All-On-X: A New Standard of Care for Implant Prosthetics.

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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. It may be difficult to argue that blocking access to care is good for the patient. If it became possible to consistently optimize these connections and provide better access to care, 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)". PDE is a culmination of all those errors that go into the making of a prosthesis. One of the TE is called "Resistance to Displacement" and it relates to the resistance offered by all tissues that interact with the prosthesis or prosthetic components during the process of its installation into the mouth. 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? Simply put, better fitting parts are expected to be more stable than misfit parts. They are 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 about access to care? Plaque is a known risk factor for peri-implant disease. Making it difficult for patients to clean away plaque on a daily basis and for dental professions to access the peri-implant environment is not ideal.

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] They analyzed 3 unit bridges in the mouth for 5 years.

With all-on-x screwed-in prosthetics, the misfits are likely to be at the abutment-prosthesis junction and vary in their relationship to adjacent tissues. Many of these connections appear to have been placed into equigingival and subgingival locations. Peri-implant disease is a serious condition related to infection. Can we reduce the mechanical conditions that give rise to the proliferation of oral pathogens in the peri-implant environment?

Figure 1 shows all-on-x in the mouth of a patient. Note the plaque accumulation on the facial of the implants in the mandible. Figure 2 shows the undersurface of the mandibular prosthesis. Note the abundant plaque accumulation and the facial-lingual dimension of the prosthesis profile in the anterior region. It would be difficult to access the peri-implant tissues to assess the tissues or remove plaque or calculus from this region. Figure 3 shows the plaque and inflammation in the peri-implant environment. Note the position of the multi-unit abutments in relation to the gingiva. Their position varies from slightly supragingival on the patient's right side to equigingival and subgingival on the left side. As well the left side abutments appear to be shiny due to the movement of the prosthesis on that side. I would like to suggest that the conditions of the peri-implant environments far from ideal, as there are signs of peri-implant disease that may also be exacerbated by the unstable fit of the abutment-prosthesis connectors and the inability of the patient to practice effective oral hygiene.

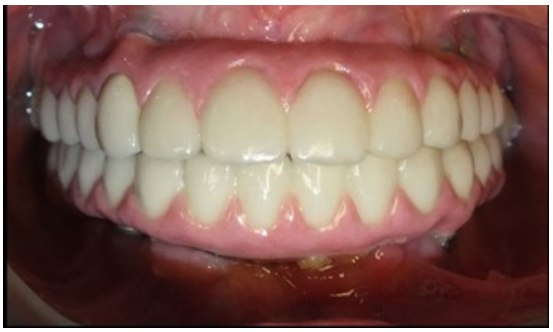

Figure 1: Upper and lower all-on-x prostheses in place. Note plaque on facial aspects of mandibular implants.

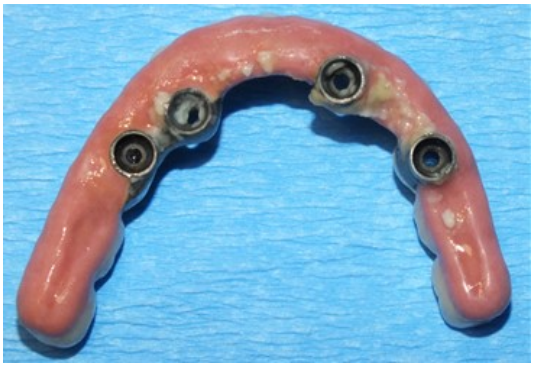

Figure 2: Underside of mandibular prosthesis. Note plaque adjacent to implants and wide profile that blocks access to care.

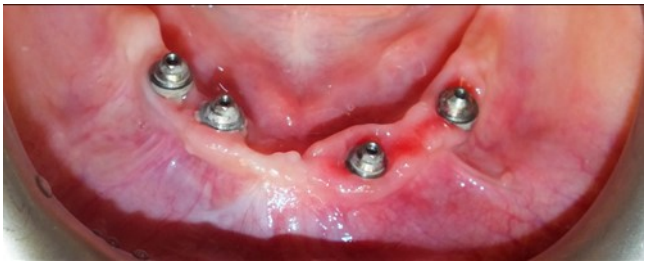

Figure 3: Shows abutments with plaque positioned in difficult to clean positions where misfit prosthetic connectors were attached.

