Misfit implant parts and poor margins are the Standard of Care for implant prosthetics. Is anyone conflicted about this?

Emil LA Svoboda PhD, DDS

What is the Standard of Care? It is a dynamic concept that changes as improvements to treatment become available. What was best yesterday, may no longer be best today. It may be difficult for a dentist to successfully argue that misfit implant parts are better than their optimized versions. If it became possible to consistently optimize these connections, would that not become the basis of a new Standard of Care?

What are the root causes of misfit implant parts?

I have named these root causes "Prosthesis Dimensional Error" (PDE) and the "Tissue Effects (TE)". Misfit parts result from prosthesis designs and installation protocols that are insensitive to PDE and the TE. Knowing and mitigating the root causes of a problem is the first logical step to preventing complications and improving treatment results.

Why would it be desirable to optimize the fit of parts assembled in the mouth? What do you think would be most beneficial for the patient? Implant parts that have been assembled optimally or less than optimally? Fit parts are expected to be more stable than misfit parts. They are also expected to reduce the movement of oral pathogens into and out of the large internal spaces between parts. More misfits create more spaces for oral pathogens to proliferate and attack peri-implant tissues. If it were possible for dentists to consistently optimize connections, would that not reduce exposing patients to risk factors for mechanical failure and disease?

What does the research say?

Signs of Peri-implant disease are seen in around 45% of implants and the prevalence is similar for prosthetics that are screwed-in or cemented in.[1-5] Many patients have more than one implant. Penarrocha-Oltra 2016 found cemented crowns presented with higher bacterial loads in the peri-implant sulcus, while the screwed-in crowns presented with higher loads in the internal structure of the implant adjacent to the implant- abutment connection.[6] Peri-implant disease is a serious condition related to infection. Can we reduce the mechanical conditions that give rise to the growth of oral pathogens in the peri-implant environment?

There are many steps in the making of a prosthesis that can contribute to PDE, from the impression process, to analogue component accuracy and integration into the dental model, to prosthesis fabrication and refinement. The laboratory technician delivering the prosthesis does not know how well it will fit in the mouth. The dentist receiving the prosthesis will try to determine whether the fit is clinically acceptable, usually after making some adjustments. If the prosthesis were accurate in the first place, no adjustments would be necessary during its installation. As well, dentists would not need to describe its fit in the mouth as "clinically acceptable" rather than optimized.

Clinical tests for accuracy of fit in the complex intra-oral environment are coarse.[7] Dentists are faced with determining clinically acceptable accuracy with tools such as pigtail explorers, screw-tightening tests and lack of rocking of the prosthesis when challenged by finger pressure; all-the-while, prosthesis connections are subgingival or otherwise hidden from view. Use of x-ray imaging to assess the fit of installed prosthesis components has limited value for diagnosing the misfit parts because of resolution, angulation, and focus issues. Peri-implant disease is a microscopic problem that dentists are trying to prevent by macroscopic means. How can this work?

If it is not possible to identify microscopic misfits using clinical tests, how are dentists to know when they have connected parts optimally? It appears that dentists need to augment their assessments of fit using their logic, or their "mind's eye". Indeed, let us see if we can optimize the screw-in prosthesis installation system in the mind's eye. Let us review the current prosthesis installation process for an all- on-x type case, as taught by key opinion leaders and promoted by many implant companies.

What are the challenges?

Dentists need to optimally connect manufactured parts that have a high degree of accuracy and low tolerance for error (±5 microns) onto implants or abutments in the mouth, while these connectors are constrained within an inaccurate prosthesis (±150 microns).[8,9] They are to make these connections while managing the adjacent tissues and working blindly. Yes, that already sounds complicated, and then they need to somehow assess and qualify the installation as "clinically acceptable". Does clinically acceptable imply that the fit of parts has been optimized or just "good enough"?

Jokstad and Shokati [10] found that the vertical misfit of parts ranged from 95 to 232 microns. Is that good enough? Is there any wonder that they and others cannot discern a relationship between level of misfit and peri-implant disease? Every prosthesis that dentists have screwed into the mouth has already potentially been filled with oral pathogens that are only 1 micron in diameter. Perhaps at those gross misfit levels, the numbers of oral pathogens pumped into the peri-implant environment with every bite the patient takes, there is little difference between a

95 micron misfit and a 232 micron misfit. Perhaps it is the patient's resistance to infection that determines the variance expressed as clinical pathology. Negative results always need to be interpreted with great caution.

