Comparing the Chamfer and Reverse Margin Systems at Preventing Submarginal Cement

While Varying Crown Installation Pressure and Margin Depth

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Abstract: *Intra-oral cementation is a common process for attaching crowns and bridges to natural teeth and dental implants. While fixed-prosthetics are cemented onto natural teeth, dental implants may also be restored by a screw-in technique. It is unfortunate that this latter installation system has inherent problems that renders patients susceptible to complications and related peri-implant disease. Treatment for this disease can be uncomfortable, unpredictable, and expensive.*

Intra-oral cementation can reduce or eliminate several problems related to the screw-in technique but has been plagued by complications related to poor prosthesis margins and residual subgingival cement. While removal of excess cement can often result in the resolution of related peri-implant disease, an intra-oral cementation system that prevented it could be key to reducing complications.

This research compared the installation of the common Chamfer Margin (CM) abutment-crown complex to a more recent installation system utilizing a Reverse Margin (RM) design. Both systems were tested in vitro, with their margins positioned at ½ and 1 mm subgingival, while their complementary crowns were pushed into place under varying pressure conditions. The RM System consistently outperformed the CM System and may thus be a preferable choice for intra-oral cementation of implant prosthetics. Also, shallower margins and lower pressure installation helped both margin systems perform better.

**Correspondence: emil@dresvoboda.com. Dr Svoboda is in private practice placing and restoring dental implants. He invented the Reverse Margin System and holds patents on the design aspects of both the crown and abutment. Related publications are available at www.ReverseMargin.com.* *Cite this article as: Svoboda ELA, Sharma A, Zakari M. Comparing the Chamfer and Reverse Margin Systems at Preventing Submarginal Cement while varying Crown Installation Pressure and Margin Depth. Www.ReverseMargin.com. 2020;1-13.*

Comparing the Chamfer and Reverse Margin Systems at Preventing Submarginal Cement while Varying Crown Installation Pressure and Margin Depth

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December 2, 2020

Intra-oral cementation is a common process for attaching crowns and bridges to natural teeth and dental implants.[1,2] While fixed prosthetics are cemented onto natural teeth, dental implants can also be restored by a screw-in technique. It is unfortunate that this latter installation system has inherent problems that can make it difficult to impossible optimize the fit of implant-abutment and abutment-prosthesis connections. Superimposed upon these problems which may compromise the stability of the prosthesis, these misfit joints also have a diminished ability to exclude oral pathogens from the internal spaces of the implant. Worse yet, the screw-in system often uses cantilevers to hide screw access holes. These can amplify stress on already misfit connections and block access for effective maintenance. Plaque and calculus are known to accumulate under these cantilevers and are known risk factors for peri-implant disease.[3,4]

Intra-oral cementation can help the dentist optimize the fit of implant parts and avoid unnecessary screw-access related cantilevers. However, this system of installation has been plagued by complications related to poor prosthesis margins and residual subgingival cement.[5,6] Residual subgingival cement is a known risk factor for peri-implant disease.[7] Reducing risk factors for complications is expected to reduce the troubling rate of peri-implant disease[8]. Treatment for this disease can be uncomfortable, unpredictable, and expensive.[9]

Purpose

An intra-oral cementation system that did not expose patients to residual subgingival cement could be key to reducing several longstanding risk factors for treatment complications. This research compared the common Chamfer Margin (CM) based abutment-crown system to a more recent installation system utilizing a Reverse Margin (RM) design. Unlike the CM design, the RM design utilizes an abutment with an inflected margin that redirects excess cement out of the tissue environment and a crown shape that facilitates that cement flow. Both systems were tested in vitro, with their margins positioned at ½ and 1 mm subgingival, while their complementary crowns were pushed into place under varying pressure conditions.

Method

Each crown and abutment were designed with 3Shape software (www.3Shape.com). **Figure 1** shows a CM design with a 45-micron cement space that diminishes to zero, 344 microns from its outside edge. **Figure 2** shows a RM margin design with an 80-micron space within the entire crown interface with the abutment. This design allows it to float within the inflected margin trough. These are scaled renditions of the cement space relative to the other aspects of the abutment-crown complex. All crown and abutment shapes were milled from similar zirconia pucks (DWX-520Ci, www.dgshape.com) sintered and refined manually. All abutment shapes were cemented to Titanium bases (Ti bases) and screwed to matching implant analogues (www.BioHorizons.com). All abutment margins were marked with a fine black marker to help visualize the margin (Sanford Super Sharpie Series 33000, www.Sharpie.com). (**Figure 3**)

Identical acrylic models were printed (NextDent 5100, www.3dSystems.com) and custom fitted with silicone gingiva (GI Mask, www.Coltene.com) to simulate the replacement of a single mandibular first molar. Gingiva was mastered to ensure even contact with abutment retainers after installation. **Figure 4** shows a RM abutment in place in the model with pink Teflon compacted into its screw-access hole. The buccal (B) and mesial (M) margins were positioned 1 mm below the simulated gingiva and their lingual (L) and distal (D) margins were ½ mm subgingival. All crowns were fabricated to be out of contact with proximal teeth.

The CM crowns have a convex shape to simulate the emergence profile of a natural tooth. This type of design is common and expected from dental laboratories. The crown margin was intended to seat directly against the abutment margin after being pushed into place. The crown profile also pressed against adjacent gingiva during its installation.

In contrast, the RM abutment has an inflected margin, and the RM crown has a concave profile adjacent to the gingiva. The 80-micron cement space was continuous between the intaglio of the crown and the abutment, including the external surface of the crown in the trough of the inflected margin. This allows it to float somewhat within the inflected abutment margin to compensate for expected prosthesis dimensional error. In addition, the shape of the crown is concave in the anticipated subgingival environment to keep it out of contact with adjacent tissue during its installation process.

Figure 5 shows a RM crown in place on its abutment on the printed model. It sits passively in place because it does not touch the adjacent gingiva. The top of the crown has a screw-access hole covered with clear acrylic and would thus be amenable to having the abutment-crown complex removed from the implant analogue. This feature was not used in this experiment as the entire analogue-abutment-crown complex could be separated from the model by removing a fixation lug from the base of the implant analogue. (**Figure 3**)

The cementation process: The intaglio of the crown was ½ filled with temporary cement (Cling2 resin temporary cement, www.ClinicalResearchDental.com). The cement was expressed from the mixing tip directly into the deepest portion of the crown by dentist AS. The crown was then cemented into place on the model sitting on a weigh scale (AccuWeight Digital Kitchen Scale, Item 3836-48, www.Amazon.com), using finger pressure to reach a desired seating pressure.

In the first group ES1, the pressure was exerted to bring the scale reading to approximately 4 Kg. (Figure 6) Once cemented into place, the crown-model complex was lifted from the scale, and clamped to hold the crown in place (2" Spring Clamp, Mastercraft, Canadian Tire Corp.) while it set for a minimum of 10 minutes. (**Figure 7**)

The implant-analogue-abutment-crown complex was unscrewed from the base of the dental model and placed in a numbered location. CM and RM crown cementations were alternated, and each trial was photographed using an iPhone 11 Pro Max (Apple Inc, www.apple.com) on a stand. Photographs were taken of the buccal (B), mesial (M), lingual (L) and distal (D) aspects of each abutment-crown surface while placed beside a mm grid. (**Figure 8,9**) The images were copied into a Windows Publisher program (www.Wndows.com) and the maximum distance travelled by the cement beyond the abutment margin near the center of each surface was measured from the image on the computer screen. The measurements were recorded on a Windows Excel sheet, and the difference between groups was tested for significance using the Mann-Whitney U test.

A second group (MZ) of cementations was conducted by dentist MZ with similar instructions to ES1. Unlike the ES1 trials above, it was noted that MZ's weigh scale often registered 4.5 Kg and he appeared to be seating the crowns more rapidly than ES1.

