Screw versus Cement Debate:

Will that be Peri-implant Disease by Misfits and Poor Access to Care or Bad Margins and Subgingival Cement?

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"Screw-in versus Cement-in prosthesis installation debate assumes that longstanding risk factors for complications related to prosthesis installation cannot be prevented. This is no longer true."

Abstract: *Patients that have their prostheses installed by current screw-in and cement-in installation systems are exposed to a multitude of risk factors for complications. What appears to be lacking in the dental industry is a basic understanding of the root causes of these installation-specific complications. Without this knowledge and related terminology, it is difficult to discuss and develop new systems of installation that can make treatment better. We know that peri-implant disease is largely a consequence of infection of the peri-implant tissues by oral pathogens. The question is, can dentists reduce the microbial challenge around teeth and the peri-implant environment? Can dentists reduce the uncleanable spaces that foster the growth of oral pathogens between misfit implant parts, under prosthesis cantilevers, under overhanging and in open margins, and on residual subgingival cement? The root causes of the risk factors for mechanical complications and related biological complications are "Prosthesis Dimensional Error and the Tissue Effects". Two of the Tissue Effects have been identified as the Resistance to Displacement Effects and the Gingival Effects. This article reveals how to reduce complications by exploiting CAD/CAM technology to create prosthesis designs and installation protocols that are sensitive to the root causes of treatment complications and can thus mitigate their negative effects.*

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Introduction

Patients that have their prostheses installed by current screw-in and cement-in installation systems are exposed to a multitude of risk factors that are specific to the system of installation used[1]. As a result, 14% of implant patients can expect to experience implant failure, 20% peri-implantitis, and 47% peri-implant mucositis within 10 years.[2] Indeed, when 4 or more implants are used to retain a single prosthesis, patients are expected to experience 15 times the rate of peri-implantitis than those patients restored with prostheses retained by 3 or fewer implants.[3] These disease rates are troubling, considering that there is no predictable treatment for peri-implant disease[4] and the loss of a single implant can have catastrophic effects for the patient. Consequential rehabilitative treatment can be uncomfortable, unpredictable, disfiguring, and expensive.

Peri-implant disease is largely caused by oral pathogens residing in and about dental implants and their retained prosthetics[5]. Oral pathogens can reproduce rapidly and are

about 1 micron in diameter. To understand how to reduce their numbers between implant parts, under prosthesis cantilevers and wide prosthesis profiles, under overhanging and in open margins, and on

installation of crowns and bridges. These places can foster the growth of oral pathogens that challenge the patient's immune system, cause the destruction of peri-implant and adjacent dental tissues, and result in the failure of treatment. To reduce or eliminate these plaque traps, we must understand their root causes.

Root causes of Treatment Complications

The root causes of treatment complications are Prosthesis Dimensional Error (PDE) and the Tissue Effects (TE). The TE include the Resistance to Displacement Effects (RTDE) and the Gingival Effects (GE).

PDE and the TE are the root causes of mechanical problems related to current prostheses installation systems. These mechanical problems can create intra-oral environments in and about implants and their attached parts and prostheses, that expose patients to infection by oral pathogens and cause peri-implant disease.

Both PDE and the TE can cause loose and tight contacts with adjacent teeth, misfit implant parts, joint instability, poor prosthesis margins, hyperocclusion, and subgingival cement. They can both cause all these problems independently.[1,6] These mechanical problems can expose patients with dental implants to biological problems like peri-implant disease and similarly expose natural teeth to caries and periodontal disease.

It can be exceedingly difficult for a dentist to manage both PDE and TE, at the same time during the process of prosthesis installation. To consistently mitigate their negative effects, it is preferable to use a prosthesis installation system that allows the subgingival cement, we must think microscopically. We must think about that world beyond the resolution of the unaided human eye. We must think of the plaque traps that are routinely created during the

clinician to manage them separately.[1] Prevalent prosthesis installation systems, like the screw-in system and the cement-in system, were simply not designed to be sensitive to the root causes of complications, because they were largely unknown or deemed insurmountable when these installation systems were developed. I will describe the newer **Reverse Margin (RM) System** of installation that uses the best attributes of the prevalent installation systems but also has some unique design and delivery protocols that have been specifically created to mitigate the root causes of complications.

