

Dental Implant Prosthetics: Achieving Retrievability and Reducing Treatment Complications By Using a Modified Installation Technique

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Introduction

Implant treatment has greatly improved the level of care offered to patients. According to Misch 2015, implant retained prosthetics are usually installed by a means of intra-oral cementation or by a screw-in method, that involves the extra-oral cementation of the abutment-prosthesis complex on a model.^{1,2} The screw-in technique is commonly referred to as retrievable. It is implied that this installation process allows the prosthesis to be removed from the mouth and reinstalled without any critical damage to the prosthesis. It also implies that a prosthesis that is cemented intra-orally is not easily retrievable and that it would have to be critically damaged during its removal.

No differences in complication and failure rates have been found in reviews that compare the two installation systems.³⁻⁶ The cited reviews indicate that 31- 33% of the fixed prostheses retained by dental implants are associated with mucositis, 10-16% peri-implantitis^{3,4} and that the survival rates of the implants are about 96% over five years and 92% over 10 years.^{5,6} The biological complications of treatment manifest themselves as peri-implant inflammation, exudate, loss of gingiva and supporting hard tissues. All these complications require treatment¹⁻⁷ and can cause a “less than happy” experience for the patient and the dentist. Yes, treatment complications can be emotionally and financially taxing for all involved. The question is, “Can we reduce these complications?”

If we assume that all other pertinent variables have been controlled by the magnitude of the above cited reviews, it stands to reason that we should look to the differences between these two installation systems. In this way, we can identify some

ABSTRACT

Many clinicians prefer to install implant prosthetics by the screw-in method because they believe that this method allows for prosthesis retrievability. However, retrievability does not result from the prosthesis installation method, but relates to “Retrievability Features” created by the implant surgeon and enhanced by implant manufacturers. Unfortunately, these features are not free of cost or risk and they do not solve the problem of the implant-abutment misfit. The iatrogenic component of this misfit problem relates to the extra-oral assembly of the prosthesis on an inaccurate model. The resulting complications appear to be inherent to current screw-in prosthesis installation technique. The author proposes an alternative installation processes that can maintain prosthesis retrievability while controlling excess cement and optimizing the implant-abutment connection. These proposed modifications are particularly relevant to implant prosthetics that are to be installed by the screw-in method. They have the potential to reduce iatrogenic implant complications by 60%. This estimate has been extrapolated from the study of TG Wilson (J Periodontol. 2009;80:1388).

weaknesses contributing to their possible failure. Both systems involve abutment screws that attach abutments to dental implants already in the oral environment, and both systems retain and support a prosthesis that is cemented onto those abutments.

What is the main difference between the two installation systems? The main difference appears to be related to where

the prosthesis is cemented to its' abutment or abutments. In a traditional setting, the screwed-in prosthesis is assembled on a model that is not a precise representation of the mouth. This extra-oral assembly of the abutment-prosthesis complex thus forms an imprecise rigid structure that, when transferred to the mouth, causes a misfit at the implant-abutment junction. This misfit problem can be exacerbated by tight contacts with adjacent tooth structures, which also can prevent the abutment from seating fully onto its implant retainer.

A misfit at the implant-abutment junction is not optimized for stability and is also more susceptible to invasion by oral pathogens. This can create problems for the patient. These problems can include loose and broken screws, foul odour and taste, and the abovementioned complications including mucositis, peri-implantitis and implant failure. The misfit of the implant-abutment junction is a known risk factor for peri-implant disease. These complications can be difficult to mitigate because the implant-abutment misfit cannot be easily rectified.⁸⁻¹¹ In addition, one must consider the possibility that uneven loading of an ill-fitting connection by the abutment screw tightening process and/or intra-oral function could also cause damage to the adjoining components. It is possible to replace a damaged abutment, but how does one repair a damaged implant top? **In conclusion, the major weakness of the screw-in prosthesis technique, appears to result from a misfit at the implant-abutment connection that is difficult to correct.**