The third group (ES2) was conducted by ES, but this time the cementation pressure was increased gradually over a 10 second period, and then held at 2 Kg for an additional 10 seconds prior to clamping the crown in place like described above.

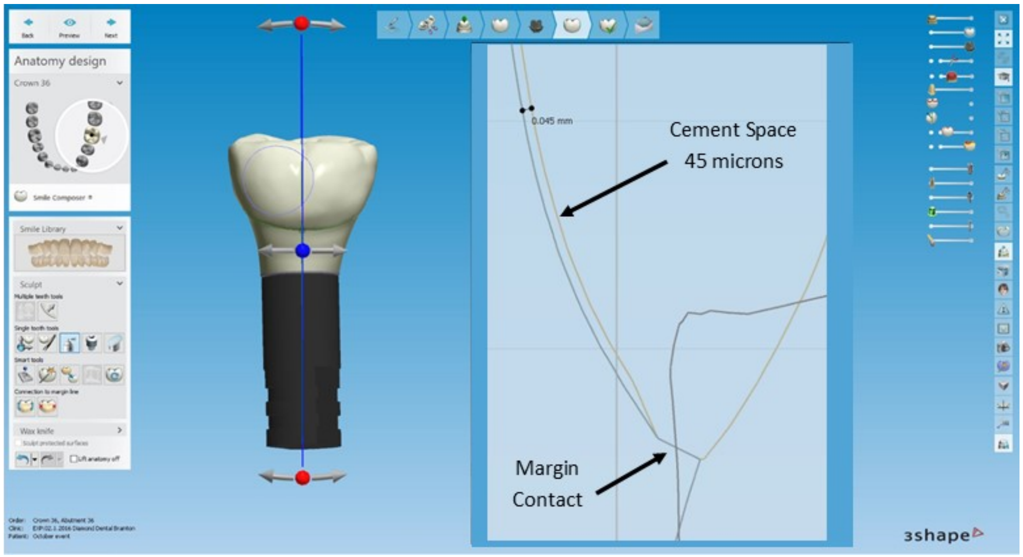

Figure 1: This is a screen display showing a 3-D view of a CM crown, abutment, and implant analogue complex with a cross-sectional view on the right. The cement space was set to 45 microns and the crown was designed to sit directly onto the abutment margin. The emergence profile of the crown is convex and wider than the underlying abutment.

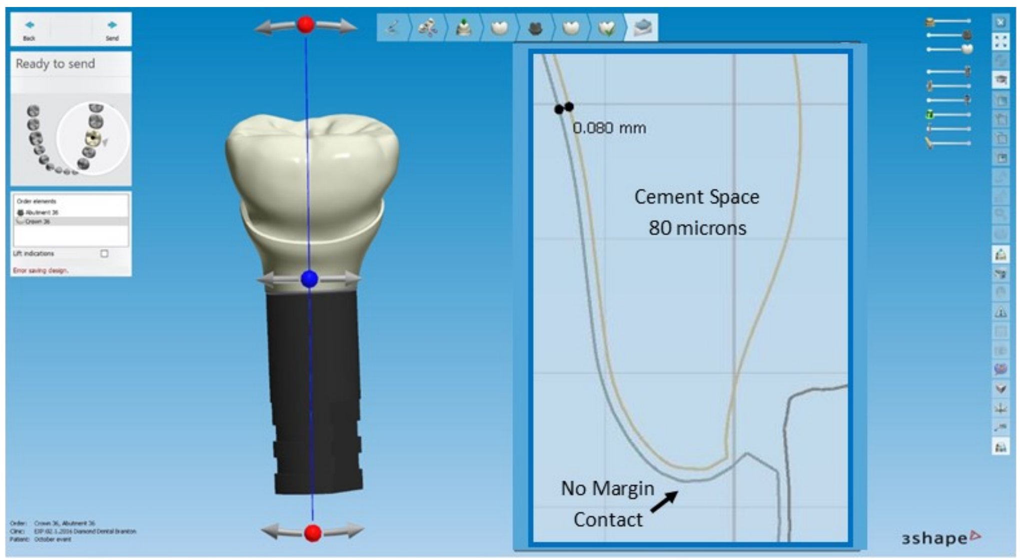

Figure 2: This is a screen display showing a 3-D view of a RM crown, abutment, and implant analogue complex with a cross-sectional view on the right. The cement space is 80 microns and the crown was designed to float within the abutment margin inflected trough. The emergence profile of the crown is concave and is narrower than the underlying abutment.

Figure 3: The buccal surface is marked with a dot and the abutment margins are marked with black marker to make them easier to identify. They are attached to implant analogues used to position them within the printed model.

Results

Comparing the combined 4 aspects of each CM with RM abutment-crown designs under 3 different installation

Figure 4: Printed model with silicone gingiva and Reverse Margin (RM) Abutment already installed. The screw access hole is filled with pink Teflon tape. Abutment margins on buccal and mesial are 1 mm subgingival and those on lingual and distal are 1/2 mm subgingival.

Figure 5: A RM crown seated in place on its abutment and it is out of contact with adjacent teeth. A clear plastic plug covers the abutment screw access hole.

pressures (MZ, ES1 and ES2)

1) The sum of measurements (Totals) of the distance excess cement travelled beyond their buccal (B), mesial (M), lingual (L) and distal (D) margins were compared to their cohort tests. Tables 1 to 3 show the maximum extensions of excess cement beyond each of their 4 aspects and their sums. Under all 3 cementation conditions, the CM condition demonstrated a greater extension of excess cement beyond their margins than the RM conditions. (p=0.01 level) Figures 10 to 12 display the average and range of distance excess cement travelled beyond the CM and RM margins in mm.

2) The MZ CM condition, where the 4 margin aspects of each trial were summed, (Table 1) had an average extension of cement 1.8 mm beyond the abutment margin with a range from 0 to 7.0 mm while the RM condition had an average extension of cement 0.13 mm beyond the margin with a range of 0 to 0.6 mm. (p=0.01). (Table 4)

Figure 6: Crown being cemented onto abutment while on a weigh scale. The scale reads 4.053 Kgs.

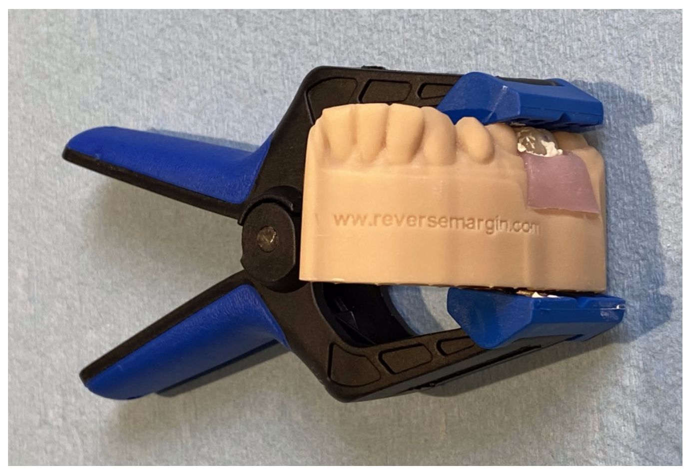

Figure 7: Crown being clamped in place with Mastercraft clamp, to await the setting of cement.

