

Longevity of the Tooth/ Restoration Complex: A Review

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Abstract

The contemporary dentist has a wide variety of materials to utilize in the restoration of defective teeth. The decision as to which restorative approach should be utilized in any given clinical situation is a joint one between the patient and the treating dentist. The dentist's primary obligations are to understand the indications and contraindications of various materials, understand how to optimally manipulate those materials, and educate the patient so that they make intelligent decisions and give proper informed consent. The ultimate decision as to which approach to use rests with the patient, and the patient must clearly understand the benefits and risks associated with different restorative options. Clearly, one of the important considerations with any treatment is the prognosis and restoration longevity.

When attempting to predict the long-term prognosis of any restoration, it is important to consider both the restorative material being considered as well as the specific tooth that is being restored. Many times the amount of remaining tooth structure has a more significant bearing on long-term prognosis than what material is used for restoration. Thus, the tooth/restoration complex must be considered as a whole when predicting potential longevity.

Many clinical trials have been conducted to attempt to answer those questions, and relatively few unbiased, unambiguous answers are available. The only completely honest answer to those questions is "It depends." This is because the prognosis of all restorative therapy depends on the complex interaction of a number of variables, some of which are controlled by the dentist, and some of which are totally out of the dentist's control.

This article will attempt to delineate some of the factors related to the long-term prognosis of the tooth/restoration complex, and specifically identify factors that decrease the prognosis of the tooth/restoration complex.

There are five main groups of factors to consider when attempting to determine the prognosis of restorative therapy (Table 1). The first consideration is what material is being used? Second, there are a number of factors related to the treating dentist. Third, there are a number of critical factors specific for each individual patient. There are also a number of variables that are important related to the tooth or teeth that are to be restored. And finally, with indirect restorations, there are variables associated with the laboratory technician.

Failures of restorations may be classified as biologic or mechanical.^{1,2} Biologic failures include recurrent caries, loss of periodontal support, biologic width violations, and pulpal involvement. Mechanical failures include tooth or cuspal fracture, restoration fracture or fracture of a veneering material, excessive wear, and loss of retention of the restoration. Most intraoral mechanical failures are a result of fatigue failures that begin with crack initiation and proceed with slow crack propagation to eventual clinical failure.

Many of the biologic factors relate to restoration contour, fit, and mar-



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Figure 1. All-ceramic crowns fail by defect propagation, and the prognosis for such restorations on posterior teeth is guarded.



Figure 2a.



Figure 2b.

Figure 2. These conservative cast gold restorations have been in service more than 35 years. (Photos courtesy of Drs. R.V. Tucker and R. Simonsen)

Table 1

Factors Related to Tooth/Restoration Longevity

- Restorative material
- Ability of the dentist
- Patient factors
- Tooth factors
- Dental laboratory factors

gin location, which are controlled by the dentist. Biologic failures also are caused by patient factors that are more or less out of the control of dentists. Mechanical failures relate to the care and skill of the dentist and laboratory technician, and also to parafunctional habits of the patient. Some failures, of course, are both biological and mechanical. Often, undetected recurrent caries may result in clinical fracture of the tooth, and vice versa, untreated cuspal fracture can lead to leakage and recurrent caries.

Material Factors

The choice of material has a clear influence on the expected longevity of a restoration. A metal restoration would, in general, have a longer expected lifespan than a ceramic restoration primarily because metal restorations are

normally not susceptible to fatigue. Metal-ceramic crowns would be expected to have superior survival rates than all-ceramic alternatives because of their ability to resist flaw propagation (Figure 1). Intuitively, materials with improved physical properties would be expected to perform better than a similar material with poorer physical properties. However, it is clear that the correlation between improvements in physical properties and clinical performance for most materials is poor.³⁻⁵