It is widely accepted that intra-oral cementation of the implant prosthesis allows the clinician to optimize the fit of the implant-abutment connection¹ but adds a problem related to the incidence of residual subgingival cement.¹¹⁻¹⁴ Residual subgingival cement is a known risk factor for "peri-implant disease". Peri-implant disease is a term used by Wilson (2009) to describe mucositis and/or peri-implantitis. He demonstrated that residual subgingival cement was associated with 81% of the peri-implant disease cases he found among a group of cemented single tooth replacements. He also found that its removal could eliminate signs of peri-implant disease in 74% of these cases.¹⁴ On the basis of this study, a clinician could expect to reduce peri-implant disease by 60% by preventing the occurrence of residual subgingival cement. Current research has identified new information about the process of intra-oral prosthesis cementation that could prevent the occurrence of residual subgingival cement.^{12,13} **In conclusion, while intra-oral cementation can optimize the implant-abutment connection, the major weakness of this process appears to be the control of excess cement. New information about the process of intra-oral cementation promises effective management of excess cement and may reduce the incidence of iatrogenic peri-implant disease by 60%.¹⁴**

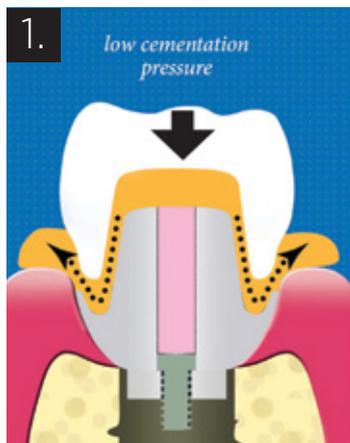
Svoboda has identified the negative effects of margin design and adjacent gingiva on the flow of excess cement and has proposed a method of mitigating these problems.¹⁵⁻¹⁸ He found

that tissue-facing margins eject excess cement towards and into the tissues, while an inflected margin design could redirect the cement away from the tissues. He called this inflected margin design the "Reverse Margin". When margins were placed into the subgingival environment, he demonstrated that gingiva could form a seal with the prosthesis, restrict the flow of excess cement out of the subgingival environment and thus cause excess cement to be projected deep into the tissues. He named this undesirable effect the "Gingival Effects". He further identified four components of the Gingiva Effects that he named the Deflection Effect, the Eddy Effect, the Plunger Effect and the Bellows Effect. Dr. Svoboda found that the Gingiva Effects could be mitigated by abutment and prosthesis design, and facilitated by alterations in the prosthesis installation process. Based on his in-vitro experiments he proposed the "Cement Control System" to prevent the occurrence of residual subgingival cement. He felt that the Cement Control System and supporting work, should be understood by all those who wish to install prosthetics into the oral environment.¹⁸⁻²¹ **Figures 1 and 2** are illustrations that show design features in the custom abutment and prosthesis that form part of the cement control system. These design features help direct excess cement out of the tissue spaces and facilitate the desired movement of cement by creating a clear passageway between the prosthesis and gingiva. Conventional abutment and crown designs often direct cement into the tissue spaces and then trap excess cement between the gingiva and undersurface of the prosthesis. This excess cement is then driven deep into the tissue spaces when the prosthesis is pushed into place.

New Technique

To create an optimized treatment plan the dentist must weigh the advantages and disadvantages related to many available treatment approaches. These include the needs of the patient and their own set of skills and support. Many dentists consider retrievability of the prosthesis to be of paramount importance. These clinicians prefer to install implant prosthetics by the screw-in method, because they believe that this method of installation allows for prosthesis retrievability. Dr. Svoboda proposes that prosthesis retrievability does not result from the installation method, but relates to "Retrievability Features" created by the implant surgeon and enhanced by the implant manufactures. The surgery related features include placing implants in a position that allows for a working path of insertion and a desirable abutment-screw access-hole location. Surgical stents and site development procedures are often used to facilitate the optimized implant positions which then allow for prosthesis retrievability. The implant manufacturers have created multi-unit abutments and special abutment screws, like the angled screw channel abutment (ASC) from www.NobelBiocare.com, to build some tolerance into the abutment-prosthesis system for restoring implants placed in non-optimal positions.

