can fail, but there are techniques you can use to make them last longer. In this e-book, Dr. Gordon Christensen shares his vast experience and offers solutions to these problems and more.

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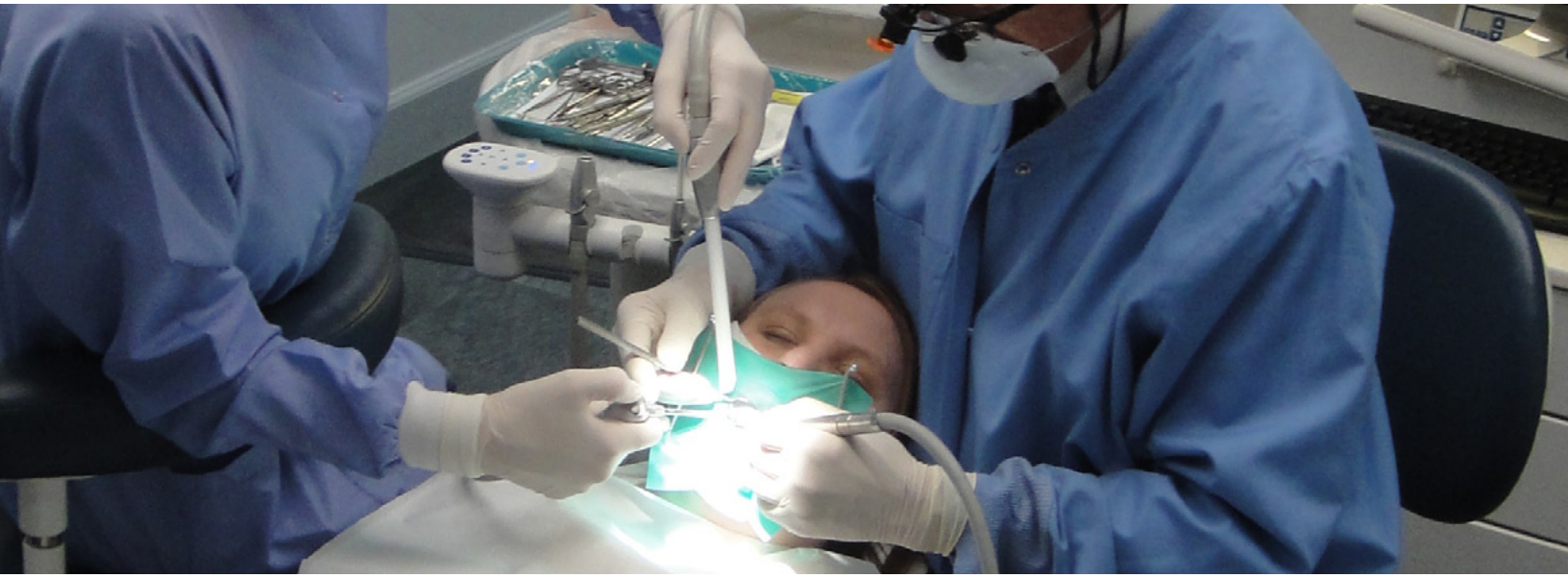

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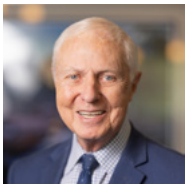
ARE YOU EXPERIENCING CLINICAL FAILURES? YOU'RE NOT ALONE.

It has been my privilege to have *Dental Economics* publish several hundred questions from their readers and my answers to those questions over the past many years. The questions range from clinical topics to conceptual, financial, motivational, and other issues. It is my pleasure to provide these answers based on research from Clinicians Report Foundation, the printed dental literature, and my several decades of practice.

The following *Dental Economics* "Ask Dr. Christensen" articles concern questions about why we dentists are having clinical failures with various techniques. I think this stimulating information will cause you to think and perhaps change a few of your dental procedures.

~ Gordon J. Christensen, DDS, PhD, MSD



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WHY ARE SOME ZIRCONIA CROWNS FAILING?

Zirconia is here. It is not going away. As such, it is our professional responsibility to understand it better and use it to an optimum level.

BY GORDON J. CHRISTENSEN, DDS, PhD, MSD

Q: A disturbing number of patients come into my practice with zirconia crowns that are prematurely failing and have not been serving for long. The crowns are coming off tooth preparations, some of which have caries on their margins, and they are not in proper occlusion. They are usually too short, the ceramic is cracking or breaking, the color is incorrect, and many have open contact areas. My colleagues are reporting the same frustrating situations. Why am I seeing these problems with zirconia crowns?

A: Many of us are also seeing the challenges you stated. In my opinion, there are some identifiable reasons. In my answer to you, I will describe the apparent reasons for zirconia crown failure and suggest some potential solutions.

DENTAL EDUCATION

The level of education and clinical experience of some new dentists are major challenges. The current large body of knowledge in dentistry does not allow for as much detail or as many hours of clinical time as in the past. Some new dentists graduate with minimal education and superficial clinical experience in many areas of dentistry. The result is they require years of practice and significant continuing education to become clinically competent. If you are a new dentist, please get some pragmatic, hands-on clinical education in the areas in which you feel weak as soon as possible.

TOOTH PREPARATIONS

This subject is probably the most important and predominant problem. Almost all dentists have been taught proper crown preparation characteristics in dental school. However, if you look at impressions of tooth preparations dentists send to laboratories, you would see that there is a significant problem. Many tooth preparations do not satisfy the known characteristics that provide adequate retention, strength, and long-term wear resistance.

Most research information on crown preps states that an adequate tooth preparation has axial walls that extend 4 mm from the gingival margin to the occlusal table, and that the axial walls should be 20 degrees or less from the long axis of the tooth preparation. The depth of the marginal chamfer for a zirconia crown should be about 0.6 mm minimum for optimum strength. The occlusal reduction for a zirconia crown should be at least 1.5 mm or more to allow adequate strength of restorative material and optimum occlusal spacing of the crown occlusal contacts to produce a crown that is not too high when seated (figure 1).

Figure 1: Many zirconia crown preparations are not being made to an acceptable level. Read the desirable characteristics in the body of this article.

Some labs are spacing the crown occlusal surfaces up to 500 microns (0.5 mm) out of contact to ensure you will not have to adjust the crown. This is far too much and places trauma on the adjacent tooth until the opposing and crowned teeth have extruded. Ideally, crowns should have perfect occlusion, but that is not likely. They should be spaced out of occlusion only a few microns to allow rapid tooth extrusion in a few days or a maximum of weeks. Seldom do you see these characteristics. Of course, sometimes tooth size and shape do not allow optimum preparations, but most of the time an optimum prep is possible.

What can be done to salvage a crown that has come off during service due to an inadequate prep?

At seating, either originally or after coming off in service, make diamond scratches on the external wall surfaces of the prep and on the internal axial surfaces of the crown. Seat with a resin cement, such as RelyX Unicem 2 (3M ESPE) or Maxcem Elite Chroma (Kerr). In near-impossible cases that lack retention, use C&B Metabond Quick (Parkell).

