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IN VITRO STUDY OF MARGINAL GAP AND MICROLEAKAGE OF THREE TYPE OF CEMENTS IN ZIRCONIA CROWNS

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ABSTRACT

Background and Aim: One of the concerns of dentists in full coverage restorations, is microleakage and marginal gap of crowns. Due to the high prevalence of decay in society and inefficiency of common treatments in some dental restorations, demand for ceramic restorations with convenient features is increasing day by day. Information about these kinds of restorations particularly those that are made of zirconia is limited. Studies showed certain inconsistencies, such as some studies suggested that most microleakage and marginal gap ocuurs in glass ionomer cements whereas some others showed more microleakage and marginal gap in self adhesive resin cements. Due to the lack of information about the physical characteristics of majority of luting cements, this in vitro study designed to investigate the influence of RelyX Unicem, RelyX ARCand RMGI cements on microleakage and marginal gap in zirconia fullcoverage crowns.Methods and Materials: According to similar articles and considering of Kruskal-Wallis One-way ANOVA test which is used for comparison between the three groups; 10 samples for each group and a total of 30 samples were collected for this study. 30 intact human premolar teeth which have been recently extracted for orthodontic purposes, were selected. After extraction, teeth being drawn in distilled water at room temperature. For storing samples 0/1% thymol solution were used. Then samples were mounted by Speedex putty and teeth preparation was done by high speed bur. By 3shape device samples were scaned at 3 angles and die spacer thickness selected as 30 micrometers on device computer. Then chosen zirconia blocks choice inserted in imes-icore CAD/CAM system and milling stage was done. Sintering processe was done by putting samples in MIHM-VOGT and and after seven hours this step completed. The samples were tested on teeth with fit checker and after the correction porcelain applied by layering technique and vacuum infusion process. After final preparations, crowns margins were checked. To evaluate the marginal gap of samples before cementation, crowns filled with light body impression and then put on teeth. After setting time excess material protruding from the edge of crowns margins was cut and the samples were analyzed by a stereo microscope eqquipped with a digital micro meter.Results: The results showed that after the cementation the marginal gap was significantly increased in all 3 groups of cements. The marginal gap of RelyX ARC cement was significantly higher than two other cements, while the microleakage of RelyX Unicem cement and RMGI showed no significant difference. There was no significant difference in the evaluation of microleakage between 3 groups of cements. In the context of evaluating the relationship between the marginalgap and microleakage no significant relationship was found (P> 0.001).Conclusion: Based on resuts of our study and due to other researches, we could conclude that self-adhesive luting cements have better physical and clinical characteristics than dual-cure or glass-ionomer cements. In current study the amount of marginal gap of RelyX Unicem cements was significantly less than RelyX ARC, and due to the more convenient clinical application and lower level of technique sensitivity, and also taking into account the better physical properties of resin cements than glass ionomer cements, we can recommend to use RelyX Unicem self-adhesive cement instead of older RelyX ARC and RMGI cement.

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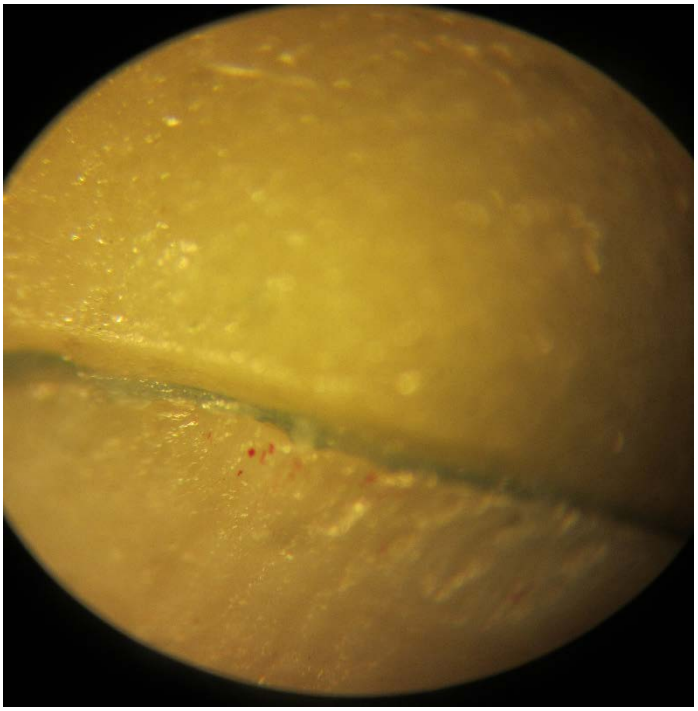
Introduction