None of the CM combined surfaces trials were without submarginal cement, while the RM was able to prevent submarginal cement in an increasing number of cases as the cementation pressure was reduced. (Table 5)

3) The ES1 CM combined condition had an average extension of cement 1.8 mm beyond the abutment margin with a range from 0 to 7.2 mm, while the RM condition had an average extension of cement of 0 mm beyond the margin with a range of 0 to 0.5 mm. (p=0.01) (Table 4)

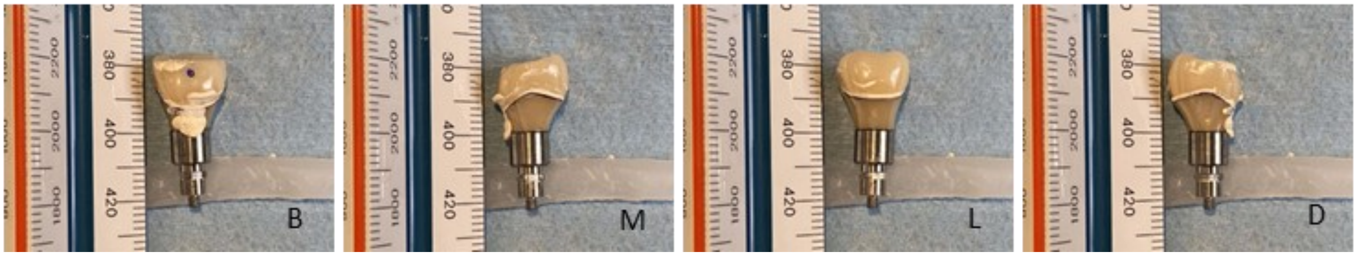

Figure 8: Photographs of CM crowns positioned adjacent to ruler with mm markings to measure cement extension beyond buccal (B), mesial (M), lingual (L) and distal (D) margins. The CM images had cement 3.9 beyond its B margin and 0.5 mm beyond its M margin. It corresponds to Table 1 MZ CM 4.

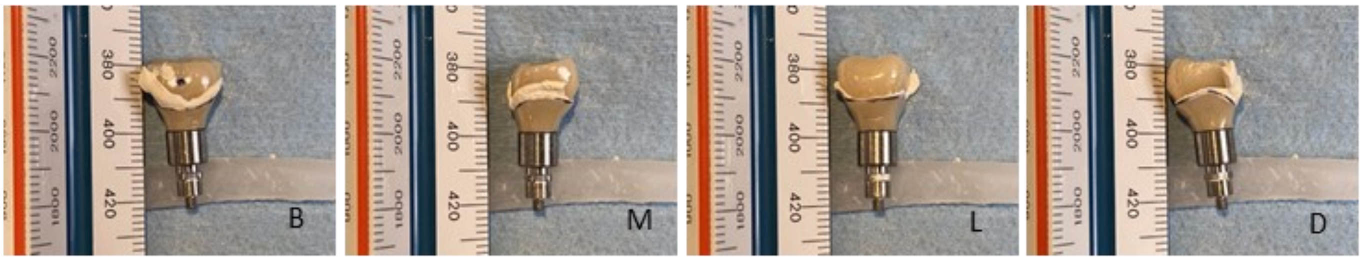

Figure 9: Photographs of RM crowns positioned adjacent to ruler with mm markings to measure cement extension beyond buccal (B), mesial (M), lingual (L) and distal (D) margins. The RM displayed cement 0.2 mm beyond the M and D margins and no cement beyond the B or L margins. It corresponds to Table 1 MZ RM 4.

MZ	CM					RM				
Trial	B	M	L	D	Total	B	M	L	D	Total
1	2.5	2	0	0.5	**5.0**	0	0.5	0	0	**0.5**
2	3.1	1.9	0	0	**5.0**	0.2	0.5	0.5	0	**1.2**
3	3	3.9	5.8	0	**12.7**	0	0	0	0	**0**
4	3.9	0.5	0	0	**4.4**	0	0.2	0	0.2	**0.4**
5	1.6	3.2	1.1	0	**5.9**	0	0.5	0	0	**0.5**
6	1.8	4.5	0	0	**6.3**	0	0.2	0	0	**0.2**
7	3.2	0.6	0.5	0.2	**4.5**	0.6	0.2	0	0	**0.8**
8	7	2.1	3.9	0	**13.0**	0	0.2	0	0	**0.2**
9	3.8	4	0	0.5	**8.3**	0.2	0.2	0	0.5	**0.9**
10	3.5	3.4	0	0	**6.9**	0.5	0	0	0	**0.5**
Totals	**33.4**	**26.1**	**11.3**	**1.2**	**72.0**	**1.5**	**2.5**	**0.5**	**0.7**	**5.2**

Table 1: Displays the measurements, in mm, of cement extension beyond the buccal (B), mesial (M), lingual (L) and distal (D) margins for all cementation trials for dentist MZ. Zeros indicate that no cement went past the margin of the abutment. The sums of cement extensions are listed under total for each trial.

When comparing the MZ group with the ES1 group, there was no apparent difference in the amount of cement beyond the CM margins. However, there was a significant difference (p=0.01) in the amount of cement going beyond the margins under the RM conditions. The MZ RM condition caused an average of 0.1 mm of cement to go beyond the margin with a range of 0 to 0.6 mm, while the ES1 RM group averaged 0.04 mm, with a range of 0 to 0.5 mm. (Table 4)

When comparing the number of ES1 trials without cement beyond any of the 4 margins; none of the CM cases were without submarginal cement, while 60% of the RM cases were without submarginal cement. (Table 5)

4) In the ES2 combined condition the pressure was halved (2 Kg) and the duration of the crown seating process was extended over 10 seconds. (Table 3) The CM average reduced to 0.4 with a range of 0 to 3.3 mm cement extending beyond the margins, while the RM condition average reduced to 0 with a range from 0 to 0.2 mm. The differences in cement beyond the margin was significantly different between both the ES1 and ES2 CM conditions (p=0.01) and their RM conditions (p=0.05).The ES2 condition was also significantly different from the MZ group in both the CM and RM conditions at

ES1	CM					RM				
Trial	B	M	L	D	Total	B	M	L	D	Total
1	2.4	0	0	2	**4.4**	0	0	0	0	**0**
2	0	0	7	4	**11.0**	0	0	0	0	**0**
3	1.2	0	0	0	**1.2**	0	0	0	0	**0**
4	0.5	0	4	2.8	**7.3**	0	0	0	0.1	**0.1**
5	2	0	2	0	**4.0**	0.1	0	0	0	**0.1**
6	7.2	0.5	6.5	0	**14.2**	0.1	0.1	0	0	**0.2**
7	0	3	0	0	**3.0**	0	0	0	0	**0**
8	1.9	2	6.8	0	**10.7**	0.5	0.5	0	0	**1**
9	7	3.5	0	0	**10.5**	0	0	0	0	**0**
10	2.9	0.8	0	0	**3.7**	0	0	0	0	**0**
Totals	**25.1**	**9.8**	**26.3**	**8.8**	**70.0**	**0.7**	**0.6**	**0**	**0.1**	**1.4**

Table 2: Displays the measurements, in mm, of cement extension beyond the buccal (B), mesial (M), lingual (L) and distal (D) margins for all cementation trials for dentist ES1. Zeros indicate that no cement went past the margin of the abutment. The sums of cement extensions are listed under total for each trial.

ES2	CM					RM				
Trial	B	M	L	D	Total	B	M	L	D	Total
1	0	1.9	0	0	**1.9**	0	0	0	0	**0**
2	0	0.5	0	0	**0.5**	0	0	0	0	**0**
3	2.5	3.3	0	0	**5.8**	0	0	0	0	**0**
4	0	0.2	0	0	**0.2**	0	0	0	0	**0**
5	0	0.6	0	0	**0.6**	0.1	0	0	0	**0.1**
6	1	0.8	0	0	**1.8**	0	0	0	0	**0**
7	0	1.2	0	0	**1.2**	0	0	0	0	**0**
8	0	0.3	0	0	**0.3**	0.2	0	0	0	**0.2**
9	1	1	0	0	**2**	0	0	0	0	**0**
10	2.1	0	0	0	**2.1**	0	0	0	0	**0**
Totals	**6.6**	**9.8**	**0**	**0**	**16.4**	**0.3**	**0**	**0**	**0**	**0.3**

Table 3: Displays the measurements, in mm, of cement extension beyond the buccal (B), mesial (M), lingual (L) and distal (D) margins for all cementation trials for dentist ES2. Zeros indicate that no cement went past the margin of the abutment. The sums of cement extensions are listed under total for each trial.

p=0.01. (**Table 4**)

When comparing the number of cases without any cement beyond any of the 4 margins, none of the ES2 CM cases were without any submarginal cement while 8 of the 10 RM cases were. The other 2 RM trials had 0.1 to 0.2 mm submarginal cement extending beyond their margins. (**Table 5**)

The buccal and mesial margins (BM) were 1 mm below the gingiva and the results of these were thus combined for comparison with the lingual and distal margins (LD) that were ½ mm below the gingiva. (Table 6)

5) In the MZ group, the average cement extension beyond the CM BM margins were 3.0 mm with a range of 0.5 to 7 mm while the in the CM LD margins had an average extension of 0.6 mm with a range of 0 to 5.8 mm. The cement extension beyond the RM BM margins averaged 0.2 mm with a range of 0 to 0.6 mm while the RM LD margins averaged 0.06 with a range of 0 to 0.5 mm. These differences were significant at p=0.01.