Shouldn't dentists be able to articulate how they were able to optimize the fit of parts during their installation process? If dentists already accept the status quo, that misfit parts are OK, despite the troubling rate of peri-implant disease, what is their incentive to get better? Can dentists do better? Can they consistently optimize the fit of implant parts?

Government regulators think the stability of connected implant parts is important. Implant parts must meet stability standards while connected with their complimentary implants before Health Canada or FDA will allow them to be sold in Canada or the USA. For these tests, implant parts are optimally connected to individual implants and subjected to mechanical challenges that are intended to simulate function in the intra-oral environment. These parts are joined "optimally" and not in a "clinically acceptable way". Is it assumed that manufacturers would inform dentists how to assemble their parts optimally in the mouth? I have yet to see such instructions. Is it assumed that clinically acceptable fit and optimal fit are the same? They are not the same for multi-unit prosthetics, for sure.

Current installation for all-on-x

In the Lab: For an all-on-x case, the lab technician has affixed multiple prosthetic attachment parts to a large prosthesis to fit the position of multi-unit abutment analogues on a dental model. **(Figure 1)** To reiterate, the lab has connected high precision parts that have low tolerance for error into a prosthesis that is way less accurate than those parts can tolerate. In so doing, the first root cause of misfits, called PDE, has become part of the current installation system.

Figure 1: A technician is cementing prosthetic connectors into a prosthesis in the laboratory to fit a dental model.

In the operatory: The dentist must try to install the large prosthesis while trying to optimize the fit of the prosthetic attachments onto the multi-unit abutments, while pushing the prosthesis against adjacent tissues. The resistance of the tissues to displacement by the prosthesis adds another challenge for the dentist. I have named this root cause of misfit connections the "Resistance to Displacement Effect" (RTDE). It is one of the Tissue Effects (TE) encountered by the dentist during the prosthesis installation process. The dentist must somehow try to manage PDE and the TE simultaneously. Ouch, that sounds almost impossible to do! At best, the misfits between the multi-unit abutments and the prosthetic connectors will become difficult to detect and a "clinically acceptable" installation result will have been achieved. Is it the goal of the installation process to hide the misfits from view or to optimize the fit of parts? Will the misfits be stable? Will they exclude oral pathogens, or will they become incubation chambers for oral pathogens that will assault the peri-implant environment during function?

Why does such a prosthesis have 15 times the peri-implantitis disease rate than a prosthesis with 3 or less retainers?[11] Is this higher rate of peri- implantitis due to the misfit of joints? Is it due to the added cantilevers that are stressing and mobilizing these misfit joints? Is it the wide profile of the prosthesis made necessary for screw-access hole positioning, that blocks access to care? Wow, what a mess!

When the patient experiences peri-implant disease or component failure, whose fault is it? How will the dentist manage these complications? Treatment for peri-implant disease is unreliable[12], uncomfortable and expensive. Who is going to pay? What about the cascade of liabilities that affects the dentist's referral circles, laboratory interactions and implant brand loyalty? What if the patient lodges a formal complaint with the Dental Governing Body?

Shouldn't dentists be able to consistently optimize the fit of implant parts? Acknowledging this problem is the first step towards solving it. Not acknowledging this misfit problem is irrational and fosters ongoing negligence. Let us consider a possible means of consistently optimizing connections to improve results.

New Way of installing all-on-x

In the Lab: This time the laboratory technician makes the prosthesis as usual, but instead of joining the prosthetic connector to the prosthesis, leaves adequate space between the prosthetic connector and its intended housing, to compensate for PDE. That space could vary depending on the technology used to create the prosthesis. A good starting point for a milled prosthesis could be 120 microns (my experience). This is about the thickness of a coarse human hair. The lab technician then seals the screw access hole opening in the prosthesis with acrylic and delivers the prosthesis and the prosthetic connector to the dentist, separately.

In the operatory: The dentist screws together all the implant components in the mouth, including the prosthetic connector.