It is important to realize that the Retrievability Features are not confined to either of the two major prosthesis installation



An illustration that shows the movement of excess cement during crown installation. The margin of the abutment and the crown form a nozzle that redirects cement out of the tissue spaces.

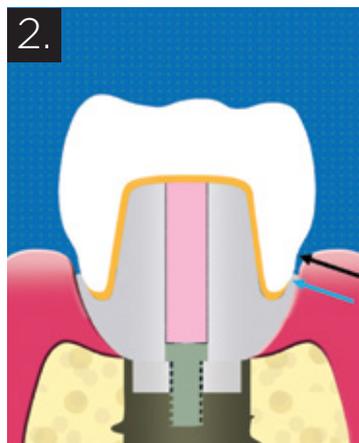


Illustration that shows the inflected margin of the abutment and crown (blue arrow). The crown shape in the subgingival portion (black arrow) allows excess cement to flow out of the gingival space. The small horizontal bumper (0.15mm) pushes the gingiva away from the crown surface.



Shows two splinted crowns installed by the screw-in technique on the same model as in Figure 4. Blue acrylic has been used to fill the crown access holes to the abutment screw. Abutment screw access holes can be created by drilling through the top of the acrylic plugs over the screw access channels.



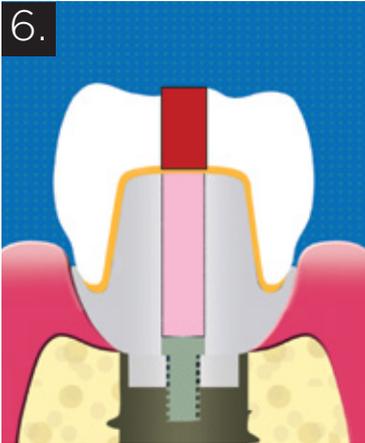
Shows two splinted crowns installed by the cement-in technique on the same model as in Fig 3. Abutment screw access holes could be created by drilling through the top of the crowns over the screw access channels.



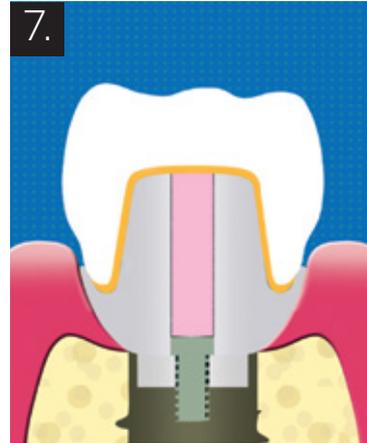
A peri-apical x-ray image the splinted crowns from Figure 4 in place on their retaining implants. This prosthesis has been cemented into the oral environment and is retrievable.

methods mentioned above. They can be used as part of the treatment process, whether the clinician wishes to install the prosthesis by the cement-in or screw-in the technique. **Figure 3** shows two splinted crowns assembled on a model to demonstrate how they would appear after being installed onto implants inside the mouth. In this example, the acrylic screw access plugs would be put into place after being “installed” in the mouth. In **Figure 4**, the crowns appear as if they were installed by a cement-in technique. **Figure 5** shows an X-ray of the splinted zirconia crowns from **Figure 4** after being installed onto implants already inside the mouth. The cement-in case has “Retrievability Features” in place and is thus fully retrievable by gaining access to and removing the abutment

retaining screws. This can be easily accomplished with the use of a course round diamond and a high speed handpiece. However, “Retrievability Features” are not responsible for solving the significant problems associated with the misfit of the implant-abutment connection caused by the conventional screw-in prosthesis installation technique. It is the intra-oral assembly of the abutment-prosthesis complex that solves this problem. The case depicted in **Figure 5** was cemented intra-orally after the abutments were already torqued into place. This allowed for the optimization of the implant-abutment fit prior to cementation of the prosthesis. This process creates a huge advantage, as it can increase the stability of this important subgingival implant-abutment connection and makes it



6. A cross-sectional illustration of a single retrievable crown with screw access hole filled with acrylic (red rectangle) during installation by intra-oral cementation. This screw access hole can be opened to allow for removal of the crown and its reinstallation after ensuring that all visible excess cement has been removed. This is part of the Svoboda Modification process.