There are many steps in the making of a prosthesis that can contribute to PDE, from the impression process, to analogue component accuracy and their positioning in the inaccurate 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 deemed "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 the 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 measure 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, makes 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 research/review results always need to be interpreted with great caution, as not *detecting* a difference does not mean that there *is* no difference.

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? Is it possible to consistently optimize the fit of implant parts?

The Government thinks 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 will 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 certainly not the same for multi-unit prosthetics.

Current installation for an all-on-x case

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 4) 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.

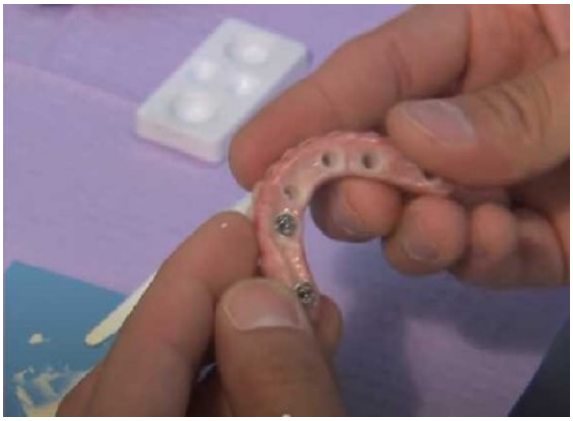

Figure 4: The laboratory technician is cementing the prosthetic-attachment parts into the prosthesis that is made to fit a dental model.

In the operatory: The dentist must install the prosthesis while trying to optimize the fit of the prosthetic-attachment parts onto the multi-unit abutments, while pushing the prosthesis against adjacent tissues. The resistance of the tissues to the optimal seating of the prosthesis adds yet another challenge. **Resistance to Displacement Effect** (RTDE) 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? Is it all three problems that combine to cause such a high peri-implantitis rate? Would it not be better to optimize the fit of parts and provide proper access to care? To do that, we need to use the mind's eye. To do better we need to use logic.

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.

A New Way of installing an all-on-x case.

In the Lab: This time the laboratory technician makes the prosthesis as usual, but instead of joining the prosthetic connector to the prosthesis, the technician 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. This is about the thickness of a coarse human hair. The lab technician also seals the screw access hole opening in the prosthesis with acrylic and delivers the prosthesis and the prosthetic connector to the dentist, separately. (Figures 5-9)

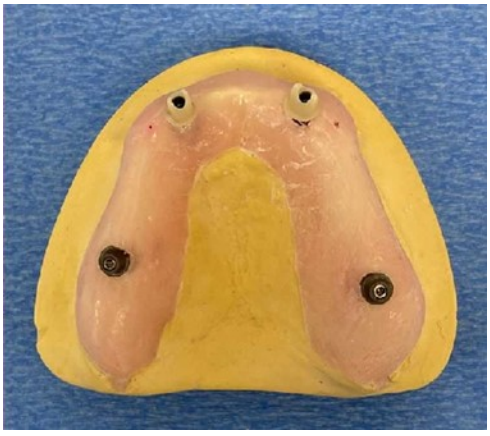

Figure 5: The laboratory technician assembles custom made hybrid zirconia abutments in the anterior and stock prosthetic connectors onto multi-unit abutments in the posterior.

Figure 6: Hybrid zirconia abutments cemented to Titanium bases

Figure 7: (Left side top to bottom) Prosthetic connector, connector retaining screw & non-engaging multi-unit abutment that screws directly into the implant. (Right side) Assembled parts.