LUTING CHARACTERISTICS ON INTERNAL CROWN AND EXTERNAL PREP SURFACES

The internal surfaces of current zirconia crowns are usually very smooth (figure 2). If the prep is adequate as described, this is usually not a problem. If there is any question about the potential zirconia crown retention, roughen the internal surfaces of the crown with a coarse diamond. If you do this, make sure you use a 3Y class 5 ceramic material. Many zirconia brands have modified material formulas that will *not* tolerate adjustment with a coarse diamond and will break. Similarly, roughen the external axial walls of the inadequate tooth preparation.

Figure 2: The internal surfaces of most zirconia crowns are smooth and lack the luting effect necessary. Roughen the internal surfaces with a coarse diamond as well as the external surfaces of the prep. Be sure to use a 3Y class 5 zirconia, or you may break the crown.

All brands of the most popular cement types are either resin or resin-modified glass ionomer. They are resilient! Lack of luting irregularities on the internal surfaces of the prep and the crown may allow the crowns to come off during service because the cement is resilient.

CARIES ON CROWN MARGINS

Current crown margins are not the tight margins that were available with the gold restorations of the past. Regardless of the ceramic material used, the margins are usually open about 60 microns (0.06 mm) or more.

Additionally, dental lab technicians verify that the majority of impressions (both conventional and virtual) that are coming to American labs are inadequate and do not show all of the gingival margins. Make sure the cements you use are adequately radiopaque so you can differentiate whether a margin is faulty or that the radiographic void is just cement. Some cements are too radiolucent. In almost all categories of materials, the products from Ivoclar Vivadent are the most radiopaque on the current market and should be used if you have a questionable margin.

If you know the margins are not fitting adequately or the patient has highly active caries, use a cariostatic resin-modified glass ionomer cement—not a resin cement. Examples are RelyX Luting Cement (3M), Fuji Plus (GC America), or FujiCem (GC America).

When caries occurs on a crown margin and a margin repair is being accomplished, there are several new materials that provide optimum fluoride release for the repair as proven by the Technologies in Restoratives and Caries Research (TRAC) Division of Clinicians Report Foundation. Among the most fluoride-releasing materials currently available are Equia Forte (GC America) and Ketac Universal (3M).

OPEN CONTACT AREAS

Contact areas should be broad and flat to prevent food impaction. Leaving a contact area open is almost a sure invitation for caries to form (figure 3). Suggest to your lab that you want broad, flat, tight contact areas on your crowns. It is far easier to reduce a contact area than to add to a deficient one. The lab technician can meet most of these characteristics easily by adjusting the computer setting for the contact area.

If the patient has tooth mobility, tell the lab technician to make the contacts very tight, and then adjust them in the mouth if necessary.

Figure 3: Note the open contact between the maxillary first and second molars. Although most brands of digital sensors often do not identify caries, as in this case, the major lesion is evident. Do not leave open contact areas.

COLOR OF ZIRCONIA CROWNS

Obtaining optimum color for zirconia crowns has been a near impossibility (figure 4). Almost all zirconia crowns come back to you a shade or two too light. If you require low-cost zirconia crowns from your lab, you have only one choice—have the crowns made one or two shades darker than the shade guide color you selected. If you want 3Y class 5 (the original formulation) zirconia crowns that actually have the correct color, you will pay significantly more (figure 5).

Figure 4: The color of most zirconia crowns is too light, despite requesting the correct color. Observe the molars in this case. The way to overcome this issue is noted in this article.

Figure 5: The molars in this case are 3Y zirconia, and the remainder of the crowns are IPS e.max. Strong 3Y zirconia can be made to be esthetic by the technique described in this article.

The 3Y zirconia can be internally stained at the presintered stage to achieve the color you desire after sintering.

New formulations of zirconia are coming on the market rapidly; for these, companies are not using the original zirconia formulation. Some of the crowns look more esthetically pleasing than the original zirconia formulation, *but* they have lower strength and need long-term research to validate their formulations.

ZIRCONIA IS NOT ZIRCONIA

The original BruxZir (Glidewell) 3Y zirconia (3 molar percent yttrium oxide content) has enormous strength and a property called transformation toughening (not allowing crack propagation). These characteristics have made the 3Y zirconia almost indestructible. Clinicians Report Foundation (TRAC division) studies over nearly 10 years on 3Y single zirconia crowns have shown almost no failures. Some of the new "esthetic" zirconia brands with modified formulations have reduced strength and little or no transformation toughening.

Ask your lab technician what type of zirconia they are using. They should know the answer to that question. If they do not, find another lab that does know what they are using.

A conservative suggestion to you relative to zirconia crowns is to use the original 3Y formulation of zirconia until such time has elapsed to validate the adequacy of a new brand of zirconia, or be willing to accept failure in the event that it occurs.

SUMMARY

Unfortunately, the current acceptability of many so-called zirconia crowns could be better because of differences in zirconia formulations. Zirconia is *not* zirconia. I have discussed the most frequently occurring challenges with these crowns. Most of the problems can be avoided by using the potential solutions described in this article for each of the identifiable challenges.

Zirconia is here. It is not going away. As such, it is our professional responsibility to understand it better and use it to an optimum level.

REDUCING COMPOSITE RESIN FAILURES

Most of the issues with composite failure can be reduced or eliminated by following a few careful procedures. Here, we'll discuss polymerization shrinkage, inadequate light-curing, lack of cariostatic properties, lack of tooth preparation disinfection, and aggressive finishing procedures.

BY GORDON J. CHRISTENSEN, DDS, PhD, MSD

Q: I often see adult patients who have had amalgam restorations serving in their mouths for most of their lives. I also see relatively recently placed resin restorations with new caries, pieces broken out of them, or outright failures. Patients spend significant money for composite restorations, yet they seem to need replacement too soon. What are the major reasons for premature composite failure, and can they be avoided?

A: Resin-based composite came into dentistry in the mid-1950s and early 1960s. This material was intended to replace silicate cement as an anterior tooth restoration. The early composites were polymerized by chemicals, not light-curing, which caused significant discoloration during service. After a few months in the mouth, they showed high wear due to their large filler particles and the "plucking" of the filler as the resin continued to wear. This phenomenon produced rough restoration surfaces and collapse of the occlusion.

Despite these challenges, in about 1968, dental manufacturers advertised resin-based composite brands for posterior restorations. The resultant early class I and class II restorations failed soon after placement. Refinement of the resin formulations continued. During the mid-to-late 1970s and early 1980s, light-curing composites were introduced and welcomed by clinicians. Ease of use and better color stability were additional improvements. Continuing efforts were made to make posterior tooth composite restorations more esthetic and have lower wear by using a smaller filler particle size. Since the mid-1980s, better long-term smoothness has been the most significant improvement.

Current composites are the most used dental restorations, according to national dental coding records.

WHAT ARE THE CURRENT GOOD CHARACTERISTICS OF RESIN-BASED COMPOSITE?