7. A cross-sectional illustration of the use of the "Simplified Svoboda Modification" for installation of a retrievable crown. Excess cement has already been removed. An abutment screw access hole could be opened if and when it became necessary to access the abutment screw for screw tightening or crown removal.

less pervious to infection by oral pathogens.

Combining the retrievability features with intra-oral cementation and/or the screw-in prosthesis installation technique presents the clinician with a new opportunity to optimize the implant-abutment connection and control residual subgingival cement. This combination of techniques can be referred to as the "Svoboda Modification". This important modification to the current screw-in technique promises a reduction in the existing iatrogenic complication rate by 60%. This reduction in complications is similar to that already discussed for intra-oral cementation technique using the cement control system. This would indeed be welcome news to those patients and clinicians struggling with the negative consequences of treatment complications and failure.

The Svoboda Modification Assumes That The Retrievability Features Are In Place

To implement the Svoboda Modification, the clinician would complete the following steps: 1) To optimize the implant-abutment connection, the clinician would install the abutments into the mouth individually and torque them into place according to manufacturers recommended torque values. Then the dentist would pack the abutment screw access channel of each abutment with sterilized Teflon tape (Plumbers' Tape) to prevent cement from entering it. 2) The dental laboratory would deliver the fixed prosthesis with adequate cement space, 80 microns would usually be sufficient, and with the abutment screw access holes closed with an acrylic plugs (Figs. 3 & 6). 3) The clinician would try-in, adjust and then cement the optimized prosthesis into place. The optimized prosthesis would fit passively onto

the already installed abutments prior to cementation. 4) After intra-oral cementation, the clinician would then drill out the acrylic plugs, remove the Teflon tape and the abutment retention screws. The prosthesis and adjacent tissues could then be checked for excess cement. Any detected excess cement could be removed. 5) The clinician may choose to use new screws and re-install the prosthesis back into the mouth according to the manufactures directions, fill the access chambers with Teflon tape and fill the occlusal portion of the access hole with a color matched acrylic plug. The patient will now have a retrievable prosthesis that looks like those installed by current techniques, but now is much better. It is better because the clinician has now optimized the implant-abutment connection and has thus reduced the possibility of idiopathic complications related to misfits at the implant-abutment connection.

Further, if the clinician wishes to eliminate the screw access holes and the annoying problems related to them, they can simply eliminate the time consuming steps 2), 4) and 5) from the above Svoboda Modification, and simply cement the prosthesis into the mouth using the features and technique of the Cement Control System (Fig 7). This system is already designed to optimize the implant-abutment connection and prevent the occurrence of residual subgingival cement. To make it easier to locate the screw access channels in the future, the clinician could have their lab technician mark the occlusal access positions of the screw access channels and/or record their position prior to cementation of the prosthesis. It is usually not difficult to open the access channels with a course round diamond, on a "need to do so" basis. However, the screw access holes may never need to be opened, because the clinician has

already controlled excess cement and optimized the fit of the implant-abutment connection. This simplified process could be called the “**Simplified Svoboda Modification**” as it reduces both installation steps and treatment complications. Using this technique, the installed prosthesis is still completely retrievable and promises to reduce those bad days for clinicians and their patients dealing with idiopathic treatment complications.

Discussion

The cementation part of the above described process is based on the work previously published by the author and described as the Cement Control System.¹⁸⁻²¹ His publications describe the recommended process of implant prosthesis installation with the specific design features that facilitate cement control. The main aspects of the process include, installing the abutments individually to optimize their fit, trying-in the prosthesis to ensure a passive optimized fit, and cementing it in with an appropriate cement while using a “super low” cementation pressure. Indeed, use of cementation pressures in the order of 100-150 grams²¹, rather than 250 grams and 4,000 grams or more,^{22,23} supports the concept of better cement control. Once the prosthesis is deemed seated, it is appropriate for the clinician to increase seating pressure to ensure optimal placement and to hold the prosthesis in place as the cement is being set.