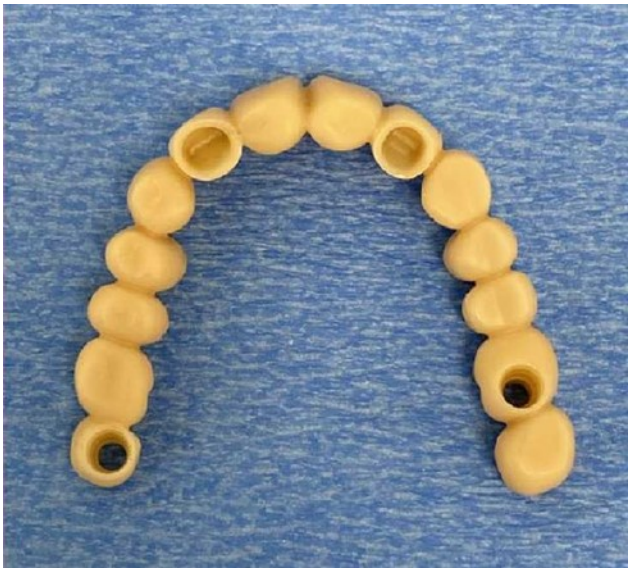

Figure 8: The laboratory technician creates the prosthesis to fit onto the retaining parts including the prosthetic connector. 120 microns cement space is used to compensate for PDE.

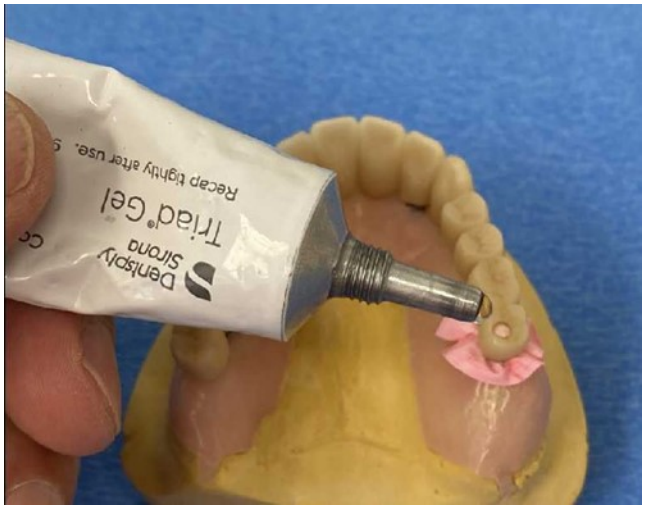

Figure 9: The laboratory technician seals the screw access holes in the posterior to help the dentist to control cement volume and extrude excess cement from the margins of the prosthesis.

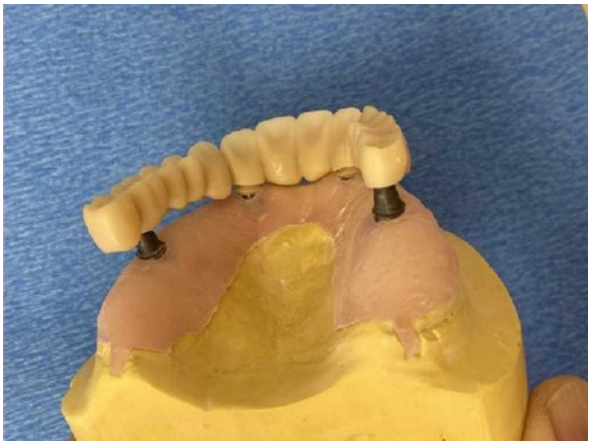

Figure 10: The dentist is able to place and remove the prosthesis from the mouth to ensure that fit and occlusion is idealized. There is sufficient cement space to facilitate this process.

In the operatory: The dentist screws together all the implant components *in the mouth*, including the prosthetic connector. (Like Figure 5) Now the dentist has optimized the fit of all implant parts *in the mouth*, for the first time. Dentists can easily explain how they have consistently managed to accomplish that important goal. If there is no prosthesis attached to the prosthetic connectors, there is no PDE influencing the fit of the connection of implant parts in the mouth.

Then the dentist fits the prosthesis onto the prosthetic connectors and can adjust it and/or the adjacent tissues to optimize its fit. 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. (Figure 10)

Once the dentist is happy with the fit and occlusion of the prosthesis, the prosthetic- connector fixation-screw can be protected with compacted Teflon tape, (Figure 11) and the prosthesis can be cemented into the mouth. The dentist then accesses and removes the prosthesis fixation screws and removes it from the mouth. (Figure 12) The cement around the prosthetic connectors can be refined and polished (Figure 13) before re-installation of the prosthesis. For the first time, the dentist can install this type of prosthesis passively in the mouth. I like to refer to this prosthesis installation process as The Svoboda Way of installation. This process can create a consistent improvement in the quality of fit of parts and prosthesis that has not been previously described in the literature for all-on-x.