In the ES1 group the average cement extension beyond the CM BM margins were 1.7 mm with a range of 0 to 7.2 mm while the CM LD margins had an average extension of 1.8 mm with a range of 0 to 6.8 mm. The cement extension beyond the RM BM margins averaged 0.1 mm with a range of 0 to 0.5 mm while the RM LD margins averaged 0 with a range of 0 mm. The differences between the RM BM and their adjacent LD groups were not significant.

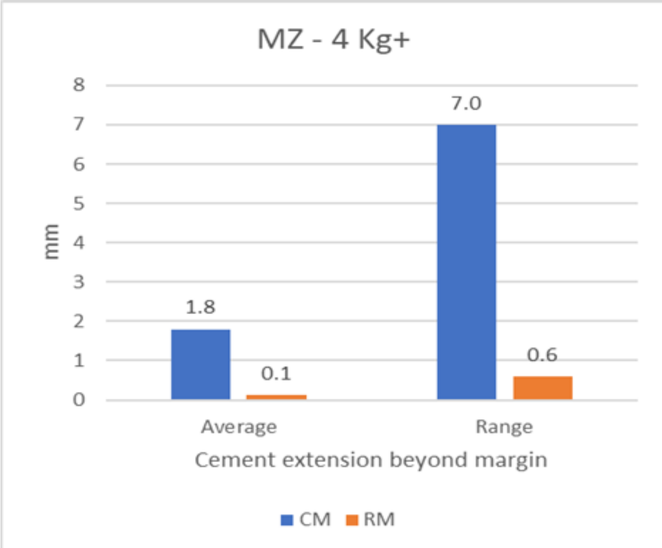

Figure 10: This bar chart compares the average and range of distance travelled beyond the CM and RM margins in mm, when crowns were cemented by MZ. This chart corresponds to measurements in Table 1.

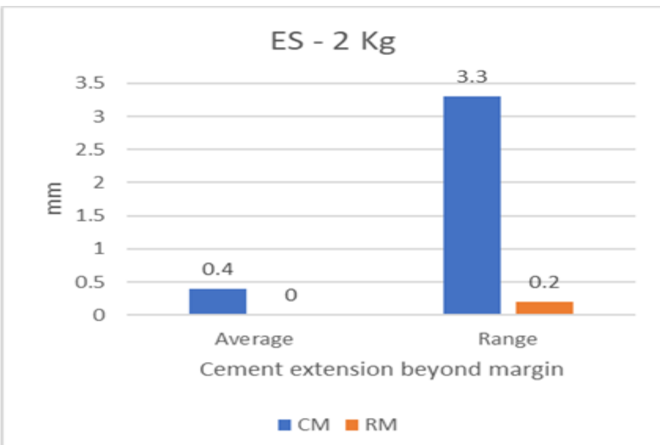

Figure 12: This bar chart compares the average and range of distance travelled beyond the CM and RM margins in mm, when crowns were cemented by ES2. Note difference in Scale from Figures 10 and 11. This chart corresponds to measurements in Table 3.

Condition	Margin	Average	Range	Sign 0.01
MZ	CM	1.8	0 - 7.0	YES
	RM	0.1	0 - 0.6	YES
ES1	CM	1.8	0 - 7.2	YES
	RM	0	0 -0.5	YES
ES2	CM	0.4	0 - 3.3	YES
	RM	0	0 - 0.2	YES

Table 4: The sum of the cement extensions, in mm, beyond the B, M, L and D margins of the CM and RM are compared under 3 conditions represented by MZ, ES1 and ES2. The cement extensions for CM was different (p=0,01) from that observed for RM under all conditions.

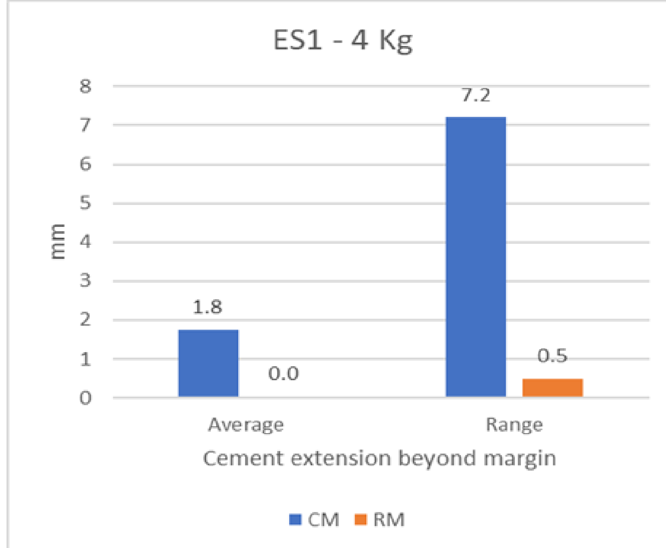

Figure 11: This bar chart compares the average and range of distance travelled beyond the CM and RM margins in mm, when crowns were cemented by ES1. This chart corresponds to measurements in Table 2.

Zeros/10	CM	RM
MZ	none	1
ES1	none	6
ES2	none	8

Table 5: None of the CM crown cementation trials were free of submarginal cement. The RM was able to prevent submarginal cement in an increasing number of cases as the cementation pressure was reduced.

In the ES2 low pressure cementation condition the average cement extension beyond the CM BM margins were 0.8 mm with a range of 0.5 to 3.3 mm while the CM LD margins had an average extension of 0 mm. This difference was significant at a 0.01 level of confidence. The cement extension beyond the RM BM margins averaged 0.2 mm with a range of 0 to 0.2 mm while the RM LD margins averaged 0 mm. There was no apparent difference between these two samples.

When comparing the ES1 higher pressure cementation to the ES2 lower pressure cementation with the CM condition there appears to be no difference in cement extension when the margins are 1 mm below the gingiva (BM). However, when we compare the shallower margins, that are ½ mm below the gingiva (LD), there was a difference (p=0.01). No cement went beyond the shallow margins in any case when lower cementation pressure was used. (**Table 7**)

We can observe this type of difference again when we compare the ES2 low pressure condition with the higher pressure MZ condition. The MZ BM and LD groups and the RM BM and LD groups were significantly different from the comparable ES2 groups at the 0.01 confidence level and the CM LD groups that were different at the p = 0.05 level. (**Table 6**)

		BM	1 mm	LD	0.5 mm	
Dentist	Margin	Average	Range	Average	Range	Sign 0.01
MZ	CM	3.0	0.5 - 7.0	0.6	0 - 5.8	YES
	RM	0.2	0 - 0.6	0.1	0 - 0.5	YES
ES1	CM	1.7	0 - 7.2	1.8	0 - 6.8	NO
	RM	0.1	0 -0.5	0	0 - 0.1	NO
ES2	CM	0.8	0 - 3.3	0	0	YES
	RM	0	0 - 0.2	0	0	NO

Table 6: Shows the average and range of cement going past the margins in mm, under all conditions tested. The differences between margin depths BM (1 mm) and LD (0.5 mm) created differences under some conditions and not others.