One of the concerns of dentists in full coverage restorations, is microleakage and marginal gap of crowns and its impact on the structure of the remaining teeth and pulp tissue [1,2,3]. Due to the high prevalence of decay in society and inefficiency of common treatments in some dental restorations, demand for ceramic restorations with convenient features is increasing day by day [3,4,5]. Information about these kinds of restorations particularly those that are made of zirconia is limited [1,2]. Unavailability of sufficient information in this field and unconscious use of these types of restirations could lead to severe consequences such as recurrent caries beneath restorations and pulp traumas [1,6]. Several studies evaluated the impact of the type of cements used for cementing of all ceramic restorations on microleakage and marginal gap, but few of the considered microleakage and marginal gap in full coverage zirconia crowns [1]. On the other hand, studies showed certain inconsistencies, such as some studies suggested that most microleakage and marginal gap ocuurs in glass ionomer cements [7,8,9,10] whereas some others showed more microleakage and marginal gap in self adhesive resin cements [11,12]. Despite the fact that adhesive cements have low solubility and also are tissue compatible, so far their clinical viability including the impact of artificial aging on their microleakage has not been studied comprehensively [13]. In evaluation of the marrginal gap in these cements some studies have shown the highest rate [1] and some other studies have shown very low rate of marginal gap [14]. For the first time Zinc Phosphate (ZP) cements introduced in 1878. Despite their high compressive strength, due to the low pH which stimulates the pulp, they were not considered acceptable [13]. In the late 60s the first Glass Ionomer (GI) cement was introduced by Alan Wilson in London [15]. Since then various combinations of GI were evaluated to improve the properties of these cements. In the late 80s light cure resin base GIs were introduced as base and liner [16]. Finally, in early 90s other hybrid systems of GIs were introduced [17]. Nowadays these types of GIs use as directly bonded restorations and luting agens. Resin cements introduced for the first time in the early 50s as a luting agent for crowns and bridges, however due to their high polymerization shirinkage, leakage and unsuitable physical properties at first there were not much tendency to use them, but these days according to improvments of their quality, resin cements are the prefered cements for the ceramic restoration and clinical and laboratory studies have proven their desirable properties [18]. Resin cements have desirable properties such as low solubility and high compressive strength. At the same time they have some flaws such as pulp irritation, leakage and high thickness. When there is a need for restoring teeth with not enough remaining structure, resin cements acts better than other cements [19]. Polycarboxylate cements were introduced in the 70's and alongside GIs they giving rise to the concept of chemical adhesion [20]. Also these days self adhesive resin cements presented with suitable resistance and physical properties. Exclusion of bonding and etching steps simplified their clinical usage [21,22]. Zinc oxide base cement (ZO and ZOE) are another group of cements which are used for temporary restorations. Some studies showed that they may have antibacterial activity against the oral organisms [23]. Piwowarczyk et al. [17] evaluated microleakage and marginal gaps in full cast crown restorations bonded with six different types of cementing agents. one zinc-phosphate cement (Harvard cement), one conventional glass-ionomer cement (Fuji I), one resin-modified glass-ionomer cement (Fuji Plus), two standard resin cements (RelyX ARC and Panavia F), and one self-adhesive universal resin cement (RelyX Unicem). The results of their study showed that RelyX Unicem has the smallest degree of microleakage both in enamel and in dentin. Panavia F und RelyX Unicem were associated with significantly larger marginal gaps than all other cementing agents. No association was observed between microleakage and marginal gap other than a weak direct correlation when using Harvard cement on enamel. Rosentritt et al. [5] assessed marginal integrity of CAD/CAM fixed partial dentures. 32 3-unit FPDs were fabricated of the CAD/CAM Y-TZP zirconia. Then they used resin cements with corresponding primer and bonding systems to lute the FPDs as following order: Compolute/EBS multi, Panavia F/ED, Variolink 2/Syntac classic and RelyX Unicem/without treatment. Aualloy FPDs were cemented with RelyX Unicem and Harvard as the control groups. The results of this studu showed that at the interfaces (cement-tooth and cement-FPD), the systems showed a 95% or higher perfect margin before and after aging. Only Variolink2/Syntac had a marginal adaptation, lower than a 70% perfect margin. Generally, the fuchsine penetration was below 20%, only BioPontstar/Harvard and Lava/Variolink2 showed penetration results between 80% and 100%. These researchers concluded that the success of the adhesive cementation of zirconia FPDs depends on the cement system. Under the conditions of this study, zirconia FPDs showed good to sufficient marginal integrity in combination with Panavia/ED, Compolute/EBS and RelyX Unicem. Due to the lack of information about the physical characteristics of majority of luting cements, this in vitro study designed to investigate the influence of RelyX Unicem, RelyX ARCand RMGI cements on microleakage and marginal gap in zirconia fullcoverage crowns.

