

# The Evolution from Stock to Custom Abutments Allows for a Better Prosthesis Design that can Control the Gingival Effects and Thus the Flow of Excess Cement

Emil L.A. Svoboda PhD, DDS, Published to [www.ReverseMargin.com](http://www.ReverseMargin.com). July 8, 2015.



## Introduction

**Abutments** are devices used for attaching dental prosthetics to dental implants. Abutments used to retain fixed prosthetics are available in many configurations. These can be divided into two broad categories – 1) Stock or Standard Abutments and 2) Custom or Patient Specific Abutments.

Perhaps this second group could also be called “Site Specific Abutments”, because they are actually custom designed and made for specific implant sites to optimize the desired prosthetic treatment. It became apparent during the research of this topic, that the transition from stock to custom abutments is similar to the evolution from stock to custom crowns.

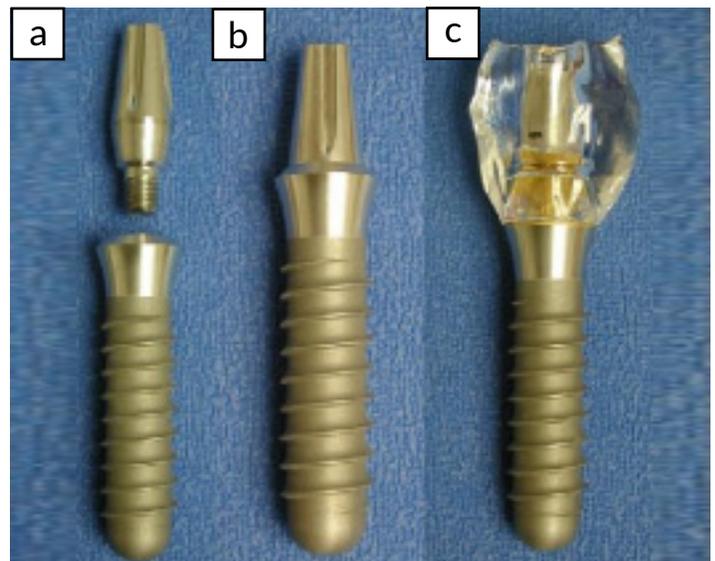
Most abutments are made of titanium or titanium alloy. Some abutments are made out of zirconia and some are hybrids of the two materials. The hybrids usually have a titanium base with a zirconia superstructure cemented onto them. These hybrids may be an industry response to a weakness of the internal connection of the solid zirconia abutment with the implant and/or the inability to achieve the precision of fit required at the implant-abutment interface. Unlike the metal color of titanium, zirconia abutments are closer to the color of the teeth they are meant to retain. They are intended to reduce the grey show-through of the titanium metal, experienced by some patients with thin gingiva, and to reduce the visibility of the abutment-prosthesis margin in case of gingival recession.

Both titanium and zirconia are able to osseointegrate, and can thus be regarded as biocompatible materials.

**Stock Abutments** are usually mass produced by implant and abutment manufacturers. They are not all the same.

Some are simple retainers for the prosthetics, while others have sophisticated configurations that try to mimic or approach shapes that “best fit” the clinical needs of a patient with a specific implant site configuration.

**The first group of stock abutments can be called “Simple Stock Abutments”,** as they are basically stems that are attached by cement or screw into the center of the implant. They can be straight or angular in shape. This type of abutment acts like a simple retainer for **the prosthesis and depends on the margin on the implant to interface with the prosthesis.** (Fig 1) Some one piece implant-abutment configurations also fall into this group, as the prosthesis is intended to sit on the implant margin while retaining the prosthesis with its center vertical component.



**Fig 1 (a)** the abutment is above the implant. **(b)** the abutment has been screwed into a channel in the top of the implant. **(c)** has a crown attached to the implant and abutment with its margin resting on the margin of the implant.

This arrangement is highly dependent on the clinician determining the position of the implant-prosthesis margin during surgery. Of course, the final position of this abutment margin, relative to the gingival margin, is variable as the healing process is variable. This system depends on margin position that is not that critical for esthetics and is often supragingival or equigingival. Linkevicius et al. <sup>(1)</sup> and others <sup>(2)</sup> have shown that subgingival excess cement is difficult to locate and remove from margins that are over 1 mm below the gingival margin.