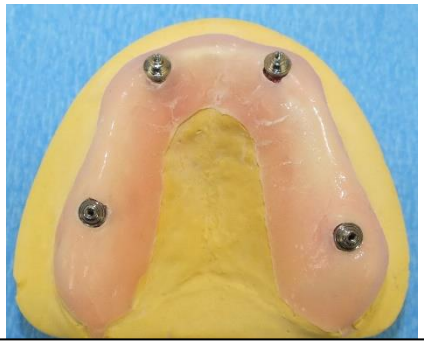

Figure 2: This model is intended to simulate the intra-oral situation. The dentist removes the temporary prosthesis and exposes the installed multi-unit abutments.

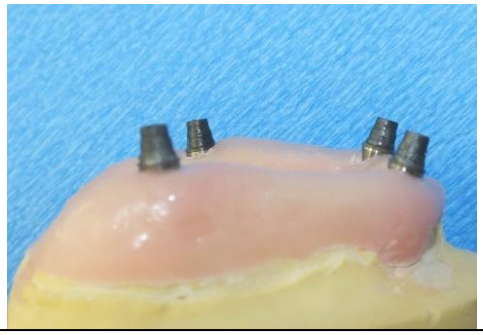

Figure 3: The prosthetic connectors have been optimally installed onto the multi-unit abutments, in the mouth.

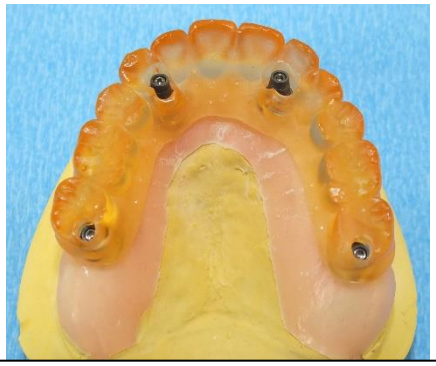

Figure 4: The dentist can easily place and remove the prosthesis to adjust fit and occlusion.

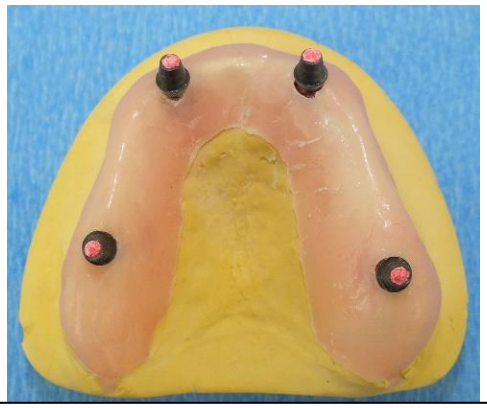

Figure 5: The prosthetic connector screws are protected with compacted Teflon tape.

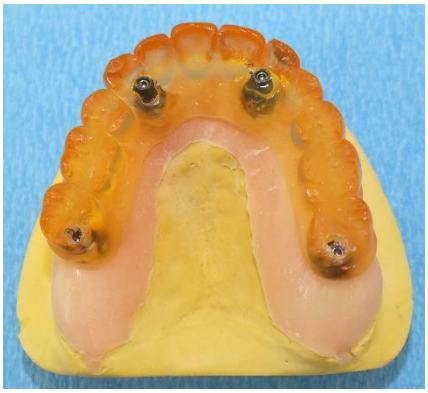

Figure 6: The prosthesis has been cemented into the mouth and the prosthetic connectors have been exposed.

Now the dentist has optimized the fit of all implant parts, for the first time. (Figures 2&3) The dentist can articulate how they have consistently managed to accomplish that important goal. If there is no prosthesis attached to the prosthetic connectors, there is no PDE involved in the connection of implant parts.

Then the dentist fits the prosthesis onto the prosthetic connectors and can adjust it and/or the adjacent tissues to optimize its fit. **(Figure 4)** This is much easier to do in a controlled fashion, because it is not difficult to place and remove the prosthesis multiple times during its adjustment phase.