Materials and Methods: Rely X Unicem is a Dual cure self-adhesive resin cement that has a phosphorylated methyl methacrylate base and requires no tooth pretreatment due to manufacturer claims [21]. RelyX ARC cement is a dual cured resin cement which requireds tooth pretreatment before its application [24]. RMGI cement is a glass ionomer resin cement which its powder combination is Fluoro-Alumino-Silicate and its liquid combination is a copolymer of acrylic and maleic acid. This cement has the ability to release of fluoride [25]. According to similar articles and considering of Kruskal-Wallis One-way ANOVA test which is used for comparison between the three groups; 10 samples for each group and a total of 30 samples were collected for this study. 30 intact human premolar teeth which have been recently extracted for orthodontic purposes, were selected. Samples have no caries, filling, wear and other defects [26,27,28]. Immediately after extraction, teeth being drawn in distilled water at room temperature. For storing samples 0/1% thymol solution were used [29]. By using a scaler and a Periodontal curette all calculuses were removed from teeth and then samples were brushed with pumice [26,30,31]. Then

samples were mounted by Speedex putty and teeth preparation was done by high speed bur as follow: At first occlusal suface reducted as 1.5 mm and functional cusp bevel was done. Axial surfaces reducted as 1.2mm and deep chamfer finishing line was preped circumferentially. The convergence of proximal walls was considered as 6 ° [28]. After preparation finishing lines were checked using a 3.5X magnifier [26]. Then teeth were placed in special molds and placed inside the chamber of 3shape device [32]. This scanner scaned the theeth at 3 angles and die spacer thickness selected as 30 micrometers on device computer. Then chosen zirconia blocks choice inserted in imes-icore CAD/CAM system [33] and milling stage was done. Sintering processe was done by putting samples in MIHM-VOGT and and after seven hours this step completed [34]. The samples were tested on teeth with fit checker and after the correction porcelain applied by layering technique and vacuum infusion process [13]. After final preparations, crowns margins were checked. To evaluate the marginal gap of samples before cementation, crowns filled with light body impression and then put on teeth. After setting time excess material protruding from the edge of crowns margins was cut and the samples were analyzed by a stereo microscope eqquipped with a digital micro meter [25] (Image 1). The acceptable marginal gap before cementation considered as a maximum of 50 microns [13]. 30 acceptable crowns randomly divided into 3 groups. Before cementation inner surfaces of the crown and tooth surfaces were cleaned with alcohol [26].