In some cases, the clinician may elect to adjust the implant margin to manage the unfavorable margin position. These modifications often result in subgingival margin configurations that are feather edge or shallow chamfer in design. This can predispose the patient to problems related to residual subgingival cement relating to margin design and the “Gingival Effects”. <sup>(3)</sup> I will discuss this in detail below.

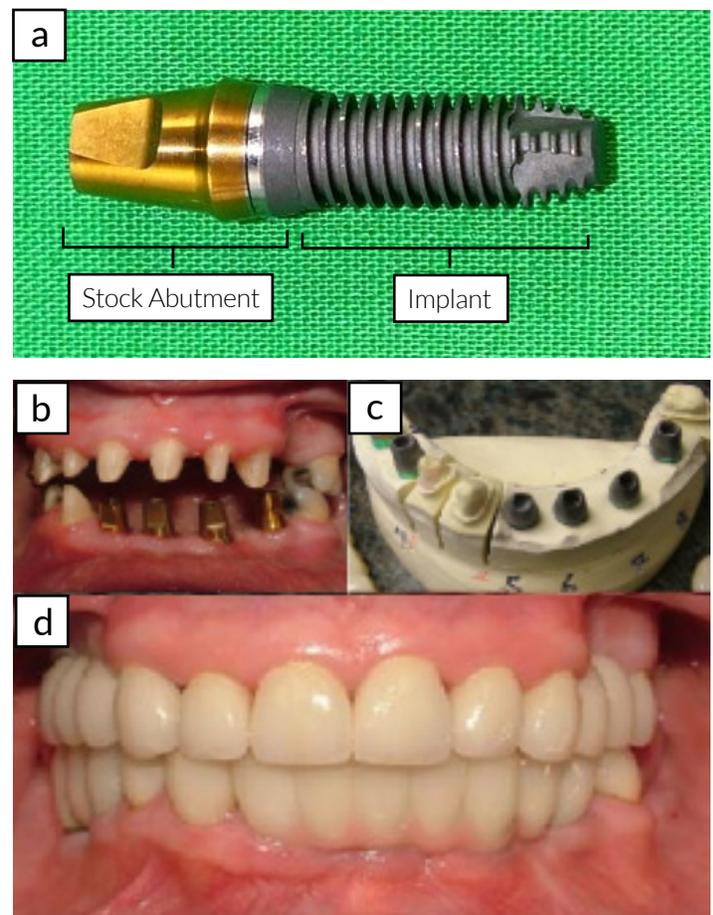
Recently Wilson <sup>(4)</sup> has raised some concerns about the possibility of particles of titanium, zirconium and cement in the peri-implant environment causing a tissue reaction that may result in inflammation and peri-implantitis and thus possible failure of dental implants. This research does not bode well for those <sup>(5)</sup> that plan to modify or “customize” the shape of the implant, abutment or prosthesis near or under the gingiva, in the intra-oral environment.

**A second group of stock abutments can be attached to their retaining implants and are intended to both retain the intended prosthesis and serve as a place for the prosthesis to terminate.** By far the majority of mass produced stock abutments in this second group are round in circumference at the proposed margin, because they are easier to mill with this configuration. They may also have some added flattened surfaces to aid in impression taking and laboratory procedures. (Fig 2)

These abutments may be shaped somewhat by the clinician or laboratory technician to remove undercuts that would impede prosthesis installation. The margin position may also be modified somewhat, by the laboratory technician

or clinician. This abutment modification would be limited because the metal of the abutment is not very thick. The modifications often result in subgingival margin configurations that are feather edge or shallow chamfer in design. <sup>(5)</sup> This can predispose the patient to problems related to residual subgingival cement. <sup>(1, 2, 6)</sup>

The prostheses retained by such abutments would usually be customized to form the emergence profile of the replacement teeth. Intra-oral cementation of such a prosthesis would predispose the patient to problems related to residual subgingival cement as a result of the “Gingival Effects”. <sup>(3, 7, 8)</sup> I will discuss this in detail below.



**Fig 2 (a)** has a gold color stock abutment attached to an implant. **(b)** has several abutments attached to implants and used as impression copings, **(c)** shows the modified abutments from **(b)** on a laboratory stone model and **(d)** shows the prosthetics cemented onto abutments in the mouth.