One important materials-related factor is its relative level of technique sensitivity.⁶ A material is described as “technique-sensitive” when the clinical results achieved with the material have a high level of variability. It could rationally be argued that technique sensitivity is a dentist variable rather than a materials variable. This is because materials with low-technique sensitivity essentially neutralize the dentist factor in determination of the result. Dental amalgam has a very low level of technique sensitivity and it is likely that every recent graduate from every dental school in North America can place a serviceable amalgam that will provide a good service for their patients.⁷ This lack of technique sensitivity is primarily a result of percolation and buildup of corrosion products at the

amalgam/ tooth interface, which results in a self-sealing process independent of the operator. On the other hand, composite resin materials have a high level of technique sensitivity, and it is doubtful that all recent graduates will be as successful using composite resin. Properly placed, in small to intermediate cavities, composite resin can provide a service equal to, or perhaps superior to, dental amalgam.⁸ However, it is likely true that a considerable percentage of posterior composite restorations are not “properly placed.”

Cast gold restorations can also be described as technique-sensitive. Cast gold restorations can provide an exceptionally long service, again assuming they are properly placed (Figures 2a and 2b).⁹ However, while some clinical studies have reported excellent long-term results with cast gold restorations, others have reported less positive data.¹⁰⁻¹⁴ The surprising differences in the results of these studies are primarily attributable to differences in the experience, discipline, and ability of the operators.

Dentist Factors

Data from clinical studies is often treated with a statistical analysis that reports the results in terms of a mean or average. However, it is increasingly clear that neither patients nor dentists neces-



Figure 3a.



Figure 3b.

Figure 3. Patients abusing methamphetamine often present with rampant caries.
(Photos courtesy of Dr. Jinus Emrani)

sarily conform to the median. In dental school, in most properly evaluated courses, dental students' grade scores will fit into some sort of bell curve, with some students achieving very high scores, some lower scores, and most will be grouped somewhere in the middle. Student achievement in any given course is related to a number of variables, including the student's interest in the subject, the quality of the instruction, the effort invested by the student, the student's inherent intelligence and clinical ability, external personal factors, and also the quality of the evaluation.

The quality of restorations placed by a dentist is similarly affected by a significant number of variables. As much as we do not want to believe it, all dentists are not equal. The current standard for graduation in dental education is that students meet the criteria for minimum competency. As a result, there are significant differences in dentists' basic knowledge base when they graduate from dental school, and that gap often widens in the years following graduation. Despite mandatory continuing dental education that is in place in most jurisdictions, there are huge variations in the approaches taken by dentists to

participate in postdoctoral education. The best dental students don't necessarily continue to expand their knowledge base, and often average dental students gradually become outstanding dentists as they pursue a committed, consistent course of continuing education. One of the optimum strategies for continued improvement is attending hands-on courses and study clubs with master clinician mentors.

An oft repeated phrase used by dental educators is, "First, do the right thing, then, do the thing right." (Personal communication, Dr. William McHorris, 1986). Dentists require both knowledge and experience to do the right thing, and need knowledge, experience, and skill to do the thing right. In spite of extensive efforts to put dentistry on a more scientific level, much of what we do continues to have a significant artistic component. Dentists vary considerably in their level of skill, and probably more importantly in their discipline to pay meticulous attention to detail. Those clinicians who combine superior knowledge, skill, and discipline will likely attain better and longer lasting results, especially with materials that are classified as technique-sensitive.

Dentists also vary considerably in their communication skills. This affects their ability to motivate patients to return regularly for required maintenance, perform adequate oral hygiene procedures, diet control, smoking cessation, and their ability to command an adequate fee to allow them to perform restorative dentistry at a high level. Variations in these communication skills clearly can positively and negatively affect the long-term outcome of care, independent of the quality of the initial restoration. Communication skills can also influence the acceptance or lack of acceptance of proposed treatment plans, as well as compliance with regular use of occlusal night guards. The prognosis for restorations in patients with nocturnal bruxism is severely compromised with poor compliance related to use of an occlusal night guard.