mage 1. Stereo microscope image from crown marginal gap before cementatio

Then 10 samples cemented by RMGI, 10 samples cemented by RelyX Unicem and 10 samples cemented by RelyX ARC in accordance with the manufacturer's instructions. Samples were put under 6kg pressure for 7 minutes [39]. Samples were stored in 37 ° C in distilled water were for 7 days [29]. After 7 days thermo cycling process was done at 5-55 ^{oC} temperature in 30 seconds cycles with 2 seconds intervals [29]. To conduct microleakage test, root surface of teeth covered up to 2 mm to the crown margins with two layers of varnish. After that samples were immersed in 2% Fushin dye solution for 24 hours [26]. After microleakage test the samples were washed and kept at room temperature for 24 hours before they were cut buccolingually by cutting machine [26,29]. Samples examined by stereo microscope to evaluate marginal gap and dye penetration rate. Dye penetration was meassured on two area of each sample and a scoring system was used as follow: 1- In the absence of dye penetration the sample scored 0, 2- In the case of dye penetration is limited to the preparation step the sample scored 1, 3- In the case of dye penetration to $^{1}/_{3}$ axial walls the sample scored 2, 4- In the case of dye penetration to $^{2}/_{3}$ axial walls the sample scored 3, 5- In the case of dye penetration to the full length of axial wall the sample scored 4 and 6- In the case od dye penetration to occlusal surface the sample scored 5 [36] (Image 2).

Statistic analysis: To compare the marginal gap before and after cementation the paired t test was used. Post Hoc Tests was used to compare the marginal gap between 3 groups of cements. To compare the extend of microleakage between cements Kruskal-Wallis Test was used and to evaluate the relationship between microleakage and marginal gap Spearman's rank correlation coefficient test was used.

Results

The results showed that after the cementation the marginal gap was significantly increased in all 3 groups of cements (Charts 1,2,3). The marginal gap of RelyX ARC cement was significantly higher than two other cements, while the microleakage of

RelyX Unicem cement and RMGI showed no significant difference (Chart 4). There was no significant difference in the evaluation of microleakage between 3 groups of cements (Chart 5). In the context of evaluating the relationship between the marginalgap and microleakage no significant relationship was found, in other words the amount of marginal gap has no effect on the extend of microleakage (P> 0.001).

mage 2. A sample with score 3 in dye penetration evaluation

Discussion

Based on the results of this study, marginal gap has been increased in all samples after cementation and this difference was statistically significant in RelyX ARC cement (p <0.05). According to this fact that the terms of all samples unificated prior to cementation and same force and condition were used in cementation process, these differences can be attributed to the effect of cements film thickness. As manufacturers claim that these cements have a film thickness of 15µ, these results are noteworthy [29,38]. Piwowarczyk et al. study [17] showed that RelyX Unicem has the smallest degree of microleakage but was associated with significantly larger marginal gaps, these results are againt current study results, but this could be caused by different test conditions, as they used full metal crowns in their study. Although they also observed no association between microleakage and marginal gap which is in accordance with our results. Goods et al. [42] assessed the margin surface profile of all-ceramic crowns at try-in and 1-week after cementation with RelyX ARC dual-cured resin, RelyX Unicem self-adhesive/dual-cured resin, RelyX Veneer light-cured resin and RMGI chemically cured resin luting cement. Results of this study shows that There were no significant differences in the crown margin surface profile between the four cement groups at try-in. The change in crown margin position between try-in and post-cementation was significantly greater for RelyX ARC than for RelyX Veneer and RMGI. There were no significant differences in the crown margin extensions between the four cement groups, however most of the IPS Empress all-ceramic crowns in this study were underextended but this was not statistically significant. So they concluded that IPS Empress all-ceramic crowns seated more fully with RelyX Veneer and RMGI than with RelyX ARC cement. Rossetti et al. [1] assessed the correlation between margin fit and microleakage in complete crowns cemented Zinc Phosphate, RMGI and resin-based luting agent (RC) luting agents. In this in vitro study they used 30 human premolars that were prepared for full-coverage crowns with a convergence angle of 6 degrees, chamfer margin of 1.2mm circumferentially and occlusal reduction of 1.5 mm. Ni-Cr cast crowns were cemented with either zinc phosphate, RMGI and RC. The results show that seating discrepancy and marginal gap values ranged from 81.82 microm to 137.22 microm (p=0.117), and from 75.42 microm to 78.49 microm (p=0.940), respectively. Marginal microleakage scores were ZP=3.02, RMGI=0.35 and RC=0.12 (p<0.001), with no differences between RMGI and RC scores. The correlation coefficient values ranged from -0.27 to 0.30 (p>0.05). These researchers conclude that margin fit parameters and microleakage showed no strong correlations; cast crowns cemented with RMGI and RC had lower microleakage scores than ZP cement. Hooshmand et al. [43] assessed microleakage and marginal gap of adhesive cements for noble alloy full cast crowns. The purpose of their study was to evaluate the microleakage and marginal gap of two self-adhesive resin cements with that of other types of adhesive luting cements for noble alloy full cast crowns. Crowns were made from a noble alloy using a standardized technique and randomly cemented with five cementing agents as follows: 1-GC Fuji Plus resin-modified glass ionomer cement, 2-Panavia F 2.0 resin cement, 3-Multilink Sprint self-adhesive resin cement, 4-RelyX Unicem self-adhesive resin cement with pretreatment and 5-Rely X