**Teeth that are being replaced by a fixed prosthesis are not usually round in shape or have the same diameter as the implant.** Thus, the base of the prostheses are usually shaped to transition from the round shape of the retaining implant-abutment interphase to the various shapes of the teeth they are replacing. Further, the contour of the gingival margin around the abutments are also not usually level, but are higher on the mesial and distal and lower on the facial and lingual. The height of gingiva is also highly variable in all of these locations. This can create great difficulty for the clinician who wishes to control the flow of excess cement during the intra-oral cementation procedure and even greater difficulty for its' complete removal. <sup>(1, 2)</sup>

Wilson<sup>(6)</sup> has shown that residual excess cement is a known risk factor for peri-implant disease that may lead to the failure of the retaining dental implants. According to Wadhvani and Linkevicius, <sup>(1, 2)</sup> it is very difficult to control cement flow and complete excess cement removal when using stock abutments. Furthermore, Svoboda has shown, "in vitro", how the commonly used feather and chamfer margins can direct cement into the tissues <sup>(9, 10, 11, 12)</sup> and how gingiva can contribute, to causing excess cement to be propelled deeper into the subgingival spaces by the **"Gingival Effects"**. <sup>(7, 8)</sup> These include the 1) "Deflection Effect", that occurs when the gingiva adjacent to the implant-abutment complex deflects excess cement ejected from tissue facing margins (feather and chamfer margins) towards the tissue spaces, 2) the "Plunger Effect", that occurs when the wider base of the prosthesis forms a seal with the gingiva adjacent to the implant-abutment complex, traps subgingival cement, compresses it and injects it deeper into the tissue spaces as the prosthesis is being seated, and 3) the "Bellows Effect" where the base of the prosthesis expands the gingiva laterally and thus causes a vacuum that sucks cement deeper into the subgingival spaces. Recently Dr. Svoboda has identified another "Gingival Effect" that he has named the "Eddy Effect". It can be observed when the excess cement being ejected from the margins of the prosthesis cannot leave the confines of the gingival space fast enough and thus create a backflow of cement into the tissues. This backflow pressure can be reduced by several

techniques. Get a more detailed explanation at [www.ReverseMargin.com](http://www.ReverseMargin.com). <sup>(3, 13)</sup>

**The third group of stock abutments are also mass produced but are more complex in shapes, sizes and margin design.**

The clinician and/or the laboratory technician can choose the abutment that "best fits" the proposed needs of the patient and can also modify these abutments somewhat, to try to achieve an even better fit for a particular implant site and proposed prosthesis. It is difficult to have enough variety of these abutments to actually achieve the "best fit". Since available abutment shapes are limited, they often depend on the prosthesis to create some or all of the natural shape emergence profile of the resulting prosthesis and thus can contribute to the "Gingival Effects" and residual excess cement. <sup>(3, 7, 8, 13)</sup>

The margin designs of this group also varies from feather to chamfer and to butt designs and thus can still contribute to directing excess cement into the tissue spaces. Existing complex stock abutments, still do not have the "Reverse Margin™ Design" to help redirect excess cement flow out of the tissue spaces. They still can contribute to the problem of residual excess cement like the above mentioned stock abutments. <sup>(3, 9, 10, 11, 12)</sup>

These more complex stock abutments can be somewhat better than the less sophisticated stock abutments, but they would not be expected to be as good as **"well designed custom site-specific abutments"** at controlling the advent of residual excess cement. They are also expected to be more expensive to produce, and keep in inventory, than less sophisticated stock abutments, as they have many more variations of shape. There are many clinical situations that would not make them ideal at controlling the advent of residual excess cement. <sup>(2, 3, 13, 14)</sup>

### Custom Abutments (Site Specific Abutments)

Custom abutments are abutments that are designed and created for a particular implant sites to retain and support

a prosthesis. They could also be called “site specific customized abutments”. (Fig 3)

The earliest custom abutments were stock abutments that were modified or customized by the clinician or lab technician to better fit a particular need. The most common customizations were modifications of abutment angle and margin relocation by trimming away of some of the abutment material. The prosthesis was then used to create the desired emergence profile of the replacement tooth.<sup>(15)</sup> This type of abutment is usually grouped with the standard or stock abutment group. Some of the disadvantages of these customized stock abutments are addressed above. (Fig 2)