Dr. Svoboda would like to acknowledge that there is a system of implant prosthesis installation referred to as the “Screwmentation Technique” (www.Dentaltown.com). The Google search engine was used to retrieve an article written by Dr. J Scott (2014) about this technique²⁴ and another by Dr. B. Birdi (2015).²⁵ These techniques appear to have some similarity to the above mentioned Svoboda Modification.

The Screwmentation technique involves adjusting the prosthesis contacts inside the mouth before extra-oral cementation and then installation of the assembled abutment-prosthesis complex into the mouth. Because it involves the assembly of the abutment-prosthesis unit outside the mouth, it thus suffers from the same problems as the conventional screwed-in prosthetics. It has the probability of creating a misfit at the implant-abutment connection due to model and prosthesis inaccuracy. Also for a more accurate adjustment of the contacts on the prosthesis, it may be necessary to fully torque down the abutment(s). As the abutment is torqued down it tends to settle into the implant connection and can upright itself while doing so. Without fully torqueing the abutment, the contact may still shift when placing the abutment-prosthesis complex back into the oral environment and create a misfit. Nonetheless, it is a progressive concept that attempts to mitigate a problems of residual subgingival cement and implant-abutment misfit due to tight contacts with adjacent teeth.

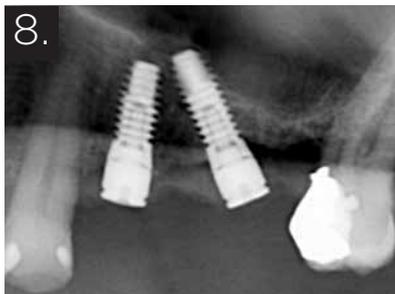
M. Rajan and R. Gunaseelan (2004) proposed a technique that is similar to the Svoboda Modification.²⁶ There were a few differences. 1) Like the Screwmentation technique above, they did not

fully torque down their abutment screws prior to intra-oral cementation. As discussed above, this can affect the fit of the contacts with adjacent teeth and thus fail to optimize the implant-abutment connection. 2) They did not close off the screw access holes prior to intra-oral prosthesis cementation. This would have altered their control over the cementation process, as they would not have been able to control their cementation pressure to ensure the elimination of cement voids and control the volume of cement exiting the margins of the prosthesis. 3) They presumed that there were cemented cases that they did not need to retrieve to clean away subgingival cement. As they were not yet privy to the “Gingival Effects”, the Cement Control System and the work of Tomas Linkevicius¹¹, they might not have been able to determine when they should remove the prosthesis for residual cement removal. In any case, they appear to have been on the right track and were certainly concerned about removal of residual subgingival cement and thus reduce its possible damaging effects.

After the ravages of oral disease, the resulting oral anatomy can be challenging for treatment involving dental implants. The maxillary anterior ridge is often shrunken and proclined, the posterior maxilla has significant sinus cavities and the mandible has various concavities and the location of the mandibular nerve to consider. Yes, we know how to do some very sophisticated site development procedures to alter the anatomy of the remaining tissues to accommodate parallel dental implants. However, these procedures are not free of cost or additional risk. Grafting procedures can fail. Also, there may be an additional cost of special imaging procedures and surgical guides to help align multiple parallel implants, and additional laboratory costs relating to screw access channels and specialized parts. These procedures and parts add cost and risk to treatment. Patient financial and health considerations can make all the above procedure related site development procedures even more difficult and risky to carry out.