Unicem with no pretreatment. The results show that the Rely X Unicem (with or with no pretreatment) exhibited the smallest degree of microleakage at both tooth-cement and cement-crown interfaces. The greatest amount of microleakage was found for Panavia F 2.0 resin cement followed by GC Fuji Plus at both interfaces. No statistically significant difference in the marginal gap values was found between the cementing agents evaluated ($p>0.05$). The self-adhesive resin cements provided a much better marginal seal for the noble alloy full cast crowns compared with the resin-modified glass ionomer or dual-cured resin-based cements. Yüksel et al. [44] assessed the Influence of marginal fit and cement types on microleakage of all-ceramic crown systems. The purpose of this study was to evaluate the effects of both marginal fit and cementing with different luting agents on the microleakage of all-ceramic crown systems. Thirty-six extracted upper central incisors were prepared for full-coverage crowns and were divided into three groups. Group 1: CAD/CAM-fabricated ZrO2, Group 2: Heat-pressed lithium-disilicate, and Group 3: Cast Cr-Co copings as the control group. Groups were assigned cementation with either self-adhesive resin cement or glass-ionomer luting cement. Microleakage was scored using a five-point scale, and the marginal gap was measured using image analysis software. The results show that Group 1 has significantly smaller gaps than Group 3 ($P=0.042$). Self-adhesive resin cement showed a lower level of microleakage than glass-ionomer luting cement in all groups ($P=0.029$). Microleakage scores of '0' were 83% for Group A cemented with self-adhesive resin cement, 50% for Group A cemented with glass-ionomer luting cement, 50% for Group 2 Cemented with self-adhesive resin cement, 16% for Group 2 cemented with glass-ionomer luting cement, 33% for Group 3 cemented with self-adhesive resin cement and none for Group 3 cemented with glass-ionomer luting cement. They Concluded that marginal discrepancy and cement type both had significant effects on microleakage. Lower levels of microleakage were recorded with self-adhesive resin cement, while CAD/CAM-fabricated ZrO2 copings showed smaller marginal discrepancy and less microleakage in comparison to cast Cr-Co.

Conclusion: Based on resuts of our study and due to other researches, we could conclude that self-adhesive luting cements have better physical and clinical characteristics than dual-cure or glass-ionomer cements. However the technique that used for tooth preparation and crown fabrication could significantly affect on cements performance. Self-adhesive resin cements have high compressive strength, very little microleakage and very high retention, but their film thikness is more than glass-ionomer and zinc phosphate cements, so this could lead to more marginal gap and harder seat of crown. But because of their resin structure they show less microleakage than other conventional cements. Note that in current study the amount of marginal gap of RelyX Unicem cements was significantly less than RelyX ARC, and due to the more convenient clinical application and lower level of technique sensitivity, and also taking into account the better physical properties of resin cements than glass ionomer cements, we can recommend to use RelyX Unicem self-adhesive cement instead of older RelyX ARC and RMGI cement. In general we should use resin cements in cases with low retention and accuratly preped teeth which have adequate space for cement layer. Also manufacturers instructed procedures always shoud be followed [45].