Zeros/10	BM		LD	
Trials	Subging	1 mm	Subging	0.5 mm
Dentist	CM	RM	CM	RM
MZ	none	1	4	7
ES1	1	7	4	9
ES2	none	8	all	all

Table 7: When separating the 1 mm (BM) from the (LD) 0.5 mm subgingival group, the RM reduced the occurrence of submarginal cement in all conditions. Both the CM and RM eliminated submarginal cement in the ES2 group.

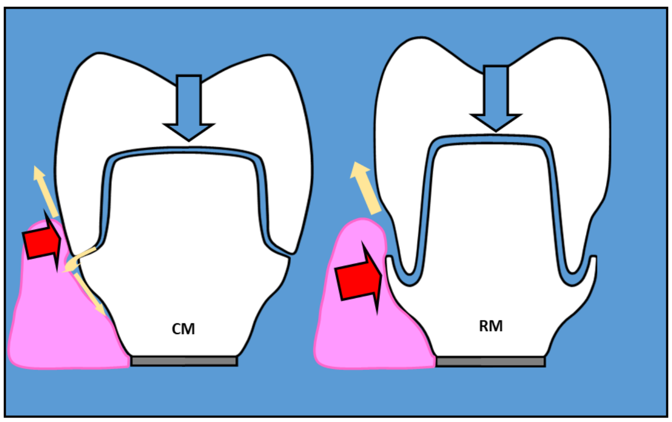

Figure 13: An illustration of CM and RM. Both abutment margins have similar vertical relationships with adjacent pink gingiva. When the CM crown is seating, the tissue facing contour of the crown pushes the gingiva laterally. The red arrow indicates pressure exerted by the gingiva against the CM crown. The yellow arrows show how this gingival seal can prevent excess cement from exiting the tissues and causing it to be forced into the subgingival environment. In contrast, the RM abutment pushes the gingiva away from the crown surface (red arrow) and prevents cement from entering the submarginal environment. The abutment's inflected margin redirects excess cement away from the tissues and the concave contour of its crown facilitates that cement flow. This illustration is not to scale, as the cement space on either side of the RM crown margin is 80 microns, like the diameter of a human hair.

Discussion

Crowns out of contact with adjacent teeth

Prior to intra-oral cementation, prosthesis contacts are usually adjusted to fit between existing dental units. This is done to compensate for an accumulation of prosthesis dimensional errors inherent to the construction of the prosthesis made to fit on a dental model. Tight contacts may prevent a prosthesis from seating on its retainer in an optimal position. This variable was eliminated by making crowns that do not contact adjacent teeth when installed on their retainers.[10]

Predicting the relationship between the abutment margins and gingiva

It is often difficult for the clinician to control the relationship of the prosthesis margins to that of adjacent gingiva. This uncertainty may be affected by the difference in the shape of the trans-tissue portal formed by the healing abutment and the shape of the final abutment. When a healing abutment is narrower than a final abutment, the wider final abutment will displace adjacent gingiva laterally during installation. This movement will tend to stretch the soft tissue opening and cause the gingival margin to move towards its hard tissue tether and expose more of the abutment-crown complex to view. It is easier to predict the abutment margin-gingival margin relationship if the healing abutment used to shape the trans-tissue portal has a similar shape to the intended final abutment-prosthesis complex.[10]

For this experiment, the position of the CM and RM margins below the adjacent simulated gingiva were measured on the models to confirm their positions. All buccal and mesial abutment margins were 1 mm subgingival and the lingual and distal margins were ½ mm subgingival.

Chamfer Margin crown design

The CM crowns were made to compliment the abutment emergence profile. This emergence profile transitions from a narrower abutment to a wider crown profile and thus causes the crown to push against the adjacent gingiva when being installed. Extrapolated from previous studies, this contact of the CM crown with the adjacent gingiva would be expected to stimulate the "Gingival Effects" that can impede the flow of excess cement from the subgingival environment.

This can cause the cement already in the tissue space plus the cement being expressed from the intaglio of the crown to become pressurized and to flow into the tissue spaces, where it can be difficult to locate and clean away. (Figure 13) Note these illustrations are not to scale like Figures 1and 2. Residual subgingival cement is a common consequence of intra-oral cementation. Indeed, any prostheses that stimulates the Gingival Effects may be at risk of having residual subgingival cement after installation by the cement-in process.[10,11]

Cement space

The CM crowns were designed with 45 microns of cement space that diminished to 0 microns beginning 0.34 mm from the margin. Smaller cement spaces are expected to increase the amount of seating pressure required to expel excess cement from the intaglio of the crown during its installation. A

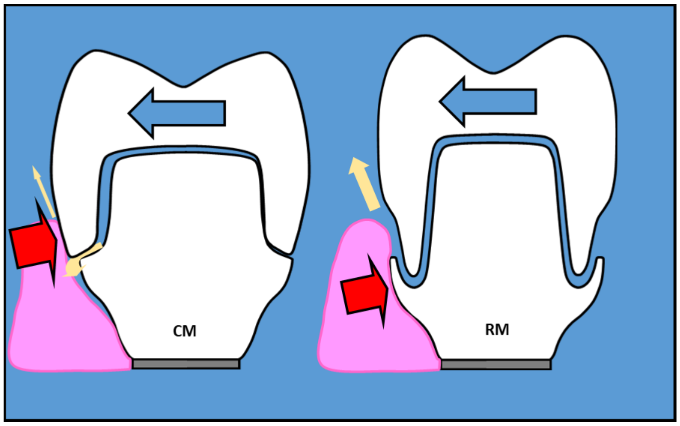

Figure 14: is an illustration of the CM and RM on the right, like figure 4. This time the crowns have been shifted to the left (blue arrows) due to a tight contact on the right or due to the direction of insertion by the clinician. The tissues adjacent to the crown may have also caused the crown to shift by becoming trapped between the crown margins and the abutment or simply due to their resistance to displacement during its installation. Now the pressure exerted by the crown against the gingiva in the CM case will have increased (red arrow) and this could prevent even more excess cement from escaping out of the tissues. The Gingival Effects will have increased during cementation. It can also cause an overhanging margin on the left side.

In contrast, the RM crown shift does not cause it to interact with adjacent gingiva and thus prevents the Gingival Effects and the other Tissue Effect, the Resistance to Displacement Effect. As well, the cement space makes this system tolerant of expected Prosthesis Dimensional Error by allowing the crown to shift its position within the trough of the abutment margin, without causing open, overhanging or overextended margins. Perhaps more cement will flow from the right-side margin because of the increased opening, but the excess cement will be easy to access and it will fill in the margin space. The Performance of this margin complex is not negatively affected by the lateral shift.

Note: This illustration is not to scale. The actual cement space for a CM is 45 microns and for the RM is 80 microns, the thickness of a human hair.

study exploring the use of increased cement space concluded that this could facilitate a better crown margin fit. [12] This decreased cement space and expected contact with the margins intra-orally, can also render the crown intolerant to lateral or rotational displacement due to Prosthesis Dimensional Error and the Tissue Effects, and expressed clinically as open and overhanging and overextended margins.[4,10] (Figure 14)

The Reverse Margin (RM) crown design

RM crowns are designed to have several features that are intended to complement the functionality of their complementary RM abutments during their installation. The RM crown has a concave tissue facing profile, that together with its complementary abutment shape is designed to prevent adjacent tissues from contacting the crown surface. This allows the crown to be placed and removed from its retainer during its adjustment phase without needing to displace or otherwise traumatize the adjacent tissues. This shape also mitigates the Gingival Effects and facilitates the flow of excess cement away from the tissues during its installation process. (Figure 13)

The RM crown margins are nested within the inflected margin of the RM abutment and have 80 microns of cement space on the intaglio and tissue facing surfaces of their margins. This is expected to facilitate the flow of excess cement out of the intaglio of the crown during installation under lower than prevalent seating pressure. This also allows the crown to tolerate 80 microns of error in 3-dimensions by shifting its seating positioning within the abutment margin trough without resulting in open or overhanging margins. It allows the crown to be somewhat self-centering between adjacent tooth contacts. These RM crowns have been specifically designed to make the installation simpler for the dentist and to prevent excess cement from being injected into the tissue environment.[10,11] (Figure 14)