- Wear during service is relatively acceptable and near equal to enamel wear.

- Most companies have reduced filler particle size adequately to produce long-term smoothness to the naked eye.
- Strength is adequate and fractures of properly placed composite material are infrequent.
- Color stability is good.
- Ease of handling is greatly improved and satisfactory to most practitioners.

Those characteristics sound good! What are the remaining challenges with composite materials that are causing premature failures, and what can clinicians do to reduce the potential failures (figure 1)?

Figure 1: What has caused these composite restorations to degenerate? The patient says they had been in her mouth only a short time. Many factors cause this challenge—operator error, composite shrinkage, material properties, and many other reasons discussed in this article.

POLYMERIZATION SHRINKAGE

Based on both research and my clinical experience, this characteristic is the most significant remaining negative of composite material. Most composite resins shrink about 2% during polymerization. The result is open margins that are not visible to the naked eye but certainly evident to the electron microscope (figure 2). It is a foolish belief that composite margins are "sealed." They are obviously open, allowing access to mouth fluids and any oral microbes.

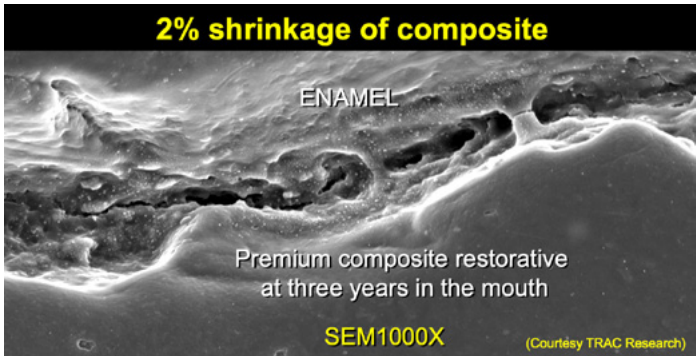

Figure 2: When observing composite resin restorations at 1,000 X, all of them have wide-open margins that allow ingress of oral fluids and microbes.

Most composite companies have attempted to solve the polymerization shrinkage problem, but it remains to this day. The margins of composite restorations are open, causing potential caries. So, what can clinicians do? Volumetrically, the amount of shrinkage of a small piece of composite is not as much as that of larger increments. To reduce the amount of marginal opening, reduce the amount of resin being cured at one time.

For example, consider the shrinkage in a class II box form. The resin is usually cured from the occlusal surface. Research at the University of Alabama (Dr. Nathaniel Lawson and other locations) has shown that when a significant quantity of resin is cured in a class II box form from the occlusal position, the gingival margin is opened. Consider if a small quantity (approximately 0.5 mm) of resin is placed in the box form on the apical part of the box and cured before placing the majority needed for the box form. There is proportionately less shrinkage volumetrically in that small piece, and the margin gap is less.

Additionally, consider using smaller increments when restoring most of the restoration. Many researchers and clinicians support curing resin in approximately 2.0 mm increments to reduce the overall volumetric resin shrinkage.

INADEQUATE LIGHT-CURING

This problem is usually from *operator error*! Inadequate light-curing is among the most major reasons for composite failure. Most of the currently used lights are adequate—*if used properly*—but curing large quantities of resin at one time encourages inadequate polymerization conversion, remaining monomer in the restoration, and subsequent caries. Dual-cure composite materials (Bulk EZ, LuxaCrown, etc.) should be considered in large composite resin restorations to compensate for inadequate resin polymerization by light-curing.

LACK OF CARIOSTATIC PROPERTIES

Composites usually do not have cariostatic properties, and microbes are free to create new caries lesions in the wide-open margins of composite restorations. Some companies have placed fluoride particles in composites, but the fluoride release in such restorations is minimal, according to research at the TRAC (Technologies in Restoratives and Caries Research) division of Clinicians Report Foundation.[1,2]

Placing glass ionomer (Equia Forte, Ketac Universal, or others) or resin-modified glass ionomer (Ketac Nano, Fuji II LC, or others) alone or under composite resin is well-known to offer cariostatic properties for dental restorations (figure 3).

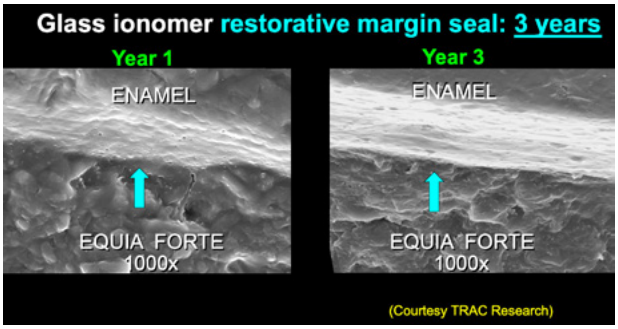

Figure 3: The new conventional glass ionomers provide an actual seal of restoration margins as well as fluoride release.

A new composite recently introduced in the US (Infinix) has a characteristic called antimicrobiologic. This concept, which does not dissipate over time, kills microbes on contact. It is being investigated in several locations, including Clinicians Report Foundation. The concept is promising not just for composite but for numerous dental uses, such as on orthodontic brackets or implants.

LACK OF TOOTH PREPARATION DISINFECTION

Tooth preparations have millions of organisms in them on completion. Historically, it was considered necessary to disinfect the tooth preparation, but over time, dentists have illogically moved away from this procedure. Research from the TRAC division of Clinicians Report Foundation has shown that disinfection of preps should be a mandatory procedure. Two one-minute applications of 5% glutaraldehyde–35% HEMA (Gluma, MicroPrime, etc.) are adequate to kill the microbes in tooth preparations and desensitize the tooth.[3]

AGGRESSIVE FINISHING PROCEDURES

Some dentists use aggressive procedures when finishing and polishing composite restorations. Aggressive finishing mutilates composite-tooth margins, leaving them wide-open microscopically and inviting dental caries. I suggest the following concepts:

- Loupes on
- Low-speed handpiece, electric preferred for precision cutting, high torque, and optimum speed control (Bien-Air, KaVo, NSK, etc.)
- Light touch on tooth material-composite interface

- *No water*. Water during this delicate procedure does not allow acceptable vision and encourages mutilation of the margin.

I consider resin-based composites to be only interim restorations. Research verifies that statement.[4] Composite restorations are not what are needed today, and I do not see any new ones coming to satisfy the negatives listed above. In the meantime, dentists should advise patients of the relatively short service expectation for composite restorations and do their best to provide high-quality composite restorations (figure 4).

Figure 4: Resin-based composites accomplished competently (Filtek Supreme Ultra on no. 12 DO and no. 13 MOD) can provide a few years of service, but the causes of premature failure are many.

SUMMARY

Composite restorations have relatively short service expectations because of their physical characteristics and their low revenue production, potentially encouraging less adequate restorations and operator errors. This article provides some of the reasons for composite failure, most of which can be reduced or eliminated by careful procedures using the suggestions here for how to avoid them.