A recent study has identified the risk factors for peri-implant disease.[7] The authors propose that **a prosthesis should 1) have optimally fitting parts, 2) be maintainable and 3) prevent residual subgingival cement to reduce the risk of peri-implant disease.** Achieving these goals would also make implant joints more stable and thus reduce their related mechanical problems, including loose and broken retaining screws. It is now possible to achieve all 3 of the abovementioned goals under most treatment conditions. I will explain how below. Hopefully, this new knowledge will stimulate the dental industry to rise to the challenge of finding innovative ways to further support clinicians in their efforts to make dental treatment better for patients.

The Screw-in Installation System

The prevalent screw-in system of implant prosthesis installation has many inherent problems that are difficult to overcome. It is based on misleading assumptions regarding its benefits and disguises the consequential high biological cost of its perceived benefits.

This has unfortunately led some dental practitioners to implement suboptimal prosthesis installation protocols at the expense of patient well-being. When considering risk reduction for treatment complications, including peri-implant disease, **the screw-in installation system often fails to enable the dentist to optimize the fit of implant parts, nor provide adequate access to care of the peri-implant environment by patients and/or the dental team.** This system subjects patients to risk factors for complications, unnecessarily.[7]

Who thinks the fit of parts is important? Health Canada and the FDA in the United States of America do.[8] Optimized fit of parts can make implant joints more stable and reduces spaces between parts that can become breeding grounds for oral pathogens. Indeed, misfit parts can cause unstable joints that act as micropumps during patient function.[9,10] Prosthetic cantilevers offset from retaining implants amplify stress on misfit joints during function. Resulting joint mobility during function can pump billions of oral pathogens and their endotoxins from between implant parts into the peri-implant environment.

Worse yet, larger prostheses of the “all-on-x” variety often involve huge reductions of alveolar bone to hide the gingival-prosthesis interface from the smile line. They use large anterior cantilevers to hide lingual screw access holes and provide patients with adequate lip support. In addition, the dental laboratory technician may need to add material bulk to strengthen the prosthesis to compensate for mechanical stress related to these prosthesis cantilevers and the weakening effect of multiple screw-access holes through the prosthesis structure. All the above negative conditions are specifically created to support the screw-in installation protocol and can further result in a wide prosthesis profile that is difficult to maintain by both professionals and the patient. **Shouldn’t dentists be able to optimize the fit of implant-abutment and abutment-prosthesis joints and provide access to care before embarking upon such aggressive treatments?**

Many articles suggest that it is not possible to optimize the fit of implant parts and achieve a passive fitting prosthesis using the screw-in system of installation. A recent review article[11] also reports the misfit parts problem but does not offer any practical solutions. Indeed, the authors state that this treatment modality is desirable because the screw-in prosthesis is retrievable. The unstated and misleading assumption is that the cement-in system of installation creates a prosthesis that is not retrievable. That is far from the truth.

Prosthesis Retrievability is not dependent on the installation technique. It is dependent on the inclusion of retrievability features into the design of treatment.[12] Thus, both cemented and screwed-in prostheses can be made equally retrievable by including similar retrievability features.

In addition to those retrievability features included in the screw-in prosthesis, the cement-in prosthetics can also be installed using temporary cement. This can allow the prosthesis to be removed without having plastic-covered screw access holes. Indeed, cement-in prosthetics can use intact occlusal dental units that are better able to maintain a stable occlusion and avoid the frequent maintenance of unaesthetic plastic covers required by the screw-in system.

For cemented implant-retained crowns, it is not difficult to create an access opening to abutment retaining screws when their location is well planned. It is also possible to have the laboratory technician mark the position of the screw-channel to make its location evident. Retaining screws loosen much less often when the fit of the parts they

are clamping together has been optimized. It is also important to realize that a prosthesis does not usually need to be removed from the mouth to tighten or replace retaining screws. As such, implants do not need to be parallel to allow dentists to access and tighten or replace retaining screws.

Arguing for the use of the screw-in system of installation because of retrievability can be misleading. Those same retrievability features can be built into any prosthesis installed by the cement-in technique. Unfortunately, in the anterior of the mouth, the need for hidden screw access holes can result in prosthesis cantilevering, misfit parts and related mechanical and biological problems.