Intra-oral Cementation Pressure

It is difficult for the dentist to measure cementation pressure while installing a prosthesis in the mouth. In the past, it was desirable to use high to extremely high cementation pressures to seat a prosthesis.[13-15] These forces varied greatly from about 4 Kg of finger pressure to 60 Kgs of force transferred to the prosthesis by using the patient's bite to help drive the prosthesis into place. These high forces seemed prudent, because the dentist was trying to overcome resistance to displacement by adjacent and underlying tissues and tight contacts with adjacent teeth, while trying to eject cement through small cement spaces, while trying to minimize the width of the cement line at the margin. Yes, this blind process was also intended to prevent the advent of the open margins that might be visible on an x-ray image. It is no wonder that the results of intra-oral cementation were, and still are, unpredictable. Open and overhanging margins and subgingival cement are common consequences of this procedure.[16]

The first installation pressure used in this study was about 4 kg of force exerted by finger pressure and measured by a weigh scale placed under the crown-model complex. This force was chosen to reflect that exerted by multiple dentists asked to cement a single crown into place.[13] This study appears to reflect the expression of common practices learned in dental schools and continued into clinical practice.

This experiment measured distance cement travelled beyond the margin.

Other researchers have elected to measure volume, weight or area covered by residual submarginal cement, before or after attempts were made to clean it away.[5,6,17] The problem with these measures is that they do not tell the clinician where the cement is with respect to the margin location. Information regarding the extension of cement beyond the margin may be important to designing a way to prevent it. Certainly, it would be logical to assume that the greater the distance the cement is projected beyond the abutment margin, the greater will be the difficulty for the clinician to find and remove it. A similar volume of cement located just below the margin may be much easier to detect and clean away than cement that extends deeper into the tissues.

It may be possible to clean away excess cement when it is located 0.5 mm below a margin that is 1 mm below the gingiva. However, that same extension of cement below a margin placed 1.5 mm or more below the gingiva could make it difficult or impossible to access and clean away without surgical access. Certainly, arbitrarily suggesting that a 1.5 mm subgingival margin might be safe, may be a little presumptuous considering even equigingival margins using the CM design can cause abundant subgingival cement.[1,17]

In addition to margin depth, access to submarginal cement can also be impeded by the convex profile of a prosthesis, the concave profile of an abutment and the poor fit of prosthesis margins. It should be noted that all these shapes can be somewhat controlled by design. However, better designs require an understanding of the root causes of the problems that one wishes to prevent. Besides residual subgingival cement, intra-oral cementation has problems related to open, overhanging, and overextended prosthesis margins. The root causes of these problems have been identified as Prosthesis Dimensional Error and the Tissue Effects sub-classified as Resistance to Displacement and the Gingival Effects.[10,11] Indeed, the abovementioned complications should be expected if their root causes are not mitigated.

Many studies do not address the issues caused by poorly fitting downward facing margins that may be offset from their ideal positions by adjacent tissues and tight contacts. Indeed, with natural teeth, fit has always been a problem and achieving an ideal fit with a smooth transition between the retainer and prosthesis seems to be a rare event.[16] Rather, overhanging and overextended margins appear to be common, not to mention the problem of open margins. It may be difficult to impossible to effectively clean away cement projections from under overhanging ledges of any prosthesis margin. Such overhanging margins are expected to contribute the incidence of subgingival cement as well as prevent its removal.[10]

Cementing a convex crown with equigingival or subgingival margins can approach or press against the gingiva and block the unimpeded egress of excess cement, and thus cause it to be forced deep into the tissue environment.[10,11] This type of gingival-crown interaction was purposely produced in this experiment with the CM crown and perhaps unwittingly in other studies.[5,6,17] This appears to be a common problem with conventional prosthesis designs that has been addressed by the RM design.

The Reverse Margin by contrast, has an abutment margin design that pushes gingiva away from the crown and a crown design that is nested within the abutment margin trough. Its concave tissue facing shape works together with the abutment design to prevent the Gingival Effects and facilitates the free flow of excess cement out of the subgingival tissue spaces.

There was no attempt to clean away excess cement from on top of the abutment margin because we wanted to observe the pattern of excess cement in relation to its margins. An occlusal facing abutment-crown margin interface that is positioned 1mm below the gingiva is readily accessible for cement removal and future maintenance. This feature is quite different from that of a downward facing margin, which not only directs cement into the tissues but also makes it difficult to access and clean it away. The RM design simply anticipates and mitigates the negative effects of Prosthesis Dimensional Error and the Tissue Effects to prevent their negative consequences.[10,11]

The RM design was effective at reducing the maximum of extension of cement extrusion beyond its margins by 14 to 44 times that measured for the CM design under all cementation conditions tested. (Table 4) The RM design has demonstrated a large improvement over the CM design at reducing the extension of cement beyond the margins. Reducing the extension of cement beyond the margin improves the ability of the clinician to access and clean it away.

Some studies reported a reduction of cement volume extruded from the margins by reducing the amount of cement in the crown prior to cementation. These include studies using a retainer replica to extrude cement from the intaglio of a prosthesis prior to cementation[18] and those that use a vent to allow cement to escape into the internal screw access channel[19] or out through some part of the prosthesis other than from between its margins. All these processes essentially reduce the volume of cement available to fill the space under the prosthesis and expel from its margins. They would be expected to both extrude cement from the margins and leave voids under the prosthesis. Voids not only reduce retention by reducing cement contact area but create space for the growth of oral pathogens that can cause peri-prosthesis disease.[20] This is like simulating a cement washout condition at the margins of a prosthesis right on installation day.

The RM System reduced the extension of cement beyond margins 14 to 44 times that measured for the CM System

Since it is almost impossible to balance loading enough cement into the crown to both prevent excess cement and prevent cement voids under the prosthesis, **cement minimization techniques should be avoided.**[21]

Avoid Cement Minimization Techniques

In this study, both dentist ES and MZ were given instructions on how to install single crowns onto their retainers. After AS ½ filled each crown with cement, ES and MZ pressed the crowns into place while bringing the underlying scale reading to 4 Kg. It was desirable to load the crown with excess cement to prevent cement voids.[21] In trial ES1, ES demonstrated the cementation process for 20 trials for MZ. During MZ's 20 trials, ES noted that MZ frequently brought the weigh scale reading to 4.5 Kg and that his force was exerted more quickly than ES expected. There was a noticeable variation in the application of cementation forces between ES1 and MZ.

There was no apparent difference in the average extension of cement beyond the CM margins between the ES1 And MZ trials. There was however a difference in the performance of the RM design. While only 1 of 10 MZ's RM abutments were without any submarginal cement, 6 out of 10 of ES1's trials were free of submarginal cement. Also, MZ's RM cases experienced about 4 times the average extension of cement beyond the margins. The RM performed much better than the CM under both high-pressure conditions, while an apparent small drop in pressure appeared to have made RM significantly more effective during the ES1 trials. This stimulated the additional experiment to test the effect of pressure on the performance of the two margin systems.

Effects of Lower pressure on excess cement travel: A third group of trials (ES2) was then done by ES and AS to test a lower 2 KG pressure, that was gradually applied over a 10 second period. Under this condition, both the CM and RM reduced the extension of cement beyond their margins. However, the CM condition resulted in a range of cement extension from 0 to 3.3 mm beyond the margins and none of its trials were without any submarginal cement. (**Tables 4,5**)

The RM condition had no cement beyond the margin in 8 of the 10 trials and the cement in the 2 trials with submarginal cement extended only 0.1 and 0.2 mm beyond the margin. This small breach of the margin by cement may be easy for a dentist to locate and clean away when the margin is positioned ½ or 1 mm below the gingiva.