Installing a passively fitting prosthesis onto optimized fitting parts is likely to reduce the prevalence of complications and goes a long way to reducing dentist liability for those complications. Optimized parts 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.

Next, the dentist will use the prosthetic-connectors-prosthesis-complex to help line up the prosthesis in the optimized position, and cement the prosthesis over the anterior retainers. We can use a temporary cement for this purpose to keep this prosthesis easy to retrieve from the mouth. In this case I used chamfer margins on the anterior hybrid abutments and kept the margins supragingival.

In the cases where the prosthesis margins are expected to interact with the adjacent tissues, it would be advisable to use a margin specifically designed to prevent subgingival cement,

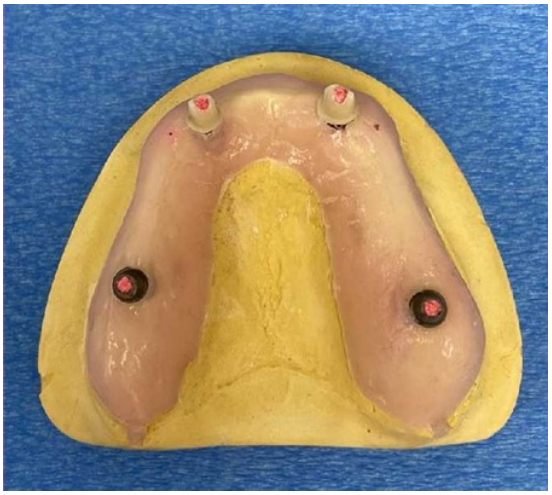

Figure 11: The dentist places Teflon into the screw access channels to create easy access to screws for prosthesis removal.

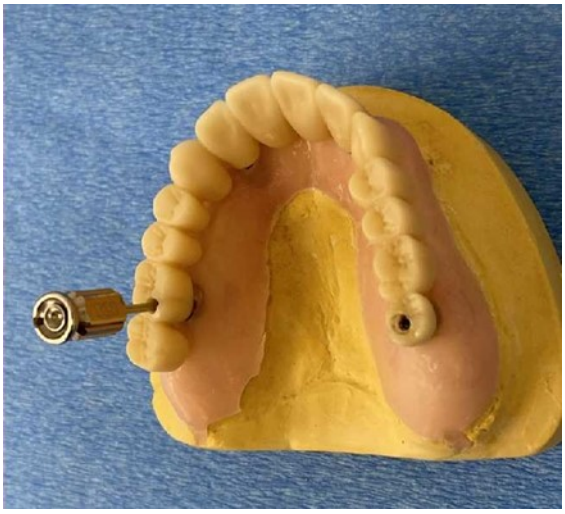

Figure 12: The dentist cements the prosthesis into place and then drills out the posterior screw-access holes to remove the abutment-connector-prosthesis-complex.

Figure 13: The tissue facing surface of the prosthesis is exposed and the polymerized excess cement around the prosthetic connectors has been removed. The cement line was polished.

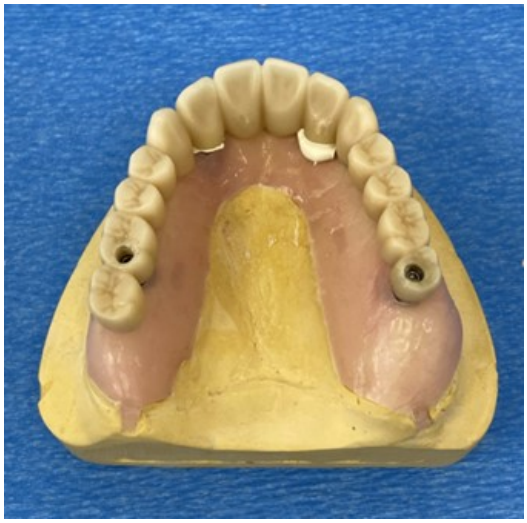

Figure 14: The dentist cleans away the supragingival excess cement and then fills the posterior screw-access holes with Teflon tape and a resin material.