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WHAT ARE THE MAIN REASONS FOR IMPLANT FAILURE?

There are many ways dental implants can fail. Dr. This article offers insight regarding occlusion, bone density, prosthodontic design, and more.

BY GORDON J. CHRISTENSEN, DDS, PhD, MSD

Q: I have been placing and restoring dental implants for about 10 years. There are times when I feel I have placed an implant nearly perfectly, yet after a short time of adequate service, the implant fails. There have been other times when I could have done a better implant placement, and the implant is successful over many years. There appear to be many reasons for implant failure. What are the most important and common reasons why dental root-form implants fail? Can I avoid these situations and expect more predictable service?

A: I feel the same frustration you have described. Because of these unpredictable surgical situations, I suggest realistically advising those patients considering implants that over 90% of implants serve very

well for several years, but some begin to have peri-implantitis or other challenges after approximately 10 years. Patients should be educated about the potential problems that involve implants just as they should be advised about those associated with natural teeth, as well as how to potentially prevent the challenges.

The dental literature is filled with scientific articles suggesting reasons for implant failure and how to prevent failures. I will summarize some of the researched reasons for implant failure and express my own clinical observations on failures I have experienced.

Implant placement for properly diagnosed healthy patients who have adequate bone quantity and quality is a relatively simple procedure that can be accomplished by any dental practitioner who has taken the time to become competent with the procedure. Similar success can be expected with implant restoration.

Implants should be for all patients who need them when all other treatment modes do not appear to be adequate. They are not an equal replacement for a natural tooth and should not be considered as such. However, with proper placement and restoration, implants are an excellent substitute when all clinical conditions are considered.

Every effort should be exerted to retain restorable natural teeth before removing them and placing implants.

Our organization, Practical Clinical Courses, has four levels of implant videos and courses, some of which are described later. Our implant failure course is one of the most popular courses in our 15-course series.

Rather than include all the known potential reasons for implant failure, I will limit this discussion to those I have found to be most significant and commonly occurring. Also, I have not included references for my statements since they are based on innumerous research projects and my own clinical observations over 30-plus years of implant dentistry.

OCCLUSION

Occlusion on implants is very different from occlusion on natural teeth. Inadequate occlusion is one of the most important reasons for implant failure. Implants do not move when osseointegrated into bone, whereas natural teeth move significantly in bone. Implants have only a few microns of movement. As a result, occlusion is even more important when implants are involved than when only teeth are

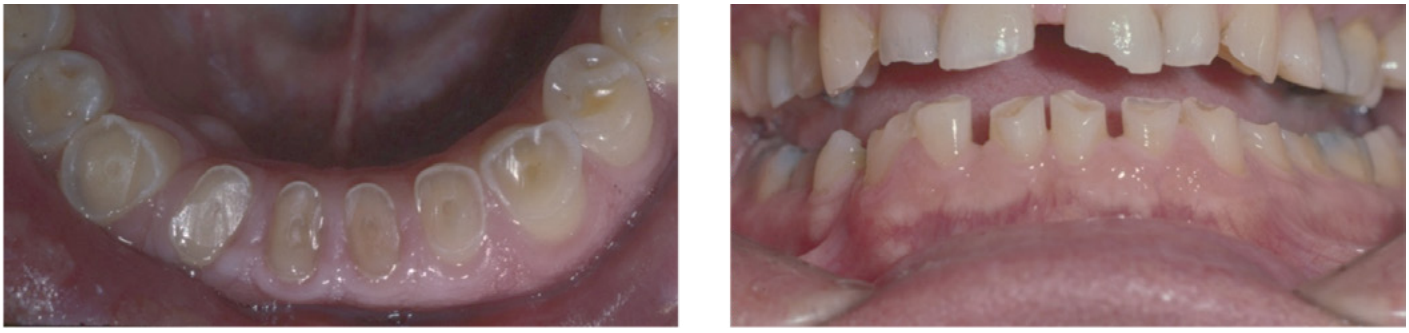

Figure 1: Among the most frequently identified reasons for implant failure is occlusion. These images show grinding and clenching bruxism for which implant-supported prostheses would require meticulous planning and procedures for success.

present. Implant occlusion needs meticulous adjustment at the time of implant restoration and at recare appointments. I am confident that this factor is not currently understood or practiced adequately. Use of thin articulating media (Parkell AccuFilm II), occlusal indicator wax (Kerr Dental Occlusal Indicator Wax), and other concepts are necessary to place shared occlusal load on implants and teeth (figure 1).

SMOKING

Try to find any scientific article that supports smoking (figure 2). The literature is replete with reports of smoking being a negative factor for dental implant success. Although the effect of vaping is not as well researched, there is growing literature showing the negative influence of vaping. Patients should be provided with adequate informed consent if considering implant placement. Dentists are advised to avoid implant placement in patients who will not significantly reduce or cease smoking.

Figure 2: Research shows a way to nearly ensure implant failure, which is putting implants in a heavy smoker.

POOR BONE

Practitioners can easily see the quantity of bone by observing radiographs, especially cone beam images. However, many dentists do not analyze bone quality or even discuss it adequately with patients. Radiographs can provide hints concerning bone density by allowing observation of the size of bone trabeculations.

If the patient is taking bisphosphonates (Boniva, Fosamax, etc.) as indicated when collecting their diagnostic data, ask what practitioner placed them on the bisphosphonates. Call that practitioner. He or she will usually have completed a T-score test to determine the severity of the bone quality. Usually, the patient will be osteopenic or osteoporotic if taking bisphosphonates (figure 3). It is nearly impossible to significantly increase bone density, although there are a few medications indicated for that use. I suggest considering treating patients who have poor bone density with conventional dental treatment rather than gambling with potential implant failure.

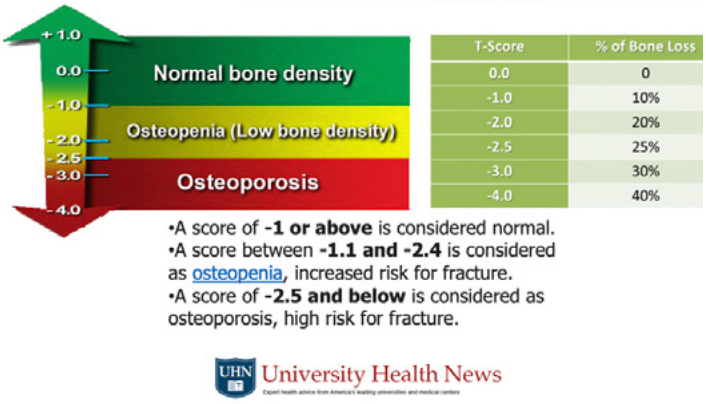

Figure 3: Osteopenia and osteoporosis are often overlooked in diagnostic procedures. Poor bone density has a guarded potential for implant placement.