Lower pressure installation appears to reduce the extent by which excess cement breaches margins. It may thus be important for researchers to specify the amount of pressure used to cement prosthetics when discussing efficacy of causing or preventing submarginal cement.[2,19]

The RM system is already designed to reduce cementation pressure needed to seat a prosthesis. It can safely tolerate an increased cement space to decrease the amount of pressure needed to exhaust excess cement from the between the prothesis and its abutment margins. The cement space is distributed so that the margins can shift and compensate somewhat for prosthesis dimensional error and remove the need to use increased force to overcome tight contacts with adjacent teeth. Also, both the abutment margin and prosthesis profile are designed to keep the adjacent tissues from interacting with and impeding the proper seating of the prosthesis. This allows the prosthesis to be put in and out of the mouth without traumatizing the tissues adjacent to the retainers and while the undersurface of the prosthesis is adjusted to fit against the underlying tissues. All these features work together to reduce the pressure needed to seat the prosthesis and reduce the probability of residual submarginal cement.

Low pressure installation reduces the incidence and depth of subgingival cement

Conversely, the CM convex shaped crown is likely to increase interaction with adjacent tissues that may prevent it from seating properly. The adjustment phase of prosthesis installation can be much more challenging if the tissues adjacent to the margins need to be displaced and even traumatized during try-ins. The presence of blood and tissue swelling does not make installations easier.

Prosthesis Dimensional Error and related tight contacts may shift the position of the CM prosthesis and cause its margins to get hung up on the incline plains of their retainers and cause open margins as well as overhanging margins. This is a big problem for all downward facing margins, as they are intended to come together while directly interacting with adjacent to tissues during the installation process.

Of course, as we can see from these results, they also can cause abundant and deep subgingival cement, likely due to the Gingival Effects[11]. Reducing cementation pressure with this sort of abutment-crown design would probably be difficult because Resistance to Displacement by adjacent tissues may result in a higher incidence of open margins.[10]

Effect of margin depth on submarginal cement: This experiment compared the effect of the two margin systems at 2 different margin depths. Under the highest-pressure condition (MZ) there was a significant difference in the cement extension beyond the margin under both CM and RM margin conditions when comparing the 1 mm margin depth to the ½ mm margin depth. However, no such difference was detected between margin depths for the ES1 condition. (**Tables 6,7**)

From previous studies ES found that the direction of pressure application can have a large effect on the pattern of cement being extruded from between margins. As such, MZ may have preferentially applied his pressure on the crown on the lingual-distal aspect during cementation. This may have caused the cement to be primarily extruded from the buccal and mesial margins. This might explain why his results were somewhat different from those of ES. Indeed, ES might have pressed on the crowns more on the mesial aspect of the crowns during cementation and thus caused more cement to be injected on the shallower margin side. The patterns of cement extrusion are highly variable. (**Tables 1,2,3**)

These results speak to one of the problems with intra-oral cementation. In the complex intra-oral environment with obstructed vision and with tissues interacting with the prosthesis, it may be difficult to control the pressure vectors on the prosthesis during installation. **In this complex environment it may even be more important to be aided by a system that have been specifically designed to minimize tissue interactions, redirect excess cement out from tissues and allow the prosthesis to installed under low pressure installation.**

In both the MZ and the ES1 cases, the RM cases clearly outperformed the CM cases by greater than 10 orders of magnitude, except in the low pressure ES2 0.5 mm margin condition. Here both the CM and the RM margins had no cement beyond the margin. This may be a result of minimal tissue interaction with the prosthesis at this depth and thus minimal Gingival Effects causing submarginal cement for the CM condition. However, there was a significant difference between the CM 1 mm margin and the 0.5 mm margin. The deeper margin had an average of 0.82 mm of cement extension beyond the margin with a range from 0 to 3.3 mm while there was no cement beyond the 0.5 mm margins.

It is interesting that trials with equigingival margins also caused submarginal cement in other studies.[5,17] Perhaps the base of their crowns came close enough and even pressed against the gingiva and thus prevented the free outflow of excess cement. Perhaps, due to the rapid high-pressure seating, the excess cement extruded from the crowns could not escape from under the crown profile fast enough, and thus became trapped and forced under the gingiva. Either of these processes simply may have stimulated the Gingival Effects. It may be more desirable to have an abutment-prosthesis system that reduces or eliminates the ability of the adjacent tissues to prevent the outflow of excess cement, like the RM system is designed to do.[11]

When looking for clinical significance, any condition that permits cement to go past the margin could put the patient at risk from residual subgingival cement. If we look at the results this way, only the 0.5 mm subgingival margin conditions for both CM and RM designs appear to have done that successfully under the 2 Kg low-pressure installation condition.

If we could agree that cement going 0.2 or less mm past the 1 mm subgingival margin would be easy to remove, we can add the low pressure ES2 RM for the 1 mm and the higher pressure 0.5 mm subgingival margin from the ES1 RM condition to the clinically acceptable group.

If a clinician feels that they can clean away submarginal cement up to 0.6 mm below a 1 mm subgingival margin, then we can include all the RM conditions. This would still exclude all other CM conditions with margins deeper than 0.5 mm.

The silicone gingiva in this in vitro model is unlikely to be able to duplicate the varying stiffness of the gingiva in vivo. Clinical studies are desirable to test the RM under clinical conditions.

A clinical study was done by Tomas Linkevičius and his research group[24] in 2020 and presented at the European Academy of Osseointegration. My laboratory (DiamondDentalStudio.com) received the digital impression images from the research group and designed a trial CM and RM systems, and a RM abutment and final crown for each of 10 patients. Each trial crown had an acrylic sealed screw-access hole to allow for their easy retrieval after the crown was installed.

The margins were designed to be ½ and 1 mm below the gingival margin. However, at the time of the clinical trial the margins appeared to be 0, ½ or 1 mm below the margin. This difficulty in predicting the precise relationship of the abutment margin to gingival margin is common in our industry. Certainly, a ½ mm or more of variation is to be expected. The closer the shape of the abutment-crown complex matches the shape of the transgingival portal, the easier it is to predict the position of the desired margin.

They measured the position of each abutment-margin in respect to its depth below or at the crest of the gingiva on all 4 crown faces: buccal, mesial, lingual, and distal. There were 4 measurements for each crown cemented under each condition. They simply scored each face as having cement below the margin or not.

When they combined all the measurements for RM and CM, regardless of margin depth, they concluded that 17.5% of the RMs and 45% of the CMs had some cement below the margin. The RMs performed much better than the CMs at preventing submarginal cement.

The trials were then grouped according to the abutment margin relationship with adjacent gingiva. In the trials where the margins were ½ mm subgingival, 13% of the RMs cases and 44% of the CMs had some submarginal cement. The 1 mm subgingival margins resulted in 20% of the RM margins and 60% of the CM margins having some submarginal cement.

No attempt was made to measure the distance the cement travelled beyond the margins and thus there is no indication whether the cement that went beyond the RM and CM could be considered easy to access and remove or not. There was also no description of the cementation pressure used to seat the crowns. I suspect they were cemented at high pressure, as the results look more like that condition in this in vitro study.

What is also interesting from the above Linkevičius Study is that the margins deemed to be equigingival also had submarginal cement. Indeed, 20 percent of the RM margin facings and 42% of the CM margin facings had some submarginal cement. I will need to assume that these equigingival margins may have been somewhat supragingival and thus some expressed cement poured over the RM and was thus scored as submarginal. This could also account for some of the CM cases, but here, the submarginal cement may have also occurred due to the Gingival Effects, as argued for the Gehrke Study above[17].

If the excess cement just poured over a supragingival margin, it would be easy to access and clean it away. It qualifies as submarginal cement, but not as subgingival cement. It is not possible for me to conceive how a RM designed abutment-crown complex can cause subgingival cement unless the crown stimulates the Gingival Effects or there is an open space between the abutment and the gingiva. I have never seen it.