Chart 1. RelyX Unicem marginal gap before and after cementation

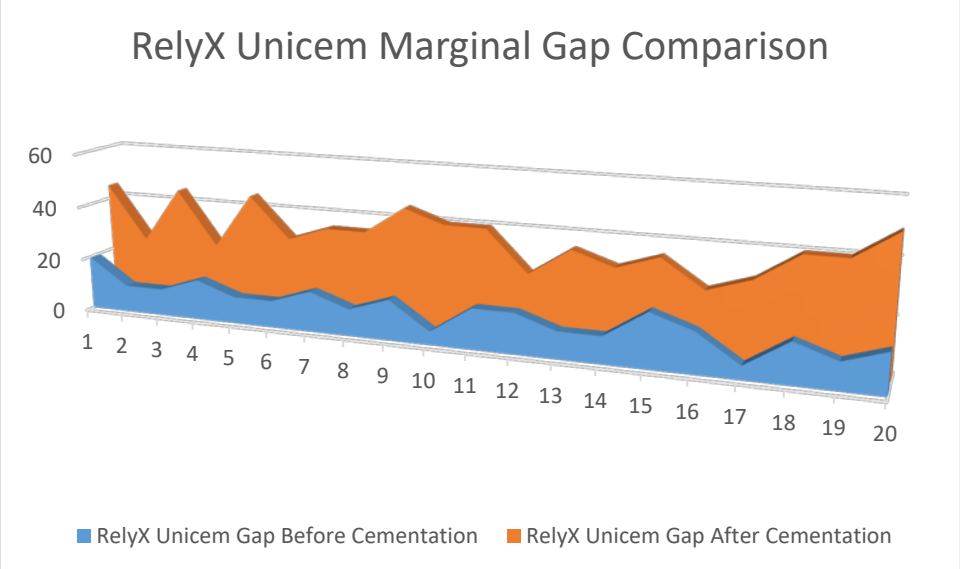


Chart 2. RelyX RMGI marginal gap before and after cementation

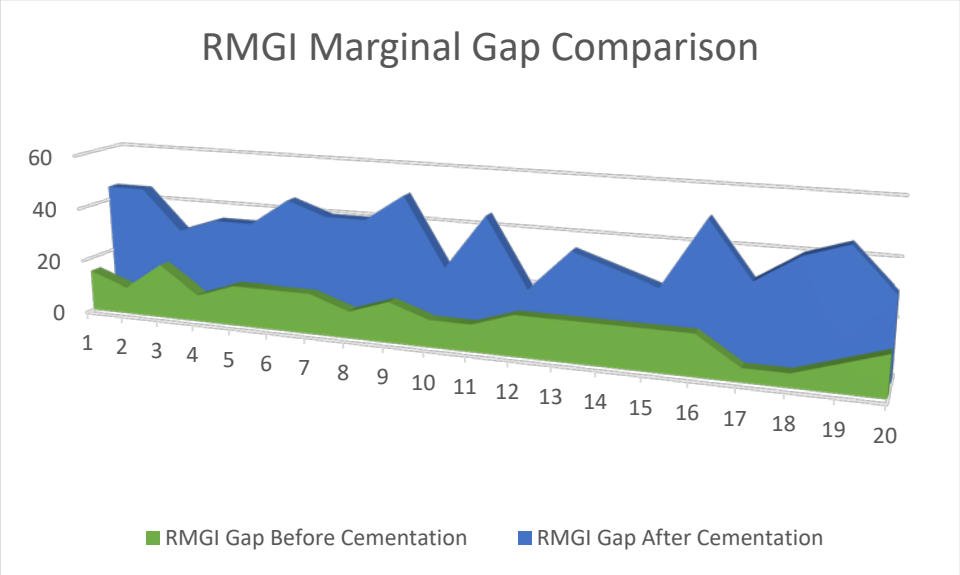