Another big problem with the all-on-x screw-in prosthetics systems is related to their reliance on the use of **stock implant parts** rather than site-specific custom parts. Stock parts have a limited selection of angles, collar heights, and dimensions. Why not exploit the use of CAD/CAM-created custom parts to better accommodate the huge variation in clinical conditions faced by the dentist? Indeed, custom parts offer a wide selection of abutment designs and materials that can simply make the task of optimizing treatment easier.[1,13]

The current screw-in prosthesis installation system creates too many challenges for dentists and the patient in its present form. It is not sensitive to the root causes of complications and does not exploit enough of the amazing advantages offered by CAD/CAM technology at the level of the abutment to prosthesis interface. **It is a failing system because we can now do better.**

How does the Screw-in System fail to optimize the fit of implant parts? The current screw-in system already fails to optimize the implant-abutment connection and/or the abutment-prosthetic connector fit because of Prosthesis Dimensional Error (PDE). Then this system adds to the complexity of prosthesis installation by forcing the dentist to manage both PDE and Tissue Effects (TE) simultaneously.[1,13] Perhaps having these implant-abutment and abutment-prosthesis connections hidden from view under the tissues or otherwise obscured by the prosthesis or adjacent dental units gives the dentist a false sense of security. **Is this a problem of "Out of sight, out of mind"?** I will explain below but have also made available a video of a 2021 presentation to the Toronto Implant Academy. It discusses many of the points made in this article, concisely.[14]

For single crowns and bridges to be installed onto dental implants by the screw-in system, the dental laboratory affixes the prosthesis to its abutment(s) and adjusts this complex to fit implant analogs attached to a dental model. Research tells us dental models are inaccurate, with a tolerance of error of ±150 microns. We also know that once the impression of the mouth is made, nobody knows how accurate a specific model or indeed a prosthesis will be.

Manufacturers of implant connections, abutment connectors and prosthetic connectors can manufacture these parts at a tolerance of ±5 microns. This is 30 times more accurate than the dental model. This also means that the manufactured connectors are quite intolerant of dental model and prosthesis construction errors (otherwise known as PDE). These precision parts can only tolerate ±5 microns of error.

When the dentist receives a single crown from the dental laboratory with its abutment attached, the abutment-connector is already held out of its ideal position relative to the implant in the mouth. In addition to this problem, the dentist is often challenged to make a blind connection with an implant under the gingiva. The distance from the

implant to the contacts with adjacent teeth may be about 8 mm. The abutment-crown complex acts as an 8 mm lever arm from the top of the implant. The longer the lever arm, the smaller the amount of resistance required by an adjacent contact to prevent the implant-abutment connection from seating. There is currently no sensitive means of verifying the optimized fit of the implant-abutment parts.

Most crowns need adjustment of contacts during installation. Tight contacts can force a crown into an aberrant path of insertion that can easily take precedence over the optimized fit of the implant-abutment connection. If the crown feels snug between contacts and almost "snaps" into place during installation, this is an indication that the path of insertion has likely taken precedence over the optimized fit of the implant-abutment connection. This can already be the beginning of big mechanical and related biological problems.

When using platform-switch type implants, the implant-abutment connection is often placed deeper under the surface of the gingiva and supporting alveolar bone than usual for platform-matching implants. This makes the lever arm from implant to contact with adjacent teeth 10 mm or more and makes optimizing the fit of the abutment even more precarious. Besides the implant-abutment connection being compromised by the implant-crown contact with adjacent teeth, the dentist may need to displace gingiva and adjacent bone. Bone and gingiva adjacent to hard tissues can be difficult to displace. Simply put, this screw-in system of prosthesis installation presents the dentist with many difficult variables to manage simultaneously.

In conclusion: It may be possible to accomplish an optimized fit of the implant-abutment connection if there are no contacts with adjacent teeth and the abutment does not get displaced or otherwise impeded from seating by adjacent tissues. However, imagine trying to adjust contacts with the accuracy of ±5 microns while blindly screwing the crown into place and managing adjacent tissues. I would say, when there are contacts with adjacent teeth, optimizing the implant-abutment connection would be inconsistent at best. The screw-in system of installation for a single tooth replacement is thus flawed, and cannot be relied upon to achieve consistent results.