LOADING IMPLANTS TOO EARLY

There has been significant marketing for both patients and dentists on "teeth in a day." Patients and some practitioners see these ads and think that this is always a viable alternative. In some clinical situations, it is an

acceptable alternative. However, the clinician accomplishing such treatment must consider all aspects of the clinical situation to determine if perhaps a slower and more predictable alternative would be better for the patient.

What should be considered? Many factors, including patient expectations, bone quantity and quality, long-term prosthesis expectations, esthetics, healing time, ability to predict where soft tissue will heal, occlusion, and so on. Often patients have had missing teeth for a long time. What is the hurry? Slow down and improve the procedure predictability and the long-term service potential. I have had several implant-supported crowns and fixed prostheses fail because of hurrying.

There are a few situations where immediate implant placement is superior to waiting for bone maturity. One of them is in the anterior smile area, where immediate implant placement can often provide better retention of papilla.

IMPROPER IMPLANT PLACEMENT

Wouldn't it be wonderful if all implant surgery instruction in dental courses required implant prosthodontic treatment planning education at the same time? Surgical placement and angulation should be guided by prosthesis design, not the reverse. Unfortunately, this is not the case. Many surgical specialists have not had significant prosthodontic education or background, and many prosthodontic specialists have not had surgical instruction (figure 4). Seek out courses that include both the surgical and the prosthodontic information simultaneously. Our implant courses described below contain both.

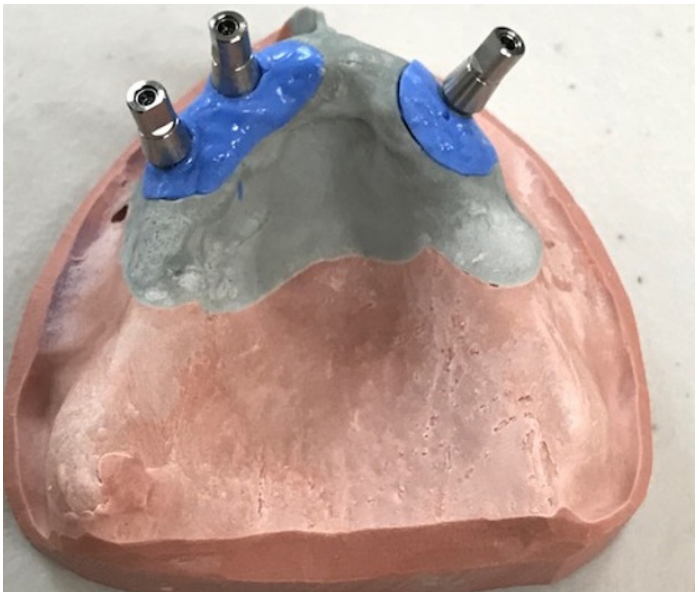

Figure 4: What can be done with this clinical situation? This patient has inadequately located and inclined implants. He could be treated by placing a bar and clip prosthesis, but even that would place unpredictable stress on the underlying implants.

IMPROPER PROSTHODONTIC DESIGN

Crown and prosthesis planning and design are directly related to anticipated stress to be placed on implants, esthetics, food impactions, open contacts, soft-tissue irritation, and potential implant failure. Dentists should be involved in the details of crown and prosthesis design with laboratory technicians.

PREVIOUS PERIODONTAL DISEASE

Contrary to previous beliefs, when a patient has had periodontal disease and tooth extraction, the odds of having peri-implantitis later may be increased. In such cases, accomplishing conventional dentistry instead of placing implants or at least having a strong informed consent for the patient before placing the implants may be better (figure 5).

Figure 5: If some of these periodontally diseased teeth needed to be extracted, conventional dentistry would probably be better since the organisms causing the periodontal disease and remaining in the mouth have high potential to stimulate peri-implantitis.

SUMMARY

Although root-form dental implants have been used for more than 30 years and are now popular, in my opinion, we still don't know more than we know. There are more than 20 factors that allegedly can cause implant failure. Do we really know what causes a specific implant to fail? Not often. This article includes the observational and research views of a prosthodontist who has succeeded and failed with implants for more than 30 years. These observations include some of the most important causes for implant failure. But there are many more reasons!

HOW TO REDUCE RECURRENT CARIES AND CROWNS COMING OFF

Many dentists have been experiencing crowns coming off and recurrent caries on margins. Much of the problem appears to be related to cement and cementing. Here are some tips.

BY GORDON J. CHRISTENSEN, DDS, PhD, MSD

Q: I have been practicing for many years with an emphasis on restorative dentistry. During that time, I have placed thousands of crowns. In past years, zinc phosphate cement was the primary cement that everybody used, including myself. When accustomed to the proper mixing, zinc phosphate cement worked well with only a few negative characteristics. The most significant one was occasional postoperative tooth sensitivity that persisted for weeks to months. Crowns rarely came off in service and recurrent caries was infrequent. The next generation of cement, glass ionomer, also had infrequent but often unpredictable severe postoperative tooth sensitivity, but the cement retained crowns well. I have now replaced some of the glass ionomer cemented porcelain-fused-to-metal (PFM) or cast-gold alloy crowns placed during the 1970s, due to wear or porcelain fracture, and I have yet to see any severe caries on the teeth.

My question is this: why are we now plagued with crowns coming off and frequent areas of

recurrent caries when using the current generation of resin cements? It appears we have gone backward with the newer cements.

A: Yes, anyone practicing during the last few years and placing zirconia crowns has observed the same challenges you stated. In some ways, the profession has gone backward with cements. However, there have also been some advancements. Examples such as triturating and self-mixing dispensing activation of cements have increased the predictability and homogeneity of dental cements. Nevertheless, your observations are correct. Zirconia crowns are frequently coming off, and this is apparently associated with current dental cements compared to previous cements. This challenge is important and frustrating, and it can be embarrassing for dentists and problematic for patients. I agree; the two challenges are: zirconia crowns coming off in service and caries on crown margins. But these issues are not going away and seem to be occurring more frequently (figure 1).

Figure 1: Zirconia crowns are strong and can be beautiful, but there are some peculiar clinical challenges associated with them (crowns coming off and caries reoccurring on margins), probably due to cements.

In this article, I will share potential methods to reduce the obvious problems that occur in using the current cements as well as potentially changing the cement being used.

ZIRCONIA CROWNS COMING OFF IN SERVICE

There are several readily apparent reasons why zirconia crowns are coming off. The following information describes these reasons and provides potential solutions for the problems.

Tooth preparations are not retentive. A visit to your local dental lab will offer evidence for this statement. It is *not* a new problem. Despite the long-present need for more retentive crown preps, the crowns cemented historically with either zinc phosphate or conventional glass ionomer almost never came off in service. Several reasons for this challenge are:

- Often crown preparations are made on teeth that have already had restorative failures, and the remaining tooth structure is inadequate to retain the crowns.
- Retention-producing buildups have not been placed on the minimal amount of tooth remaining.
- Tooth preps are too short, such as crowns on mandibular second molars. An adequate crown prep is described many places in the literature as requiring 4 mm or more of axial walls from the gingival margin to the occlusal table.
- Tooth preps are too tapered. Optimum taper of the axial walls is well known to be no more than 20 degrees from parallel.