Patient Factors

Just as there are considerable differences among dentists, there are enormous differences among patients. Factors that might affect the prognosis of restorations and outcome of care include the personality type, hygiene habits, diet, abuse of alcohol, prescription or recreational drugs, systemic health, medications, parafunctional habits, individual susceptibility to disease, esthetic expectations, and their interaction and relationship with their treating dentist. It is important to understand that every patient is unique, and the prognosis for restorative therapy is dependent on these patient-related factors, as well as a number of independent factors.

Even excellent restorative dentistry will fail if the patient fails to maintain a reasonable level of oral hygiene, or if they consume a diet with excessive amounts of refined carbohydrates and

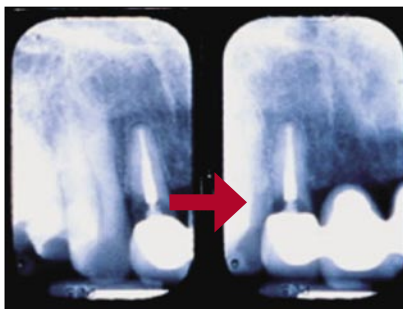


Figure 4. Crowns will not protect the teeth of patients with bulimia.



Figure 5. Bruxism patients must be provided with a custom mouth guard to protect the teeth and restorations. (Photo courtesy of Dr. R. Furuichi)

acidic foods. Few restorations can survive the ravages of severe nocturnal bruxism unless a night guard is fabricated and utilized regularly. Patients who abuse recreational drugs, such as methamphetamines, often have rampant dental caries (Figures 3a and 3 b). Recurrent caries often occurs around excellent restorations in patients with significantly reduced salivary flow resulting from pathology or as a side effect of use of many different medications for the treatment of systemic disease. Similarly, tooth structure beneath complete veneers crowns is often dissolved away in bulimic patients who continue chronic vomiting after restorative therapy has been completed (Figure 4). Patients who smoke have higher failure rates with osseointegrated implants than those who do not smoke.¹⁵

Another significant patient factor is bruxism. There is evidence that the majority of patients engage in some amount of bruxing activity, but the amount and severity varies greatly.¹⁶ The most common forms of bruxism are diurnal (daytime) and nocturnal (sleep) bruxism. Nocturnal bruxism is by far the most destructive, as normal conscious inhibition mechanisms are

not active and tremendous bite forces can be generated. Average bite forces measured in bite force studies range from 150-175 psi for diurnal bruxism, and 900-1,000 psi in nocturnal bruxism. Both the force and duration of the applied force can be elevated in nocturnal bruxism.^{17,18}

The prognosis for any restoration is reduced in patients who exhibit signs and symptoms of bruxism. While most patients are not aware of bruxing activity, the presence of wear facets seen on the teeth or diagnostic casts alerts the dentist to the habit. It is estimated that about 5 percent of patients have wear severe enough to require restorative treatment.¹⁹ These patients must be informed that they are bruxing, that they are causing destruction of tooth structure, and that no restorative material is available that is stronger than tooth structure. While some authorities believe perfection of the occlusion will stop bruxism, there is little evidence to support that belief.²⁰ Occlusal night guards should be fabricated for all bruxing patients, and they should be educated and convinced of the necessity of wearing these appliances at night (Figure 5).

Hard occlusal splints should be used as opposed to soft occlusal guards, as the latter have been demonstrated to increase EMG activity of the masseter muscles.²¹ Occlusal splints may or may not decrease bruxism, but they do improve distribution of the forces of bruxism, and they do protect the teeth and restorations. The importance of patient education and motivation cannot be overstressed in this area, as it is clear that the finest night guard cannot function if it is not worn.

It is clear the dentist has the ethical obligation to complete restorative therapy that is within the standard of care. However, even the finest restorative dentistry will fail in a short time in the absence of proper oral hygiene and regular professional dental maintenance. Similarly, well-done restorations may mechanically fail in a bruxing patient who fails to wear an occlusal night guard. These patient factors are by and large out of the treating dentist's control, but it is likely a positive dentist/patient relationship could have a positive effect with compliance.