Once the dentist is happy with the fit and occlusion of the prosthesis, the prosthetic connector screw can be protected with compacted Teflon tape, **(Figure 5)** and the prosthesis can be cemented into the mouth. The dentist then accesses and removes the prosthetic attachment screws and removes the prosthesis from the mouth. **(Figures 6&7)** The cement around the prosthetic connectors can be refined and polished, and the prosthesis can be reinstalled**. For the first time, the dentist has installed a passively fitting prosthesis. I like to refer to this prosthesis installation process as The Svoboda Way of installation**.

There are still problems related to the wide profile of the prosthesis, often required for esthetic screw access, that may block access to care. There may remain the annoyance of maintaining unattractive screw-access covers and failing adjacent porcelain. **However, installing a passively fitting prosthesis onto optimized fitting parts goes a long way to reducing the incidence and liability for complications.** Optimized parts

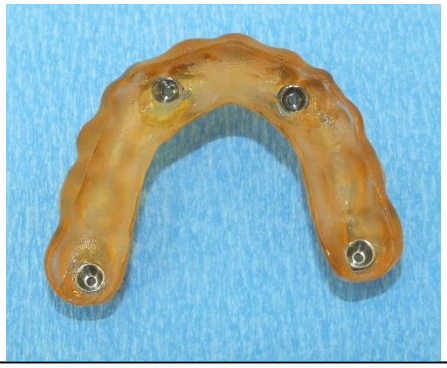

Figure 7: The prosthesis is removed from the mouth and the luting material is refined and polished around all prosthetic connectors. The prosthesis can now be re-installed passively, for the first time.

are apt to be more stable and better able to tolerate the extra stress caused by anterior and posterior cantilevers inherent to the all-on-x type of prosthesis design. **The Svoboda Way of installation results in a "New Standard of Care" and thus needs to be adopted by the dental industry as soon as possible.**

Screw-in Single Tooth Prosthesis

Let's look at single tooth replacements installed by the screw-in system. Single tooth replacements are the most common implant retained prosthetics. Just like any prosthesis installed into the oral environment they must overcome both PDE and TE to allow the dentist to optimize the fit of

implant connections. Though PDE is expected to be less than that inherent in larger prosthetics, contacts with adjacent teeth and working paths of insertion, determined by the implant alignment and adjacent tooth position, create additional challenges to optimizing implant-abutment connections. To achieve an optimized implant-abutment connection, the dentist must adjust the contacts while fitting and screwing the abutment-crown complex into place, and pushing adjacent tissues out of the way of the prosthesis. There are a lot of things going on at the same time.

If the contacts are snug, the dentist will find it difficult to determine whether the implant-abutment connection has been optimized by the tightening of the abutment screw, or whether the path of insertion constraints have taken precedence over the implant-abutment alignment and fit. Because dentists cannot see the connection, it is also difficult for them to determine whether adjacent tissues have prevented the implant and abutment connecting parts from joining optimally.

When the fit has not been optimized, there are times when the retaining screw is torqued down to specifications, causing the abutment to seat somewhat and the crown to upright. This can create a tight contact with one adjacent tooth and an open contact with another. Those instances may necessitate abandoning the installation process and sending the crown back to the lab to close a resulting open contact. On reinstallation, will the dentist really know whether the connection is optimized or partially optimized?

I would say that even installing a single crown onto an implant using the screw-in technique can be challenging and may lead to a misfit implant-abutment joint. Should achieving an optimized fit at the implant- abutment connection be a game of chance? Would you hire a plumber that could only "perhaps connect" the pipes in your house properly?

Screw-in 3 Unit Bridge

Let's look at 3 unit implant supported bridges installed by the screw-in system. These have all the problems of single unit prosthetics, but now PDE will not allow the abutments to seat optimally ever, and the prosthesis interaction with the adjacent and underlying tissues (TE) will be more difficult. I can say with conviction, that it is almost impossible to argue that the dentist has been able to optimize the fit of the implant-abutment connections for splinted crowns or any multiple unit prosthesis.

I think it is safe to say that the current screw-in systems of installation make optimizing the implant-abutment connection difficult for single teeth and almost impossible for multi-units. **I guess misfits are still the old standard of care for the current screw-in type prosthetics. Are you OK with that?**

What do we do now? The current screw-in system of installation is fatally flawed and cannot ensure the optimization of the implant-abutment connection in its present form. It seems that we must separate the abutment installation from the prosthesis installation, to separate PDE from the implant-abutment connection to prevent misfits.