Dentists can easily remedy these challenges by making tooth preparations that meet the research-supported characteristics for an acceptable tooth preparation, placing strong retentive buildups when one-half or more of the coronal tooth structure is missing. But will this solve the overall problem? *No*! There are other reasons for zirconia crowns coming off.

The intaglio (internal) surfaces of milled zirconia crowns are smooth and lack mechanical retention. How can this problem be overcome? Assuming the tooth preparation is potentially inadequate to provide optimum retention, the following procedure can solve this portion of the problem of crowns coming off. Grooves can be cut in the axial walls of short preps to augment the retention (figure 2).

Figure 2: Vertical grooves are cut by the dentist on the axial walls of the tooth preparation, and the result is shown in this zirconia fixed prosthesis. This well-known retentive procedure has been long-established from historical cast-gold restorations.

This is a simple procedure but inform your technician not to block them out when scanning. Also, the axial surfaces of the tooth preparation can be roughened with a coarse diamond just before seating the restoration but only on the original 3Y (original BruxZir type) zirconias. Sandblasting is negative for some formulations of zirconia, but it can provide a small amount of roughness for a slight increase in mechanical retention for the original 3Y zirconia.

Bond of cement to zirconia is minimal. Although bonding materials such as MDP primers (10-methacryloyloxydecyl dihydrogen phosphate) are being used to provide minimal bond of resin cement to zirconia, this mild bond has been shown to decrease with time.[1] (Example products are Z-Prime Plus from Bisco and most of the "universal" bonding agents that are available.) These "universal" bonding agents also contain silane, which slightly enhances the bond of resin to lithium disilicate. The slight bond to zirconia is helpful as an adjunctive retentive concept, but it should not be expected to retain the crown.

Bond of resin cement to tooth structure is minimal. Research in the TRAC (Technologies in Restoratives and Caries Research) Division of Clinicians Report Foundation has shown that the failure mode when zirconia crowns come off is usually at the resin-cement-to-tooth surface, not at the cement-to-zirconia interface.[2] This shows the long-term lack of success for current dentin bonding. Don't depend on bonding agents on dentin surfaces to hold the crown in place. Research shows that bond to dentin is minimal and transient.[3]

Why do crowns stay on enamel surfaces, such as ceramic veneers seated over phosphoric acid-etched enamel? Luting of the resin cement into the thousands of phosphoric acid-etched enamel irregularities and the thousands of hydrofluoric acid-etched ceramic veneer irregularities hold the veneer in place. Veneers held by bonding agents to dentin are well known to come off soon after placement.

Consider the cement type you are using. Research in the TRAC Division of *Clinicians Report* (CR)[4] has concluded from in vivo study that the cement type used makes a difference in crowns coming off in service. The CR study compared zirconia crowns cemented with resin cement or resin-modified glass ionomer (RMGI). In a practice-based study, crowns cemented with the more rigid RMGI were retained better than those cemented with the more flexible resin cement.

This finding is diametrically opposed to some of the company ads supporting resin cements for minimally retentive crown preps.

A CR survey recently showed that 72% of US dentists are using RMGI most of the time.[5] What would cause RMGI to hold crowns on better than resin cement? One potential reason is that resin cements are flexible, while zirconia is obviously rigid. The resin cement's flexibility could be the reason for its more frequent release of crowns in service. Conventional glass ionomer is rigid, and it is common knowledge that glass ionomer cements seldom release crowns in service. RMGI is about 80% glass ionomer and only 20% resin.

Roughen the tooth preparation on the seating appointment (figure 3). When seating zirconia crowns with minimal retention, roughen the axial walls of the preparation with a coarse diamond just before seating the crown. This is in addition to placing grooves in the preps, as described earlier. The luting effect produced by the diamond scratches helps hold the crown in place. The completion of both procedures is the technique used to salvage zirconia crowns that continue to come off in service.

RECURRENT CARIES ON THE MARGINS OF ZIRCONIA CROWNS

RMGI has cariostatic properties because of the fluoride release from the glass ionomer component. Resin cements do not have cariostatic properties; they shrink about 2%, producing a microscopic marginal opening that cannot be avoided.[6] Although CR has long suggested use of RMGI cement for zirconia crowns, some dentists continue to use resin. I suggest that if you are placing zirconia crowns with resin cement that you prescribe use of 5,000 ppm fluoride-containing toothpaste daily (for example, PreviDent 5000 from Colgate). Fluoride in trays should be offered to high-caries-potential patients with resin-cemented zirconia crowns, but this practice has less acceptable patient compliance than 5,000 ppm toothpaste.

SUMMARY

Zirconia crowns are currently the most commonly placed indirect restorations in dentistry, according to Glidewell Laboratories.[7] Properly fabricated zirconia crowns are working very well; the crowns are not breaking. However, there is no question that many zirconia crowns are coming off in service, contrary to those restorations

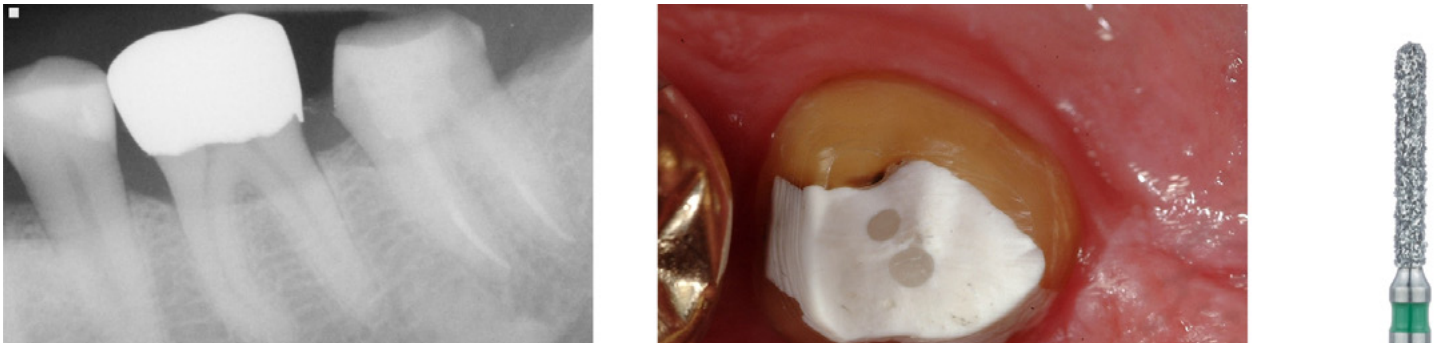

Figure 3: Roughening the external axial walls of the tooth prep with a coarse diamond at the cementation appointment allows the cement to become a luting procedure for this short, potentially weak prep, and reduces the chance of the crown coming off.

previously placed with the historic cements, zinc phosphate and glass ionomer. Much of the problem appears to be related to cement and cementing. Additionally, some dentists are complaining of caries beginning on the zirconia crown margins. I have included the challenges presented by the dominant esthetic crown type in the US (zirconia), as well as potential methods to reduce or potentially eliminate the problems.