When the dentist receives a bridge or other multiunit prosthesis from the dental laboratory with its abutments attached, the abutment-connectors are already constrained by the prosthesis and held out of their ideal position relative to implants in the mouth. PDE already creates a situation where there is no way to optimize the fit of the abutment connectors. The more implants used to retain the prosthesis, the bigger the problem. How can the dentist assemble a prosthesis with its attachment parts on a model that has ±150 microns of error and expect it to fit optimally when the connectors only tolerate ±5 microns of error? Unfortunately, the master model technique is an expensive compromise solution to the problem of misfits, rather than a more definitive solution to this problem.[1]

While PDE already prevents the dentist from optimizing the fit of abutments onto their implants, the dentist must try to maneuver the abutment connectors into place and tighten them down while adjusting contacts with adjacent teeth. Working blind, the dentist must simultaneously displace gingiva and possibly bone from around the implant top, force the connectors into place and possibly need to adjust the pontic tissue surface to seat the prosthesis. This process of installation does not only sound complex, but essentially **guarantees misfit joints, stressed abutments, stressed implants, stressed retaining screws, a stressed**

prosthesis, and stressed adjacent hard tissues. This prosthesis installation system cannot consistently optimize the fit of connections nor achieve a passive fit for the prosthesis. The screw-in system of installation is fatally flawed and can only deliver compromised results to the patient. This system of installation sadly exposes patients to a troubling prevalence of peri-implant disease and treatment failure.[2]

Fortunately, there is a system of installation that can optimize the fit of implant parts and the retained prosthesis. This system manages the TE and then PDE separately. It involves a two-part installation process where the abutment is installed first, followed by the prosthesis. This system provides dentists with much-needed control of each part of the installation process. It allows the abutment to be installed by a screw-in or tap-in friction fit technique, independent of the prosthesis. It is the cement-in system of prosthesis installation.

Cement-in Installation Systems

Cement-in installation systems are two-part systems that separate the management of the root causes of complications. This allows for the installation of the abutment without the prosthesis attached, and thus eliminates PDE from that process. The fit of the precision-made implant and abutment connectors can be optimized because their fit is dependent on the precision of the manufactured connectors rather than the accuracy of the prosthesis.

This system can also exploit improvements in precision that will be available with advancing technology. The current screw-in system of installation would be made worse by improvements in fit, as these parts would have even less tolerance to PDE and would be even more difficult to assemble intra-orally. Already we can observe the multitude of shortened connectors with less touching parts that are being used by clinicians to try to make installation easier.

The problem is, these short, non-engaging parts can only fool the clinician about the patency of the connections they are making. They do not optimize the fit and stability of the joints and they do expose patients to the microscopic assault by oral pathogens and related peri-implant disease.

It is important to review the challenges related to abutment and prostheses installation through a "new lens" that recognizes the root causes of complications. This simply helps dentists and other members of the dental industry to understand the problems with current installation protocols. Perhaps it will stimulate them to think about new ways to prevent them. Isn't the whole dental health care industry charged with the responsibility for making treatment better?

Installing the abutment

The goal of abutment installation is to enable the dentists to consistently optimize the fit of the implant-abutment connection, form an effective biological seal with adjacent tissues to protect against invasion by oral pathogens, and facilitate the safer installation of the prosthesis.

Optimizing the implant-abutment fit

This involves managing the **Tissue Effect named the Resistance to Displacement Effect (RTDE)**. The RTDE is best managed when the dentist can install one abutment at a time without an attached prosthesis. An attached prosthesis adds PDE by affixing the abutment into a non-ideal position relative to the implant, adds additional RTDE by its tissue-facing shape, and obscures the dentist's vision. All these unnecessary complexities make the optimal connection of implant parts more challenging or even impossible to accomplish when the

prosthesis is already attached to their abutments.

Stock Abutments have a limited variety of shapes with which to manage the plethora of clinical conditions faced by the clinician. There is a limited ability to change margin position or design because the material makeup of the stock abutment is usually too thin to allow for its ideal adjustment. Thus, clinicians were forced to choose non-ideal designs that compromise their treatment results. What made them popular?

Stock abutments are often easy to install onto implant retainers because their shapes are usually like the stock healing abutments they replace. This eliminates or reduces the RTDE and makes it simple to optimize their connection to implants. However, this is a good example of "kicking the ball down the road", as the dentist will now need to rely on the prosthesis to manage both the Tissue Effects and PDE during its installation.