What is clear from all the studies reviewed, is that intra-oral cementation with **the CM poses a significant risk of causing residual subgingival cement, especially under common high-pressure conditions.** Perhaps, if CM or similar systems are to be used with subgingival margins, it might be prudent to consider surgery to remove the expected submarginal cement. This might protect the patient from the likely advent of related peri-implant disease. It is likely that the Gingival Effects are also to be considered when cementing crowns and bridges onto natural teeth. The fluid dynamics of that cementation process would be expected to be similar.

Some clinicians attempt to avoid problems related to subgingival cement by choosing to install prosthetics using the screw-in technique. First: the screw-in prosthesis installation technique is not generally suitable for attaching crowns and bridges to natural teeth. Many more crowns are installed onto natural teeth than onto dental implants. Second: the screw-in technique exposes patients to a myriad of risk factors for peri-implant disease. These include misfit implant-abutment and abutment-prosthesis connections, procedure related cantilevers that mechanically stress misfit connections and can also block access to care of the peri-implant tissues. In addition, screw access holes can weaken the prosthesis and cause it to fracture. The plastic covers are subject to premature wear, fail to maintain a stable occlusion, discolor, or dislodge and therefore, need to be replaced frequently. Yes, the current screw-in system of installation is far from perfect in its present state.[23]

Using the CM System with high pressure exposes patients to submarginal cement

For those dentists that just want to make the screw-in system better, it is possible to include a few safe cementation steps that can optimize the fit of implant parts and can also reduce the profile of the prosthesis, while keeping it easily retrievable.[4]

In any case, if intra-oral cementation is contemplated and the prosthesis margins are expected to be equigingival or subgingival, it might be prudent consider the use of the RM system to prevent submarginal cement and open and overhanging margins due to prosthesis dimensional error.[23] Unlike the CM System, the RM System was designed to be sensitive to expected Prosthesis Dimensional Error and the Tissue Effects.

There may be an issue of the RM design being different in its profile than a natural tooth. Clinicians have accepted many prosthetic devices in the past that do not really look like natural teeth, because their features benefit the

The RM System is designed to mitigate the root causes of submarginal cement

patient. We used stainless-steel and gold colored crowns and because we liked their smooth hard surfaces. We are now tending to use conical connections with platform switch because we feel that these connections may be more stable in the mouth. These do not look anything like the necks of natural teeth, and they need to be placed deeper in the tissues or be restored with crowns that have wider and flatter emergence profiles. Dentists still may choose these designs because they feel they may be better for their patients.

Now we have the RM System that looks a little different, but can reduce or eliminate several risk factors for peri-implant disease. Wadhwani[25] concluded, "it is likely the abutments of the future will look very different from what we see today." Well, the future has arrived. Will we choose to use this new system and usher in a new standard of care or continue to doom our patients to enduring the current troubling prevalence of peri-implant disease?[8,9]

Conclusions

The Reverse Margin System consistently outperformed the Chamfer Margin System regarding its ability to prevent the incidence and extension of subgingival cement into the submarginal spaces. Lower seating pressure during the simulated intra-oral cementation process reduces the extension of excess cement beyond the abutment margins. More clinical studies are warranted to further demonstrate the efficacy of this margin design at preventing the advent of submarginal cement.

References:

1. Misch CE. Dental Implant Prosthetics, Elsevier Mosby, 2015; 2nd Edit: Ch 26 & 28.
2. Wadhwani CPK. Cementation in Dental Implantology: An Evidence Based Guide. Springer-Verlag. 2015.
3. American Academy of Periodontology. Peri-Implant Mucositis and Peri-Implantitis: A Current Understanding of Their Diagnoses and Clinical Implications. J Periodontol: April 2013;Vol 84,No 4,436 – 443.
4. Svoboda ELA. All-on-X: A New Standard of Care. Spectrum Implants: October 2020; Vol11 No 4:22-28.
5. Linkeviĉius T, Vindasiute E, Puisys A, Peciuliene V. The influence of margin location on the amount of undetected cement excess after delivery of cement-retained implant restorations. Clin Oral Impl Res 2011;1379-1384.
6. Linkeviĉius T, Zero Bone Loss Concepts. Quintessence Publishing Co. Inc. 2019.
7. Wilson TG Jr. The Positive Relationship Between Excess Cement and Peri-implant Disease: A Prospective Clinical Endoscopic Study. J. Periodont 2009;1388-1392.
8. Derks J, Schaller D, Håkansson J, Wennström JL, Tomasi C, Berglundh T. Effectiveness of Implant Therapy Analyzed in a Swedish Population: Prevalence of Peri-implantitis. J Dental Research, 2016 Vol 95(1):43-49.
9. Jepsen S et al. Primary Prevention of peri-implantitis: Managing peri-implant mucositis. J Clin Periodontol 2015;42 (Suppl. 16) S152-158.
10. Svoboda ELA. Stock abutments cause problems preventable by a well-designed prosthesis installation system. OralHealth October 2019;46-59.
11. Svoboda ELA. Controlling Excess Cement During the Process of Intra-Oral Prosthesis Cementation: Overcoming the Gingival Effects. OralHealth October 2015;52-66.
12. Kale E, Seker E, Yilmaz B, Özcelik TB. Effect of cement space on the marginal fit of CAD-CAM-fabricated monolithic zirconia crowns. J of Prosth Dent 2016;V 116 (6), 890-895.
13. Zortuk M, Bolpaca P, Kilic K, Ozdemir E, Aguloglu S. Effects of finger pressure applied by dentists during cementation of all-ceramic crowns. Eur J Dent. 2010 Oct; 4(4): 383–388.
14. Piemjai M. Effect of seating force, margin design, and cement on marginal seal and retention of complete metal crowns. Int J Prosthodont. 2001;14:412–416.
15. Black S, Amoore JN. Measurement of forces applied during the clinical cementation of dental crowns. Physiol Meas. 1993;14:387–392.
16. Kissov HK, Popova EV, Katsarov SG. Position of crown margin in relation to the tooth preparation line. Folia Med (Plovdiv). 2008;50(2):57-62.
17. Gehrke P, Bleuel K, Fischer C. Sader R. Influence of margin location and luting material on the amount of undetected cement excess on CAD/CAM implant abutments and cement-retained zirconia crowns: an in-vitro study. BMC Oral Health. 2019;19(111):1-12.
18. Wadhwani C. Pineyro A. A technique for controlling the cement for an implant crown. J Prosth Dent. 2009;102(1):57-58.
19. Wadhwani C, Piñeyro A, Hess T, Zhang H, Chung K. Effect of Implant Abutment Modification on the Extrusion of Excess Cement at the Crown-Abutment Margin for Cement-Retained Implant Restorations. Intern J of Oral & Maxillofacial Implants. 2011;26(6):1241-1246.
20. Linkeviĉius T, Zero Bone Loss Concepts. Quintessence Publishing Co. Inc. 2019; Ch12:160-161.
21. Svoboda ELA, Sharma A. Safer Intra-oral Cementation: Preventing Subgingival Cement & Cement Space Voids. Award Winning table Presentation. www.ReverseMargin.com. 2019:1-18.
22. Svoboda ELA. Preventing Peri-implant Disease by Safer Prosthesis Installation: Managing the Macrogap and Residual Subgingival Cement. www.ReverseMargin.com. 2017;1-4.
23. Svoboda ELA. Misfit implant parts and poor margins are the Standard of Care for implant prosthetics. Is anyone conflicted about this? Spectrum Implants. 2020:11 (3);28-32.
24. Andrijauskas P, Svoboda E, Alkimavicius J, Linkevicius T. Occurrence of cement rests on reverse margin custom abutments versus conventional custom abutments. Clinical Oral Implants Research 10/2020;31(S20):43-43.
25. Wadhwani CPK. Cementation in Dental Implantology: An Evidence Based Guide. Springer-Verlag. 2015;71.

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