Dental manufacturers should focus on research to assist in overcoming these common and frustrating problems.

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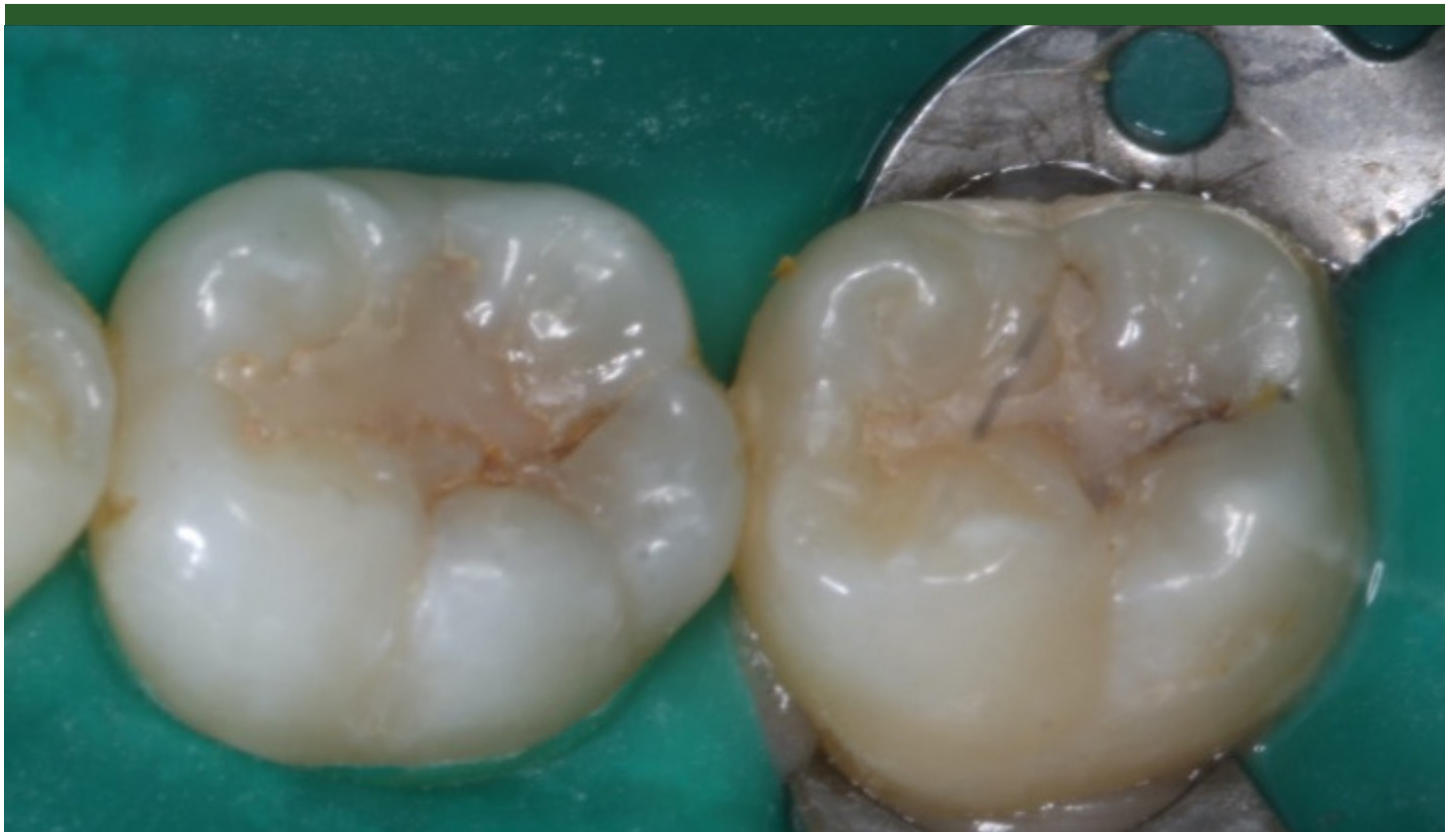
WHY ARE SEALANTS FAILING?

Sealants are one of the most likely dental procedures to prematurely fail. But it doesn't have to be that way. Here are some techniques you can use to make your sealants last longer.

BY GORDON J. CHRISTENSEN, DDS, PhD, MSD



Q: I am frustrated with dental sealants, and I need some help on how to make them last longer. I have been a dentist for nearly 20 years and have had staff members place sealants for as long. The concept appears to be a viable one, but after watching them serve in the mouth over time, I find that sealants have numerous challenges. They look good when initially placed, but just a few years later, most are chipped around the edges, some have come off and have to be replaced, and others form caries underneath. How can we make sealants last longer?

A: We have been placing sealants since they were introduced into the profession several decades ago.

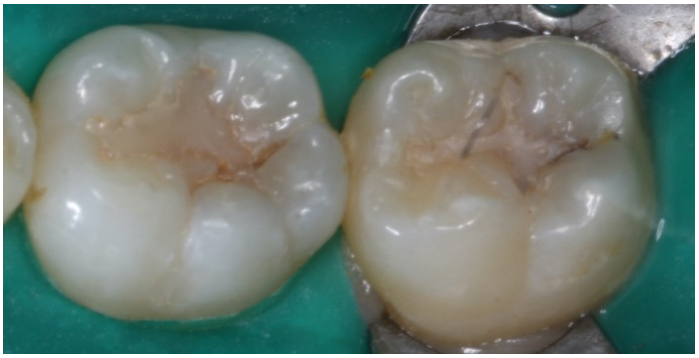


Figure 1: Failed sealants are a common occurrence. Failure can be avoided as described in this article.

As you consider the potential reasons for sealants to fail, numerous questionable factors soon become evident (figure 1). Among them are:

- Was the staff member who placed the sealant adequately educated/trained on the procedure?
- Was plaque left in the groove before etching?
- Were dental caries left in the tooth under the sealant?
- Was the patient living in a fluoridated community?
- Did the acid etch work adequately?
- Was the tooth surface disinfected before placing the sealant?
- Was the sealant placed in an adequately dry and uncontaminated field?
- Was the sealant light cured properly?
- Was the sealant material wear-resistant?

These questions are pertinent to your comments. If all of them can be answered adequately, there is no reason for the sealants to fail. Apparently, the sealant technique needs scrutiny. The dismal international data shows sealant failures are causing many dentists to have the same questions as you.

I will answer each of the questions above and describe a well-proven technique to ensure that sealants stay in place. The following information has been accumulated by the research staff of Clinicians Report Foundation (CR) and augmented by the clinical observations of dentists, hygienists, and assistants working with CR.