Figure 8 shows an X-ray of a patient with an implant placed on an angle adjacent to the maxillary sinus cavity. In order to make this case retrievable, it would have been necessary to place this implant parallel to the adjacent upright implant. This requirement for prosthesis retrievability would have stimulated the need for a site development procedure known as a lateral sinus graft. In this particular case, the patient was a smoker and his habit would have made the required grafting procedure risky. In this case I was able to avoid the risk and cost of the lateral sinus graft by the angled placement of the implant. This appears to have been a good choice for this patient. However, I have taken this approach to implant placement many times for both smokers and non-smokers to avoid grafting procedures and increase the efficiency of treatment.

Figure 9 shows the use of custom milled site-specific abutments to control abutment design features and to create parallel retaining elements to compensate for the off-parallel nature of the implants. The use of Teflon tape compressed



8. A cropped X-ray image of two implants in proximity of the maxillary sinus. The implant adjacent to the sinus cavity is angled to avoid the sinus space and to take advantage of available bone.



9. Shows customized milled titanium abutments with parallel retaining elements. They have been installed onto the dental implants shown in Figure 8. The abutment screw access holes have been filled with sterilized and rolled pink Teflon tape. The abutments are now ready to have the solid zirconia bridge cemented upon them.



10. A cropped X-ray image of the solid zirconia bridge cemented onto the custom abutments shown in Figure. These abutments were already attached to the implants shown in Figure 8, by abutment screws.

into the screw access holes appears to be widespread and it has completely replaced my use of cotton balls for the same purpose. The pink Teflon blocks luting cement from flowing into the screw access channels and thus makes it much easier access abutment screws when necessary. It is also easier to detect under cement, due to its pink color, and much easier to remove with an explorer. **Figure 10** is an X-ray that shows the prosthesis cemented into place in the oral environment. The implant-abutment junction has been optimized and excess cement removed. However, it does not possess the required features to make it retrievable. Perhaps the use of temporary cement could make it retrievable, but this particular bridge was cemented with an acrylic cement and thus would likely need to be sectioned for removal. It would not be necessary to remove this prosthesis if I need to retighten the abutment screws. For this purpose I would only need to create an opening through the crown into the abutment screw channel. This is easy to do with a course round burr.

What Are The Advantages Offered By Prosthesis Retrievability?

When prosthetic materials are not durable, like with acrylic based hybrid fixed prosthetics, retrievability may have a relatively high value, so that it will be possible to make necessary repairs or refurbish the prosthesis. When prosthetics are durable, like solid zirconia bridges, do you ever expect to take them out for repair? If they have porcelain on them and the porcelain has a critical fracture, can the dental laboratory really fix the prosthesis or will it be a remake anyway? I would suggest that it will usually be the later. What about loose screws? What do you think will have more loose screws? A prosthesis with a misfit at the implant-abutment junction, like

a screwed-in multi-unit hybrid, or one with an optimized implant-abutment fit? So, optimizing the fit of the implant-abutment junction and proper torquing and re-torquing of the abutment and would be expected to further reduce abutment screw loosening to an unusual event.^{27,28}

Do you need to be able to remove a prosthesis from the mouth in order to tighten a loose abutment screw? That is usually not necessary. In most locations, like in **Figure 10**, an access hole can be made through the prosthesis and the loose abutment screw can be tightened without removing the prosthesis. In the anterior maxilla, there might be an advantage to have a lingual access channel for possible screw tightening procedures, because making a facial screw access channel opening could render the prosthesis unaesthetic. This could be a cause for prosthesis replacement. It is also unfortunate that the lingual access channel may require the clinician to build a facial cantilever into the prosthesis. This may also cause additional mechanical stresses on the abutment screw and make the prosthesis difficult to maintain by the patient. Both of these problems may feed into the peri-implant disease process and cause the failure of the retaining implant(s) and their attached prosthesis. So, building retrievability into a treatment is dependent on many elements that are not free of cost and risk.

So What Has Made This New Treatment Approach With Site Specific, Individually Designed And Milled Abutments And Prosthetics Practical?