Tooth Factors

One factor that has not received adequate attention related to determination of the prognosis or longevity of a restoration is the nature of the tooth receiving the restoration. The position of the tooth in the arch can have an effect on the prognosis. Patients can generate significantly more bite force on the teeth most distal in the arch than they can on teeth with a more anterior position, and this may reduce the prognosis in some situations. All-ceramic crowns on molars fail at a seven times' higher failure rate than those on anterior teeth.²² Given that most second molars are not visible at conversational

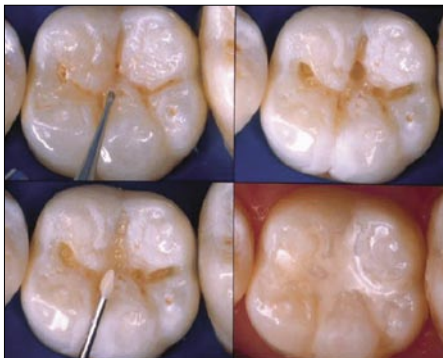


Figure 6. Preventive resin restorations are an excellent example of minimally invasive dentistry. (Photo courtesy of Dr. R.J. Simonsen)



Figure 7. Silver amalgam restorations have served the profession well but require more extensive loss of tooth structure than preventive resin restorations. (Photo courtesy of Dr. R. Kahn)



Figure 8. The slot preparation in conjunction with an occlusal sealant is a more conservative preparation than a traditional Class II preparation. (Photo courtesy of Dr. R. Leung)



Figure 9. This bonded ceramic onlay is a more conservative restoration than a porcelain-fused-to-metal crown.

distance, the wisdom and necessity of placing an all-ceramic restoration on those teeth must be questioned.

The occlusal stress to which abutment teeth will be subjected can also influence the prognosis. Abutment teeth for long-span posterior fixed partial dentures are at greater risk than teeth supporting single-unit crowns. Teeth used as abutments for cantilevered restorations are at significant risk, especially if they are endodontically treated.^{23,24} Interestingly, teeth with poor periodontal support survive better than those with good support when used as abutments for cantile-

vered prostheses.^{25,26} This seems to be because patients with reduced periodontal support produce substantially less bite force. It has also been shown that endodontically treated teeth are often subjected to excess biting force because of the absence of intrapulpal receptors that limit the amount of force a patient will generate.²⁷ Studies also indicate that the prognosis for a fixed restoration decreases when a combination of risk factors occurs.²⁸ These factors may include endodontically treated abutments, long occlusal spans, an active bruxing habit, etc.

One critical factor when determin-

ing a prospective prognosis for any given tooth is the amount of remaining tooth structure.²⁹⁻³² The words “preservation of tooth structure” which are uttered in almost all lectures related to tooth preparations, are critical to establishing a positive long-term prognosis. The amount of tooth structure removed from a tooth when preparing a porcelain laminate veneer is much less than when preparing a full crown.³³ Thus, the long-term prognosis for the veneered tooth is substantially better than that for the crowned tooth.

The advent of predictable adhesion to tooth structure has allowed clinicians the ability to practice minimally invasive dentistry, and thus preserve tooth structure and concomitantly improve the long-term prognosis of the tooth/ restoration complex. A preventive resin restoration in a mandibular first molar is more conservative than a minimal silver amalgam restoration improving the long-term prognosis for the tooth (Figure 6). A mesial slot preparation restored with adhesives and composite resin is more conservative than a Class II MO silver amalgam restoration, and cuspal flexibility is reduced with the slot preparation, thereby reducing the likelihood of cuspal fracture over time (Figures 7 and 8). A bonded ceramic onlay conserves substantially more tooth structure than a traditional porcelain-fused-to-metal crown (Figure 9). While the bonded ceramic may or may not survive as long as a PFM crown, when it does fail, there is generally a considerable amount of tooth structure remaining. Conversely, while the crown restoration may survive longer initially, when it eventually fails, the failure is often catastrophic.