STAFF EDUCATION/TRAINING

It seems apparent that those placing sealants should have adequate information relative to the procedure. However, this is not commonly observed, and it could be one of the major problems for sealant failure. Staff education can be easy. Set up an in-service education session with your employees. Obtain some groovy extracted third molars and carry out the technique I will explain later in this article. You will in turn see a marked improvement in sealant quality and experience fewer failures.

PLAQUE LEFT IN THE OCCLUSAL GROOVES

This is, perhaps, the most important reason for sealant failure. Some clinicians use an explorer to "remove" plaque from the grooves—not remembering that an explorer is at least 100 microns in diameter, and the groove can be as small as a few microns wide at the most apical level (figure 2). What does the explorer accomplish? It only pushes more plaque into the depth of the groove.

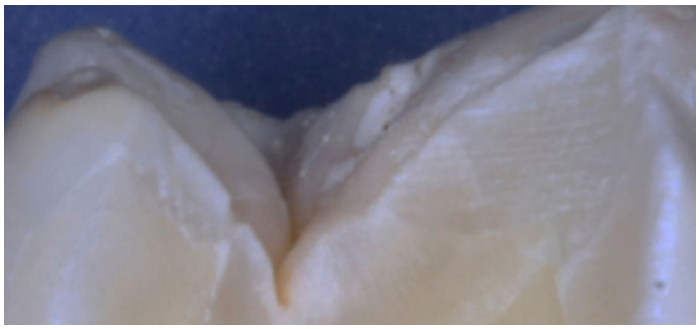


Figure 2: Note the narrow groove in a typical tooth. Instruments such as explorers fail to reach the plaque in the depth of most grooves. Rotating brushes and prophy cups clean only the superficial areas of the occlusal surface, leaving the plaque in the grooves.

You can overcome this challenge by using an air polisher (figure 3) to remove the plaque from the grooves. The sodium bicarbonate slurry the air polisher provides is water-soluble. The particles become smaller and smaller as the water is combined with them, thus penetrating to the bottom of the groove and removing the plaque. Another advantage of using an air polisher is that if any color is left in the groove after using it, the likelihood of caries being present is almost assured. In this case, a restoration should be accomplished instead of a sealant.

Figure 3: An air polisher removes plaque to the depth of the grooves because of the water solubility of sodium bicarbonate in the slurry, which dissolves and becomes smaller, penetrating to the bottom of the groove.

REMAINING CARIES

Use of an air polisher will reveal caries as described by leaving remaining color in the grooves. Also, a drop of silver diamine fluoride (SDF) on the unetched and dried occlusal surface can show occlusal caries. When you allow the SDF to sit for a minute, it stains the caries. It is an excellent caries indicator that costs less than one dollar. *Don't seal teeth with overt caries in them*. If overt caries is present, restore instead.

FLUORIDATED TEETH

It is well-known that teeth have a layer of fluorapatite on the enamel surface, which takes time to accumulate. This layer is acid-resistant, and in high-fluoride geographic areas, the layer is more resistant to acid etching. You may have noticed this when placing resin on the proximal surfaces of anterior teeth to close a diastema. If the fluoride layer is not removed from the tooth, the resin often comes off during service. That fluoride layer is on all areas of any tooth being sealed. If the patient has been living in a fluoridated geographic area, acid etching needs to be thorough.

THOROUGH ETCHING

The most recommended time for etching enamel is about 15 seconds with various concentrations of phosphoric acid (most popular is approximately 35%), followed by at least a 10-second wash and dry. In fluoridated geographic areas, 20 seconds of etching is recommended. When drying the tooth surface, if it is not "frosty" in appearance, repeat the etching and washing procedures. However, over-etching creates a weak bond. The word *bond* is somewhat of a misnomer. The main retention to enamel is caused by the thousands of 5- to 10-micron deep acid-etched irregularities in the enamel—not by a chemical bond. When thoroughly etched, the surface should appear "frosty."

DISINFECTION

Apply two one-minute applications of 5% glutaraldehyde and 35% HEMA (2-hydroxyethyl methacrylate) immediately after the acid etch and wash to kill the remaining microbes. Gluma and MicroPrime are two examples. This has been shown to be essential in sophisticated long-term research performed by the TRAC component of Clinicians Report Foundation.

DRY, UNCONTAMINATED FIELD

Resin placed and cured in a moist or contaminated operating field will fail. Products such as Isolite 2, Mr. Thirsty, or even a rubber dam in some cases can eliminate the moisture challenge after washing. If the etched area was contaminated with saliva or debris, redo the etch and disinfectant placement.

LIGHT CURING

One of the most negligent areas in restorative dentistry is adequate light curing. Have your curing lights been evaluated by a local distributor, or do you have a light tester? There are several LED curing light testers on the current market. It is generally accepted that a minimum of 1,000 mW/cm2 is recommended. For optimum curing, the light beam should be as close to the resin as possible. For a sealant, the beam should be perpendicular to the occlusal surface. During your staff in-service, find out how much time it takes to cure resin using your light. Cure a resin sample out of the mouth and observe the effectiveness of the cure. When curing sealants, the resin should be cured for the time you've found to be adequate.

SEALANT WEAR

Make sure the sealant or flowable resin you are using as a sealant has wear characteristics similar to enamel. Check with the manufacturer or contact CR for advice at www.cliniciansreport.org. Proven flowable examples are Filtek Supreme Flowable Restorative (3M), G-aenial Universal Flo (GC), Beautifil Flow Plus (Shofu), and others. Following the guidelines above is essential for developing sealants that will *serve indefinitely*. The following information lists the sealant steps in the proper order. Several of these steps (1, 2, 3, 6, 7) are not currently common procedures but have been proven to be necessary for optimum success. Including these steps will add a little time to the procedure, but the result is well worth it.

PROCEDURE FOR SEALANTS

1. Clean grooves with an air slurry polisher or small bur.
2. Neutralize remaining sodium bicarbonate with three-second etch using your typical acid, wash and dry.
3. If still stained or with obvious caries, cut the prep and restore. If not, continue with sealant.
4. Acid etch for the normal etch time (approximately 15 seconds).
5. Wash and dry.
6. Place glutaraldehyde/HEMA in two one-minute applications. Don't wash; suction only.
7. Place bonding agent and blow lightly with air to reduce film thickness.
8. Place sealant/flowable resin and cure (figure 4).

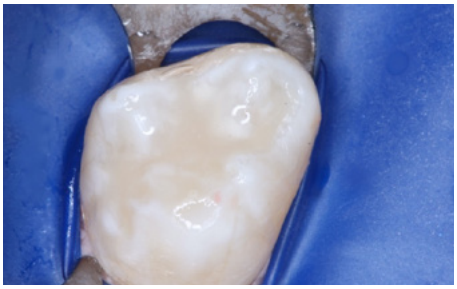


Figure 4: The sealant in this extracted tooth example was placed with the technique described in this article. Such sealants will not fail!

SUMMARY

Sealants are known to be one of the most likely dental procedures to prematurely fail. Numerous studies estimate about five years of average longevity. The procedural steps and supportive narrative in this article will improve the longevity of sealants significantly.