Intra-oral Cementation

Separating abutment installation from prosthesis installation sounds like the current cement-in prosthesis installation system. As such, this system already has the possibility to optimize the implant-abutment connections. Unfortunately, the existing system is not sensitive to PDE or the TE and thus, it cannot consistently prevent residual subgingival cement and prevent open, overhanging, and overextended margins. These poor margin adaptations are an expression of PDE and/or the Tissue Effects called the Resistance to Displacement Effect (RTDE) and another effect called the Gingival Effects (GE). I have discussed these Tissue Effects in detail in a previous article.[13]

The GE occur when the tissue facing profile of the prosthesis presses against adjacent tissues during the installation of a prosthesis by intra-oral cementation. As the prosthesis is forced into place by the dentist, the prosthesis creates a barrier with adjacent gingiva that traps excess cement already in the gingival crevice, plus the cement still being expressed from the prosthesis. This cement is pressurized by the seating movement of the prosthesis and can be forced deep into the tissue spaces. The GE can cause abundant amounts of residual subgingival cement. This term has been coined by the author from the results of his in vitro and in vivo research efforts.

Reverse Margin Installation System

How is the Reverse Margin (RM) System different from the current system of cementation? Unlike the current installation system, The RM prosthesis installation system has been specifically designed to mitigate the root causes of complications. Let us use an example to highlight its unique features and to show how it makes installation better.

1) **Shaping the trans-tissue portal.** The dentist needs to create an appropriately shaped trans-tissue space to facilitate the easier installation of an abutment onto each dental implant. This can be done at the time of implant placement or at any time before restoration. The closer this portal mimics the shape of the final abutment, the easier the installation of that abutment and the more precisely the laboratory technician can position the abutment margin relative to the gingival margin. This portal can be developed by an appropriately shaped stock or custom healing abutment. It is easier to install the final abutment because when the trans-tissue portal mimics the shape of the final abutment, the Resistance to Displacement Effects (RTDE) by adjacent tissues have been thus minimized. The final abutment can move into an optimal relationship with its retainer.

2) **Installing the RM custom abutment(s).** The RM abutment has design features that a) push the gingival tissues away from the intended prosthesis, b) redirects cement away from the tissues and 3) has additional space within the shape of the inflected margin to compensate for PDE. The shape of the margin follows the shape of the adjacent gingiva to limit its subgingival position to ±0.5 mm. This will make it easier to remove excess cement from above its margin and will enhance access for future maintenance. The implant-abutment connection is easily optimized because RTDE have been minimized and there is no prosthesis attached to introduce PDE.

3) **Installing the RM custom prosthesis by an intra-oral cementation process.** The prosthesis retainers have a concave tissue facing shape in the subgingival region where they fit into the RM abutment inflected-margin-trough. This concave profile acts like a sluice-way to guide the excess cement out of the tissue space. The shallow depth of the abutment margin and its ledge make it easier to visualize and clean away excess cement.

Each prosthetic margin has a cement space on its both sides. This space is confined within the shape of the abutment margin and is created to safely compensate for PDE. This important feature also makes the prosthesis somewhat self-centering during the "contact adjustment phase" of installation. Adjusting contacts will be much easier for dentists because the prosthesis will not touch or traumatize the adjacent gingiva during that process. There will likely be no bleeding or swelling to deal with during the cementation process.

So, there you have it. It is now much easier for the dentist to install the prosthesis without causing open, overhanging or overextended margins, or submarginal cement. Isn't that what a good system is meant to do? Shouldn't it be easier to provide quality treatment consistently? Doesn't this **RM System have the hallmarks of a New Standard of Care?**

Some dentists may prefer predrilled plastic covered abutment-screw access holes. It is easy to request them from the laboratory. I prefer to install prosthetics with intact occlusal surfaces to maintain a more stable occlusion and to avoid unsightly acrylic plugs that require maintenance. Also, there are many ways for a lab technician to mark their location, without predrilling the access holes. It only takes a few minutes to drill through the prosthesis, if access is required in the future. However, you may find little need to access abutment screws, if you are able to consistently optimize the fit of parts and prevent submarginal cement.