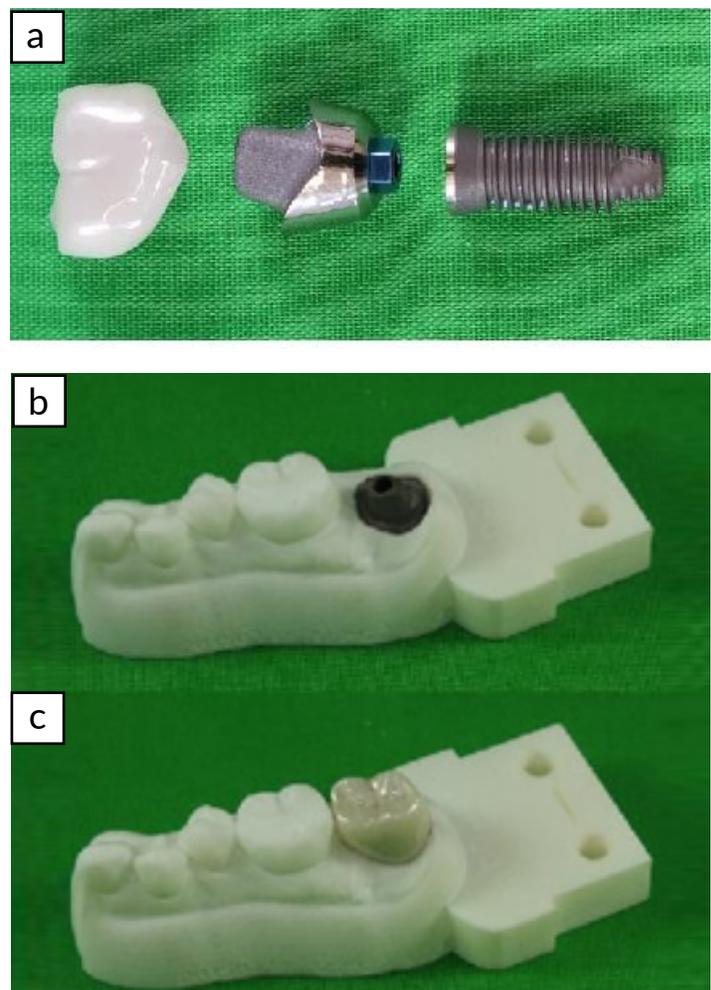
The argument about changing from the primary use of “stock crowns” (above) to “site specific customized crowns and bridges” appears to be very similar to the argument for changing from “stock abutments” to “site specific customized abutments”. It’s an argument about gaining control of the implant-abutment-prosthesis complex to improve the “over-all quality” of the proposed prosthesis and the health of the tissues adjacent to its retaining dental implants. When the implants fail, the prosthesis is also put in jeopardy. Failure is expensive. We will discuss the important features of a “well designed implant-abutment-prosthesis complex” below.

**The UCLA abutment was the beginning of the true custom “site-specific” abutment group.** It allowed the clinician to control the angle of the retaining element and its’ margin design. It even allowed the technician to wax-up a unique shape for the abutment and start the emergence profile of the replacement tooth at a more subgingival location.<sup>(2, 15)</sup> This was a great advantage, as it often resulted in better control of the shape of the prosthesis.<sup>(1, 2, 3)</sup>

Some UCLA burnout patterns had the implant-abutment interphase, unique to each implant system, as part of the burnout pattern and some had a burnout chimney attached to a specific pre-milled metal implant-abutment interphase. This pre-made metal base was shown to be

more accurate than the burnout pattern base design and is mainly used today.

A problem with the UCLA premade base is that it must still be invested, heated to a high temperature and then have the molten metal of the body of the abutment cast against it. This can somewhat distort the precision of its implant interphase and the physical aspect cleaning away the investment material can also damage its implant connection surface. This process is probably not be ideal for making the fit of the implant-abutment interphase better at the microscopic level.



**Fig 3 (a)** shows a custom crown, custom abutment and implant. **(b)** has the custom abutment in place on the model and **(c)** has the crown in place.