Can dentists rely on the prosthesis to safely manage the TE without causing poor margins and subgingival cement? Can they rely on the prosthesis to manage PDE and prevent poor contacts, poor margins, and subgingival cement? Will the prosthesis stimulate bleeding of adjacent tissue and contaminate cement, obscure vision and make it difficult to detect when the prosthesis is well-seated onto its retainer?

Can a single crown be relied upon to manage the RTDE, the Gingival Effects (GE) and PDE during its installation?

With stock abutment in place, is it possible to optimize the installation of a crown while adjusting contacts with adjacent teeth? The dentist would need to displace adjacent and underlying tissues, somehow try to manage tissue fluids, and prevent subgingival cement. Both PDE and the Gingival Effects can cause abundant submarginal cement and the RTDE can cause open margins. PDE can also cause overhanging and overextended margins.[15-18] These are all risk factors for peri-implant disease[7] and similarly, they can cause caries and periodontal disease around natural teeth.

How are "site-specific" custom abutments different?

Common custom abutments have feather, chamfer and butt margins, are designed to have small cement space between the prosthesis and the retainer (~45 microns), and are designed to come into contact or proximity to the prosthesis margins during their installation.[19-22] These margin designs direct cement into the subgingival environment and stimulate both the RTDE and the GE to cause subgingival cement, the cement space is insufficient to manage PDE and this leads to margin problems when the crown is cemented. These custom abutments were not designed to manage the root causes of complications.[23]

However, customization offers some control of the abutment margin design and position relative to the adjacent gingiva and can begin shaping the emergence profile for the proposed prosthesis below the gingiva. It is also a possibility to control the angle of the retaining element of the abutment to favour prosthesis installation. The ability to control these features takes advantage of CAD/CAM technology and indeed even controls the nature of the material used. Will it be titanium, zirconia or both or some other material?

Subgingival cement and poor margins

Several authors have demonstrated that subgingival cement was very difficult to prevent, even with equigingival margins.[19-21] Indeed, this already shows that they have yet to understand the root causes of subgingival cement. These same authors don't even speak about the problem of open, overhanging and overextended margins,

related misfit joints and how they may also be significant contributors to peri-implant and dental disease around prostheses retained by implants or natural teeth.

The use of custom abutments has been recommended by many authors[20,22] without a clear explanation about why that choice is important or how it reduces known risk factors for disease. It was the research of the author that demonstrated how the Gingival Effects (GE) could cause copious amounts of submarginal/subgingival cement and how the RTDE caused open margins. [16-18] Many authors, including Misch, recognized and discussed PDE and misfit joints.[19] The author of this article discusses PDE in relation to misfit joints and residual subgingival cement.[23]

Custom abutments can reduce the Resistance to Displacement Effect (RTDE) and make it easier to seat crowns and bridges onto their retainers. This is accomplished by custom shaping the abutment to begin the emergence profile for the prosthesis below the gingiva. This reduces the amount of tissue displacement performed by the prosthesis during installation onto a custom abutment as compared to installation onto most stock abutments. Beginning the emergence profile with the custom abutment essentially widens the trans-tissue portal[6] and thus reduces RTDE. However, with conventional tissue-facing margin designs, the margins can still traumatize the adjacent tissues during their installation and if subgingival, can also stimulate the GE that can cause abundant subgingival cement. In addition, tissue-facing margins cannot compensate for PDE without causing overhanging and open margins.[23] These are all problems with conventional cement-in installation techniques.

Can we use CAD/CAM technology to design a custom abutment margin that pushes the gingival away from the prosthesis margins to prevent both Tissue Effects and prevent poor margins by tolerating some PDE?

It is important to recognize that it is still difficult to accurately control the abutment-margin to gingiva relationship using current design technology. Perhaps it is reasonable to control margin placement ±0.5 mm. (authors research) This problem is made less impactful by the availability of tooth-coloured custom hybrid abutments. However, because it is not easy to control the margin relationship to adjacent gingiva, the Gingival Effects and PDE can still cause residual subgingival cement even with equigingival margins.[21,23,24] As well, PDE still can cause poor prosthesis margins. So, the value of using the expensive custom abutments is diminished if they are not designed to be sensitive to the root causes of complications.