So now I have identified the root causes of complications and have shown how Prosthesis Dimensional Error and the Tissue Effects interfere with the dentist's efforts to optimally install prosthetics. I have presented a means of preventing mechanical complications and related biological problems like peri-implant disease. I have presented easy-to- adopt solutions that can improve results.

More recent research has now provided a new method for accomplishing all those benefits mentioned in this article, plus a way of reducing the facial-palatal profile of the prosthesis to improve access to care by the patient and the dentist, while maintaining easy prosthesis retrievability. [14]

In Conclusion

I ask again What is the Standard of Care? It is a dynamic concept that changes as improvements to treatment become available. I believe it is time to engage this New Standard of Care for prosthesis installation, to make implant treatment better. Consider using The Svoboda Way process of installation for all-on-x type prosthetics and consider using the RM System for the installation of crowns and bridges onto dental implants. The root causes of complications named in this article are also highly relevant to the restoration of natural teeth.

References

1 Atieh MA et al. The Frequency of Peri-implant diseases: A systemic review and metaanalyses. J Periodontol 2013:84(11):1586-1598.

2 Whittneben JG et al. Clinical Performance of Screw- Versus Cement Retained Fixed Implant-Supported Reconstructions: A Systemic Review. The Int J Oral Maxillofac Implants; 2014:29 (Suppl):84-98.

3 Sherif S et al. A Systematic Review of Screw- versus Cement-Retained Implant Supported Fixed Restorations. J of Prosthodontics 2014 (23)1-9.

4 Daubert DM et al. Prevalence and predictive factors for peri-implant disease and implant failure: a cross-sectional analyses. J Periodontol 2015:86(3): 337.

5 Lee C et al. Prevalences of peri-implantitis and peri-implant mucositis: A systemic review and meta-analyses. J of Dentistry 2017:62:1-12.

6 Penarrocha-Oltra D et al. Implant Sulcus & Implant Connection of Implants Restored With Cemented Versus Screw-Retained Superstructures: A CrossSectional Study. J Periodontol 2016;87:1002-1011.

7 Katsoulis J et al. Misfit of implant prostheses and its impact on clinical outcomes. Definition, assessment and a systematic review of the literature. Eur J Oral Implantol, 2017;10 (Suppl1): 121–138.

8 Buzaya M, Yunus N. Review: Passive Fit in Screw Retained Multi-unit Implant Prosthesis Understanding and Achieving: A Review of the Literature. J Indian Prosthodont Soc. 2014, Mar;14(1):16-23

9 Mobilio N et al. Marginal Vertical Fit along the Implant-Abutment Interface: A Microscope Qualitative Analysis. Dentistry Journal, 2016;4(3):1-6.

10 Jokstad A and Shokati B. New 3D technologies applied to assess the long-term clinical effects of misfit of full jaw fixed prosthesis on dental implants. Clinical Oral Implants Research, 2015;26:1129-1134.

11 Derks et al.Effectiveness of Implant Therapy Analyzed in a Swedish Population: Prevalence of Peri-implantitis. J Dental Research, 2016 Vol 95(1):43-49

12 Jepsen S et al. Primary Prevention of peri-implantitis: Managing peri-implant mucositis. J Clin Periodontol 2015;42 (Suppl. 16) S152

13 Svoboda ELA. Stock abutments cause problems preventable by a well-designed prosthesis installation system. OralHealth October 2019: 46-59.

14 Svoboda ELA. All-on-X: A New Standard of Care for implant prosthetics. www.ReverseMargin.com 2020:1-6.

The Author

Dr. Svoboda graduated from the University of Toronto with a PhD, DDS. He is a Fellow of the AGD, an Honored Fellow of the AAID and a Diplomate of the ABOI/ID. He has received the Award of Merit from the ODA for his contributions to organized dentistry. He practices Implant Dentistry at ParkPlace Dental Centre in Brampton, Ontario. Dr. Svoboda has been granted Patent protection for his innovative Reverse Margin Abutment design. He is thankful to BioHorizons Canada, The Aurum Group® of Dental Laboratories and Core3D Milling Centres for helping to make Reverse Margin Products available to dentists across North America. Dr. Svoboda lectures Nationally and Internationally and loves to work with people that want to make implant treatment better ■