1) Dental milling technologies, that are CAD/CAM based, have allowed the dental industry to create increasingly precise implant-abutment components. Milled components can be made to fit better and thus be more stable and resist bacterial penetration better. Beware of older technologies that require a

casting process that can distort the milled implant-abutment connection. The UCLA bases are precision milled, but the casting process can damage their fit by temperature related distortion and mechanical removal of investment material.²⁹ A poor implant-abutment fit can lead to increased complications.

2) The dental milling industry can create and mill a large variety of custom shapes out of a variety of materials that can better fulfil the needs of the patient. The needs often include a desire for mechanical and biological stability, good esthetics and cost effectiveness. This article discusses new designs for custom abutments and prosthetics that can improve the mechanical and biological stability of implant treatment by preventing implant-abutment misfits. Hybrid abutments, titanium bases with zirconia superstructures, can be used with the new design concepts for esthetic purposes. Previous articles by the author describe the Cement Control System that can reduce complications by preventing the occurrence of residual subgingival cement. The recommended new procedures and processes for those who wish to incorporate retrievability into their treatments can reduce iatrogenic implant-abutment misfits and their related complications. Now we just need to incorporate these innovations into patient treatment. Complications are expensive. Preventing complications can be very cost effective for both the patient and the clinician.

3) Milled zirconia and other monolithic crowns and bridges can be esthetic and can be more resistant to failure than prosthetics that are veneered with porcelain. Indeed, newer “more translucent zirconia materials” promise to be even more esthetic and thus further reduce the need for the application of veneering porcelain. A decreasing use of porcelain means a reduced need to remove, repair and replace prosthetics due to porcelain failure. Reducing the need to remove prosthetics that are failing due to their mechanical weakness will reduce the need for retrievability. This is nice because retrievability features can be expensive to incorporate into treatment. Optimization of the implant-abutment connection during the prosthesis installation process should already reduce the incidence of screw loosening and thus the need for screw access for re-tightening purposes.

4) Newer cements can have higher compressive strengths, are fluid and have a longer, more controlled working time. Their cleanup can also be easy, when they are removed during their “gel state”. Further, they are not subject to “washout” at the margins.³⁰ Thus, together with the new cement control designs and techniques, the clinician can considerably reduce the forces involved during the intra-oral installation process. Less force means more control over the flow of excess cement.¹⁷⁻²¹ Beware of old habits and old prosthesis designs that require the clinician to compress tissues and otherwise use high pressure intra-oral cementation techniques. This exacerbates

problems related to residual subgingival cement.

5) It is the author’s opinion, that in spite of best efforts, it will be some time before the dental industry will be capable of making implant prosthetics sufficiently precise to avoid the need for cement.^{31,32} Indeed, in 1985, PI Brånemark mused about creating a fit between components that should be within 10 microns of their target.³³ This can already be considered “pretty sloppy” if one considers that oral pathogens can be mobile and are about 1 micron in diameter. Together with errors from impressions, models, scans of models, and analogues the dental industry still feels that an error of 100-150 microns is clinically acceptable.³² But is it? The best the dentist can do at the present time is to utilize components that fit as precisely as possible and ensure that their installation technique does not make the fit between components worse. Then the dentist needs to rely upon the patient’s immune system and post treatment maintenance protocol to take care of a reduced negative effects of inaccuracy of fit. Ideally, the implant industry will continue to be inspired to make their components fit better and thus be more resistant to occlusal forces and at least seal connections between components against bacterial invasion. All of this still lies in the future.

In Conclusion

The author would like to encourage the clinicians, who choose to work with retrievable prosthetics, to integrate the above “Svoboda Modifications” into their implant prosthesis installation protocol to reduce the incidence of iatrogenic implant-abutment misfits. The new proposed protocol for implant prosthetics installed by the screw-in technique may reduce iatrogenic complications by as much as 60%. Preventing complications for the patient and the clinician would be welcome news for all involved. **OH**

The author encourages further communication about the above ideas. Email Dr. Emil Svoboda at drsvoboda@rogers.com with your comments and questions. More information about this and supporting work is available at www.ReversMargin.com.

Oral Health welcomes this original article.

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