**Physical impressions, models, casting and veneering processes all add to the “error of dimensional accuracy” to the prosthesis.** Some errors of size could be compensated for by the movement of natural tooth retainers during the intra-oral cementation process. Dental implant retainers move a lot less, because they are fused directly to bone (osseointegration) and do not have a periodontal ligament. Thus, the dental implant retained prosthesis calls for an even higher level of precision of fit than was required for natural teeth.<sup>(16)</sup>

**Good optical scans and monitored precision milling technology reduces much of the errors inherent to physical impression and modelling technology.** CAD/CAM processes reduce much of the material distortion resulting from the metal casting processes and new materials such as zirconia and silicate blocks reduce the casting requirement and some of the need for veneering. Error reduction means better accuracy of fit.<sup>(17)</sup>

As CAD/CAM technology evolves, the accuracy of fit and design versatility is increasing. In my own experience, the iTero intra-oral scanner plus CAD-CAM design is rendering a precision of fit that I was never able to previously achieve. This has led me to experience less stressful and more predictable prosthesis insertion appointments. There appears to be a number of very good optical scan and CAD/CAM systems available today and this technology appears to be getting better all time. (I receive no compensation for the above statements).

The dental technician may design the prosthesis from the information scanned from conventional laboratory models or from intra-oral digital scans created by the clinician. The intra-oral digital scans are usually more accurate representations of the intraoral condition because the physical impression and model making already introduces some dimensional errors. This is true, in spite of the fact that dental laboratory scanners can be more accurate than intra-oral scanners.<sup>(17)</sup>

The technician may then design, or simply order custom

abutments and/or prosthesis and/or models from a milling centre(s). Some milling centres will create models, abutments and the prosthesis while others will specialize in one element or another. **Some custom abutment centres do not allow the dental technician or the dentist to design the abutment. Accordingly, these custom abutments may not possess the characteristics of the “Well Designed Custom Abutment” (described below) and may not be worth their extra cost.**

**Now let’s get back to the implant-abutment interphase. Its’ accuracy is very important from a stability of the implant-abutment connection and for the exclusion of oral pathogens.<sup>(18, 19, 20, 21, 22)</sup>** Accuracy costs money and detecting inaccuracy can also be difficult and expensive. So you see the problem. The blocks that are premilled to fit the various dental implant connections are often made by different companies with different tolerances and different clamping screws. The difference in cost is easy to detect, but the difference in quality may not be easy to detect by the clinician or the patient. However, precision is likely to have a huge impact on the survivability of dental implant treatment. Failure of implant treatment can be very costly for the patient and the clinician.

**Clinicians “cannot assume accuracy” and optimal fit and stability of components from all suppliers.** They must demand a higher “verifiable” standard from their implant suppliers and abutment suppliers, in order to protect their patients and themselves from the repercussions of unnecessary implant failure. The least expensive components may not be less expensive for patients or for the clinician, when the treatment fails. If the dentists are to be responsible for the quality of the product they deliver to their patients, then the dentist should also be able to choose the appropriate abutment maker through a truly open system. That system does not seem to exist today.

Both the waxed up and cast (UCLA), and the CAD/CAM milled custom abutments can be made on premade metal bases designed to optimize the fit and stability of the implant-abutment connection for the specific type of dental

implant that will retain them. However, unlike the milled custom abutment, the UCLA abutment base will likely be distorted and damaged by the process of casting metal against it to form the abutment body. **The CAD/CAM designed and precision milled implant-abutment connection can be more accurate than the UCLA type connection.**

**However, be aware of a disadvantage related to the screwed-in assembled prosthesis.**

When the clinician wishes to screw the assembled abutment-prosthesis onto dental implants already in the oral environment, contacts with adjacent teeth and prosthesis misfits (a little too big or too small) can put stress on the implant-abutment connection and make its' fit worse. This misfit can compromise the stability of the implant-abutment connection and allow the ingress of oral pathogens and can cause peri-implantitis. (18, 19, 20, 21, 22)