open and overhanging margins. This special margin design and installation system mitigates the Tissue Effects, safely provides cement space to tolerate PDE and redirects excess cement out of the tissue spaces. This installation system was created to make intra-oral cementation safer and is effective even when the retainer margins are placed 1 mm into a subgingival location. The Reverse Margin System of installation has been described in a previous publication. [13]

After cleaning away excess cement from around the two anterior retainers (Figure 14) the posterior screw access holes can be sealed with an acrylic material and the occlusion adjusted.

Is this prosthesis still easy to remove and install back into the mouth? Figure 15 shows that the prosthesis is easily disengaged from its retainers. After cleaning the prosthesis, it is simple to use the steps in Figure 12 to 15 to reinstall it.

You will notice the narrow facial-palatal profile of the anterior of the prosthesis that makes this restoration much easier to maintain by the patient and the whole dental team. (Figure 16)

The dentist may have some concerns about the anterior retainers failing to hold the anterior of the prosthesis in place. In this case it is not difficult to have the laboratory technician place retaining screws on the palatal aspect of the prosthesis to grip the anterior retainers. If there are more posterior implants, additional retaining screws may provide sufficient clamping power to keep the anterior of the prosthesis from coming loose.

In any case, we now have a proof of concept, whereby the dentist can optimize the fit of implant parts and prosthesis, render the prosthesis maintainable by the patient and removable by the dentist. This is better! This is a New Standard of Care.

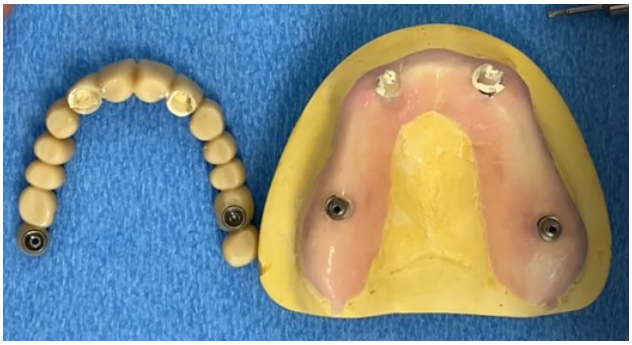

Figure 15: The dentist removes the posterior retaining screws, easily overcomes the temporary cement bond in the anterior and lifts the prosthesis out of the mouth. It is easily retrievable.

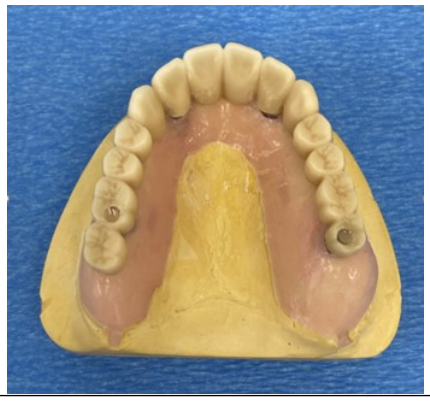

Figure 16: The dentist can easily reinstall the prosthesis. It is maintainable by the patient and the dentist. This is important.

In Conclusion: It is possible to install an All-On-X prosthesis without exposing patients unnecessarily to complications resulting from misfit implant parts and poor access to maintenance. These are common consequences of the current installation systems. The Svoboda Way of installation enables the dentist to optimize the fit of implant parts, optimize the passivity of the prosthesis, provide the patient and dentist access for maintenance and retains easy prosthesis retrievability. The Svoboda Way establishes a "**New Standard of Care**" for All-on-X prosthesis installation. It should be implemented into practice today.

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Dr. Emil LA 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 and practices Implant Dentistry at ParkPlace Dental Centre in Brampton, Ontario. Dr Svoboda has been granted Patent protection in Canada and USA for his innovative Reverse Margin Abutment design and is thankful to BioHorizons, 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.