Clinicians are often faced with a dif-

difficult decision whether to retain a tooth that may require extensive therapy (endodontics, build up, orthodontic extrusion, periodontal therapy, full-crown preparation) or to extract the tooth and replace it with an osseointegrated implant. The success rates and excellent prognoses for implant-supported restorations are uniformly high compared to those for teeth requiring multiple procedures for restoration.³⁴ Implants have quietly become the method of choice when restoring missing teeth, and are being used more and more in favor of restoring teeth with a guarded prognosis.

Dental Laboratory Factors

Indirect restorations are fabricated in the dental laboratory, and survival rates of the restorations depend on the dentist's preparation and impression, the materials used in fabrication, and upon the knowledge, ability and skill of the laboratory technician. Experts have advocated for years that with PFM restorations, a full contour wax-up be made and "cut back" in a controlled fashion prior to casting. This will provide optimum support for the porcelain with the metal coping, result in a uniform thickness of porcelain, which will result in minimal stress at the porcelain/metal bond, and will also result in optimum esthetics. Assuming quality alloys are used, this approach can reduce the incidence of porcelain fracture to almost zero. Yet, this approach is rarely used in commercial laboratories, resulting in a higher than necessary incidence of porcelain fracture.

As was discussed with dentists, all laboratory technicians are not alike and their abilities probably would be distributed in a bell curve. The responsibility

for ensuring that quality laboratory work is routinely obtained remains with the dentist. Based on the substantial amount of porcelain-fused-to-metal restorations that are currently fabricated using base metal and offshore laboratories, it would appear that many clinicians are choosing laboratories more on the basis of price than quality, and that this will probably be reflected in lower survival rates.

Discussion

Numerous studies have been carried out over the past 30 years to attempt to determine how long a restoration should last. Unfortunately, these studies do not provide clear, unambiguous guidelines to assist clinicians in giving their patients a reasonable prognosis for anticipated therapy. This is primarily because there are so many related and unrelated variables that factor into the actual result.

Some authorities flippantly state that insurance companies will replace a fixed-partial denture or crown after five years, so that should be our goal and determine the warranty provided. This type of thinking is irresponsible, irritating, irrelevant, and incorrect. Many studies indicate that fixed-partial dentures demonstrate about a 5 percent failure rate at 10 years. (Personal communication, Dr. Maxwell Anderson, RV Tucker Symposium, University of British Columbia, Vancouver, B.C., October 2005.) The real truth of the matter is that the survival rate of restorations depends on several factors, including the choice of material, quality of the service rendered by the dentist and technician, the amount of tooth structure remaining, the presence or absence of parafunctional habits, oral hygiene, diet, and others.

When dealing with biological and mechanical variables, the clinician should be cautious about making guarantees, and should instead give the patient a range of expected outcomes and explain that these are only guidelines.

Summary and Conclusions

Patients deserve and want to know what a reasonable expected outcome might be for proposed restorative therapy. Dentists must educate patients and help guide their decision making, but in the end, the decision belongs to the patient. While there is little "black and white" information regarding the expected prognosis, some conclusions can be drawn.

- There is no "best" material. All materials have indications and contraindications. Some possess low levels of technique sensitivity and others high levels.

- With materials with high levels of technique sensitivity, the knowledge and skill of the dentist are critical in achieving the desired result.

- Not all dentists and laboratory clinicians are equal.

- Patient factors including those of diet and hygiene are important to long-term survival, as are factors related to saliva and systemic health.

- Restorations placed in patients who suffer from nocturnal bruxism are at risk of mechanical failure. Mandatory use of a night guard is required.

- The amount of remaining tooth structure plays a major role in determining the prognosis. Minimally invasive adhesive restorative dentistry can assist in the preservation of tooth structure.

- The answer to the question, "How long will it last"? should be "It depends."

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