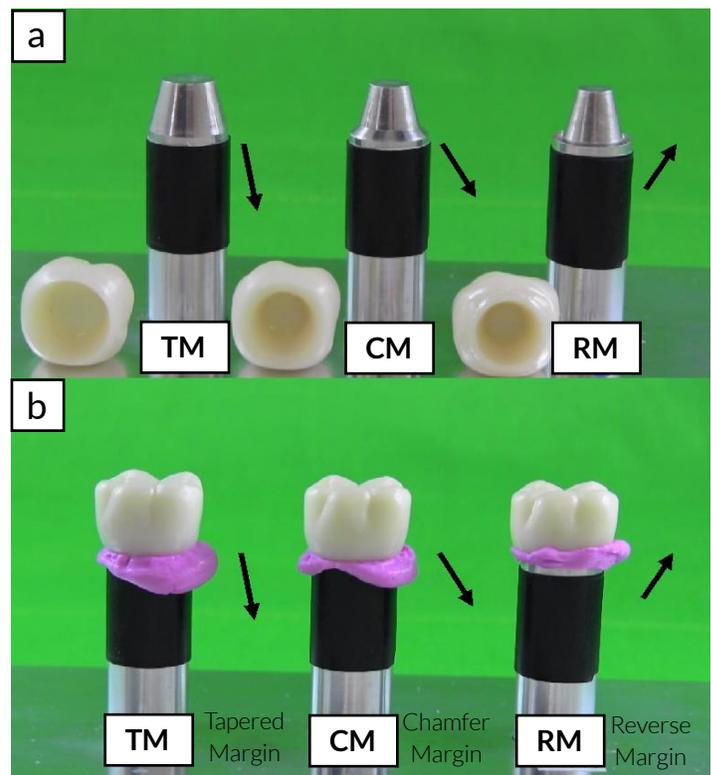
#### The “Well Designed Site Specific Custom Abutment”

The well designed custom abutment should have an optimized implant-abutment fit and stability. This is difficult for the implant industry to accomplish at the 1 micron level of accuracy, but milling can be more precise than casting. Intra-oral cementation of a prosthesis, on already installed custom abutments, is one of the best ways to assure an optimal fitting implant-abutment connection and a passive prosthesis. However, **residual excess cement is a big problem** faced by dentists who cement prosthetics into the mouths of their patients. (6)

Svoboda (2014-2015) has published the results of his “in vitro” research on the effects of margin design on the flow of excess cement. (Fig 4) He then discovered how peri-implant gingiva, bulky prosthesis design and high cementation forces could cause excess cement to be propelled deep into the peri-implant tissues. (Fig 5) He countered this problem with an innovative margin design, an abutment-prosthesis design and installation technique that could prevent the unintended flow of cement into the tissues.

A well designed custom abutment may not optimize the result if the prosthesis design is bulky or the cementation forces are too high. **It is the relationship between the abutment and the prosthesis and the gingiva and the cement and the installation pressure and the cleanup that optimizes the result.** (7, 8, 13)

“The Well Designed Custom Abutments” exert optimal control of the flow of excess cement by their emergence profile, margin position and margin design. They also support the shape of the prosthesis so that the prosthesis can do its' part in the control of excess cement and esthetics. One could say that the custom abutment already functions as the base of the prosthesis and is thus is an integral part of the prosthesis.



**Fig 4 (a)** shows 3 aluminum rods with different margin designs. **(b)**—Shows the rods with zirconia crowns cemented into place. The arrows indicate the direction of the margins and the cement flow. Note, the Tapered and Chamfer Margin designs direct the cement downwards while the Reverse Margin directs the cement upwards.

As the custom abutment transitions from the round shape of the implant to the shape of the prosthesis, the abutment emergence profile needs to push against the gingiva, to stretch it and thus form a barrier against the ingress of excess cement. The margin position only goes subgingival when necessary for esthetics, and it must be kept in a place that is easy to access, to clean away residual excess cement. This position would be 1 mm or less below the gingival margin. The margin design should direct the excess cement away from the tissues and not into them. Use the Re-verse Margin™ Design to redirect excess cement out of the tissue spaces. (7, 8, 13, 14)