What I find interesting, is that some authors[24] show that equigingival margins can result in subgingival cement, do not offer any explanations as to how that is possible and then suggest that margins up to 1.5 mm subgingival are OK. They are not OK unless subgingival cement is the desired outcome.

In a recent experiment, the Chamfer Margin System (CMS) was compared to the new Reverse Margin System (RMS) to compare their efficacy at preventing submarginal cement.[23] The study demonstrated that the RMS was far superior to the CMS at preventing submarginal cement and that preventing submarginal cement was even more effective under low-pressure installation conditions. This article also discussed why the common CMS may not be suitable for low-pressure installation conditions.[14,23]

These same ground-breaking publications also explained how the RMS was able to compensate for PDE and the TE, while the CMS was not. Understanding the “HOW” is

basic to preventing multiple risk factors for peri-implant disease. Indeed, using the embedded concepts can also make crown and bridge restorations on natural teeth better too. This is a subject for another day. Hint: Single teeth often have the smallest PDE. Use a shallow scooped margin to redirect cement away from the tissues, and use the margin elevation technique to bring deep margins[25] to 0.5 mm subgingival. Whenever practical, choose a single implant over a 3-unit bridge to reduce future complications related to poor margins and subgingival cement.

Conclusions

It is now possible to prevent multiple risk factors inherent to current prostheses installation techniques and usher in a new standard of care for our patients. The research that supports the use of the new RMS has not only revealed and named those root causes but has also shown how they cause problems and how they can be mitigated by intelligent design and protocol.

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Author's Comments

I have practiced dentistry for close to 40 years. There is ample literature describing the problems of prosthesis misfits related to the screw-in installation technique. Judging from the prevalence of the screw-in installation technique, this information has been largely ignored. This is unfortunate, as treatment based on this installation system can be quite aggressive, and consistently exposes patients to many risk factors for serious complications, including the dreaded peri-implant disease. How can we continue to support this system in its present form?

About 8 years ago, I found myself faced with the fact that I could not prevent the occurrence of subgingival cement. This stimulated me to begin my journey to discover the root causes of subgingival cement. **I have now clearly identified the root causes of both misfit parts and subgingival cement.** Understanding the root causes of problems is basic to their prevention. Are we not obligated to continue to strive to make dental care better? Where are the committees that encourage development, sharing and assessment of new information from outside the university sphere?

My research project is self-funded. To discover the root causes of complications and incorporate their benefits into my treatment protocols, I needed to identify and fool software to design the shapes I needed and find the machines that could mill those shapes. To communicate to my colleagues, I needed to create the words to describe those root causes[6] and now have about 7 years of experience, observing the effects of those designs on my treatment results. I am very happy with what I see. I am very happy that I have learned how to use my research training and ingenuity to help my patients avoid being exposed to known risk factors for complications unnecessarily. I am happy that many of the concepts I have developed can also be applied to the safer restoration of natural teeth. This is a big deal as 10 times more natural teeth are being restored with crowns and bridges than dental implants.

There are many stakeholders in the dental health care industry. What disappoints me most, is their apparent lack of effort to understand and implement the steps necessary to improve the standard of care for our patients. I don't see evidence of their proactive efforts to study or even question the significance of the findings I and many others have presented in many formats. Has the system of communication between clinicians, Ph.D. alumni and universities broke down? Did they ever exist?

My findings have huge clinical implications that are positive for the whole industry but most importantly for the patients that we all serve. I have sometimes wondered whether anyone in dental health care, really cares enough to make changes to old treatment protocols that need upgrading. The world is changing around us at breakneck speeds. Perhaps everyone is just too busy dancing to the tunes of the status quo and singing the songs taught to them by key opinion leaders supported by manufacturers. There needs to be a visible portal that is sensitive to ideas for improvement. I have not yet found that portal.

Logic is the highest attribute possessed by humans.[26] I call upon my colleagues to dig a little deeper and use logic to assess the implications of my work. I ask the educators to use their logic to assess their work, and not just continue teaching the same old stuff that has a great record of exposing patients to the risk factors for peri-implantitis. Peri-implantitis and indeed caries and periodontal disease around teeth restored by crowns and bridges are a big deal. These diseases cause our patients a lot of grief. Perhaps we can all do a little better.

All Research references created by Dr. Svoboda are available for free download at www.ReverseMargin.com.

Please email your questions and comments to drsvoboda@rogers.com.

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