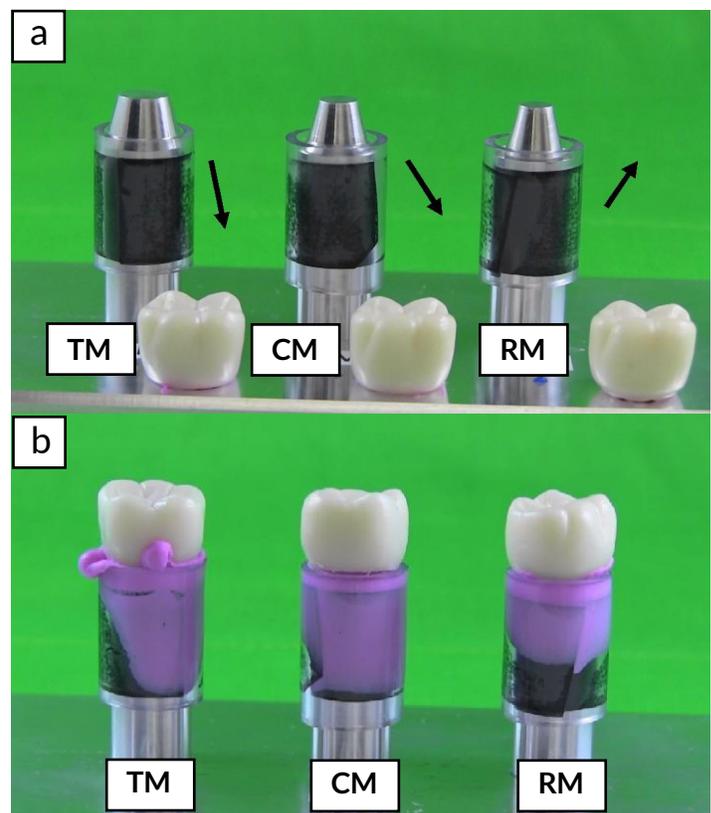
**“The Well Designed Custom Prosthesis”** exerts optimal control of excess cement with a shape that compliments the above well designed custom abutment. Its margin design works with the abutment margin to redirect excess cement out of the tissue space (Reverse Margin™ Design). In addition it does not impede the flow of excess cement out of the tissue spaces, by preventing or reducing the “Gingival Effects”. This will help control the location and cleanup of excess cement.

To minimize the “Gingival Effects” the prosthesis is designed to facilitate the flow of excess cement up and out of the tissue spaces. To do this, the emergence profile of the prosthesis should not become wider than the abutment until after it has emerged from the gingiva. (Fig 6) If gingiva is thick and margins deeper, it may be necessary to actually indent or create a concave profile to the prosthesis as it emerges from the gingiva, to ensure the easy exit of the excess cement. When pontics are involved, the connectors between the retainers and pontics should not block the upwards flow of excess cement. (13, 14)

It is also possible to use a device that pushes out the gingiva temporarily and blocks the ingress of cement. These above design features have been submitted for patent protection.

**“The Well Designed Installation Technique”** is described in a previous publication. (24, 25, 26) An important feature

of this technique presupposes the use of the above design features for the abutment and prosthesis and, the use of **“super low cementation forces”** (0.1 Newtons) to cement the prosthesis in place. Heavy forces are not necessary because, according to the published technique, the prosthesis should already be verified “intra-orally” to fit passively. When the seating of the prosthesis is not impeded by lack of cement space, tight contacts and adjacent soft tissues, it is easy to seat the prosthesis with very little pressure. The clinician can use an appropriate fluid cement with a long working time. A dual cure acrylic cement with a high compressive strength can work well. There is no need for excessive cementation forces! (25)



**Fig 5 (a)** shows 3 aluminum rods with 3 different margin designs that terminate 1mm below the top of the clear Tygon tubes (gingiva). The black electrical tape was placed 1 mm below the margin and is 0.125 mm thick. It fills the space between the tube and the rod. The black arrows indicate the direction of the margins. **(b)** Depicts the zirconia crowns cemented into place. Note the huge amount of submargin cement, regardless of margin design.

The use of super high heavy cementation forces (biting forces up to 600N), evolved from the day when it was necessary to obtain minimum film thickness because the cements had poor compressive strength and poor resistance to dissolution at the margins. The heavy forces were also necessary to overcome resistance of the tight fit onto prepared teeth (use of minimum cement space), to move retaining teeth to compensate for dimensional misfit, to overcome resistance from adjacent soft tissues and contacts, and reduce the fear of premature hardening of cement. These days are hope-fully over. Cements have improved. Cement control is most important, because residual excess cement is a big problem. It is easier to control cement the flow of excess cement when using super low installation pressures to install the prosthesis.

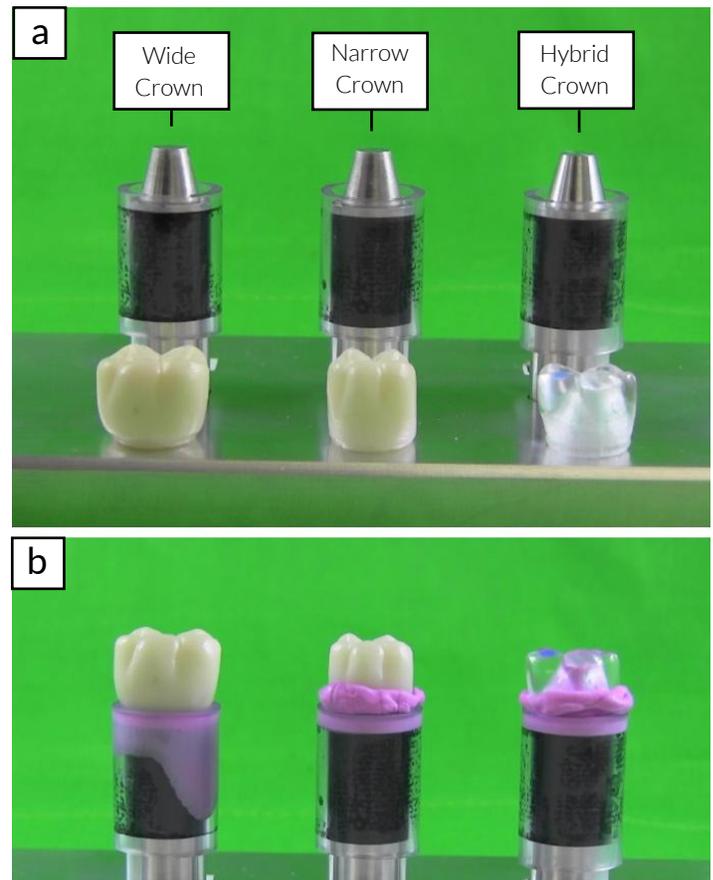
The recommended intra-oral cementation technique is described in Dr. Svoboda's publications on the process of intra-oral cementation. (26, 27)

## Summary

Treatment with dental implants has revolutionized the level of care that we can offer our patients. There are still some longstanding problems of misfit and stability of the implant-abutment connection under function. This misfit can be worsened when the abutment-prosthesis complex is installed by the "screwed in technique". The fit of the implant-abutment connection can be improved by the process of intra-oral cementation. Unfortunately this brings the problem of residual excess cement. It can also cause peri-implantitis and possible failure of the dental implants and their retained prosthetics. Implant failure is expensive.

Dr. Svoboda has created some "in vitro" models that allowed him to better understand the process of intra-oral cementation, including the effect of margin design, gingiva, abutment-prosthesis design, and cementation pressures on the flow of excess cement. **As a result, he proposes the use of "well designed custom abutments" that include features that redirect cement out of the tissues and im-**

**pede flow of cement into the tissues.** These custom abutments should be used to support "well designed prosthetics" that allow excess cement to flow out of the tissues spaces by minimizing the "Gingival Effects". It is good to have developed a system of prosthesis installation that is "safer by the design" of the "abutment-prosthesis complex" and the use of a low pressure installation technique. (14, 27)



**Fig 6 (a)** shows 3 aluminum rods with Reverse Margins that terminate 1 mm below the top of the clear Tygon tubes (gingiva). The black electrical tape was placed 1 mm below the margin and is 0.125 mm thick. It fills the space between the tube and the rod. There are 3 crown designs, wide, narrow and hybrid. The narrow is smaller in diameter than the tube, and the hybrid has a narrow part sub-gingival tapering to a wider profile 1/2 mm above the tube. **(b)** Depicts the crowns cemented into place. Note the huge amount of sub-margin cement under the wide crown, while the narrow and hybrid crowns did not have any cement that breached the black tape border.

## Supplementary

The process of intra-oral cementation is widely used in dentistry for restoring natural teeth and dental implants. Now that we understand how the process of intra-oral cementation process works, Dr. Svoboda feels that the principals derived from his work should already be used to change the way prosthetics are delivered to our patients. This course of action is much more logical than continuing to use margin designs that direct cement into the tissues and bulky prosthesis designs that trap cement and cause it to be forced deep into the tissues, where it is difficult to remove.

Stock abutments often require clinicians to use bulky prosthetics and high installation forces to cement them into the mouth. There is already ample evidence that huge amounts of cement are found in the subgingival environment of failed implants<sup>(2)</sup> and that the distribution of that cement is consistent with the “Gingival Effects”. So “Stop causing Implant Failures” by controlling the flow and cleanup of excess cement by using **“Well Designed Abutment-Prosthesis Complexes”**. Also “Stop causing Implant Failures” by creating misfits at the implant abutment connections by installing “already assembled abutment-prosthesis complexes” by the “screwed-on” technique. (2, 24, 27)

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