Chart 3. RelyX ARC marginal gap before and after cementation

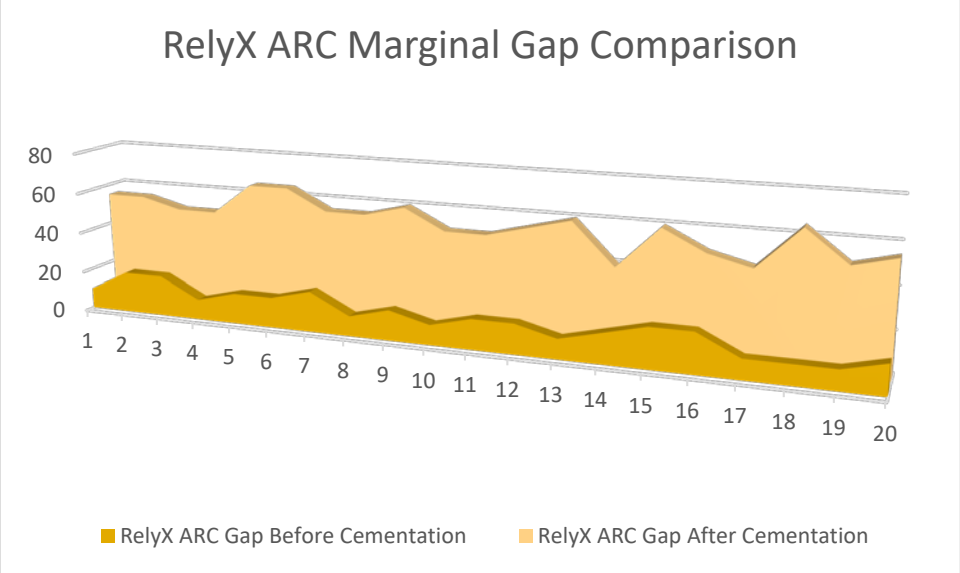


Chart 4. Comparision of all cements marginal gap after cementation

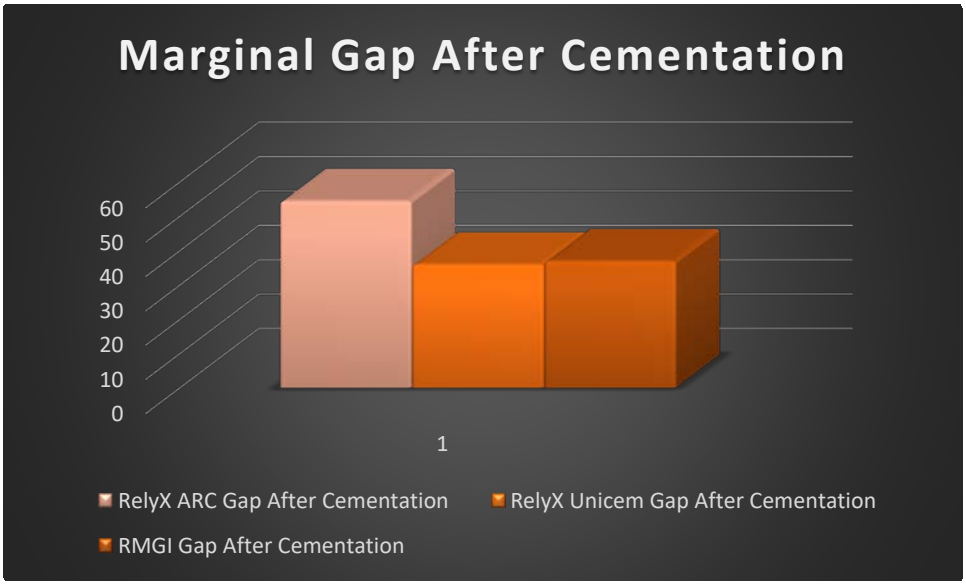
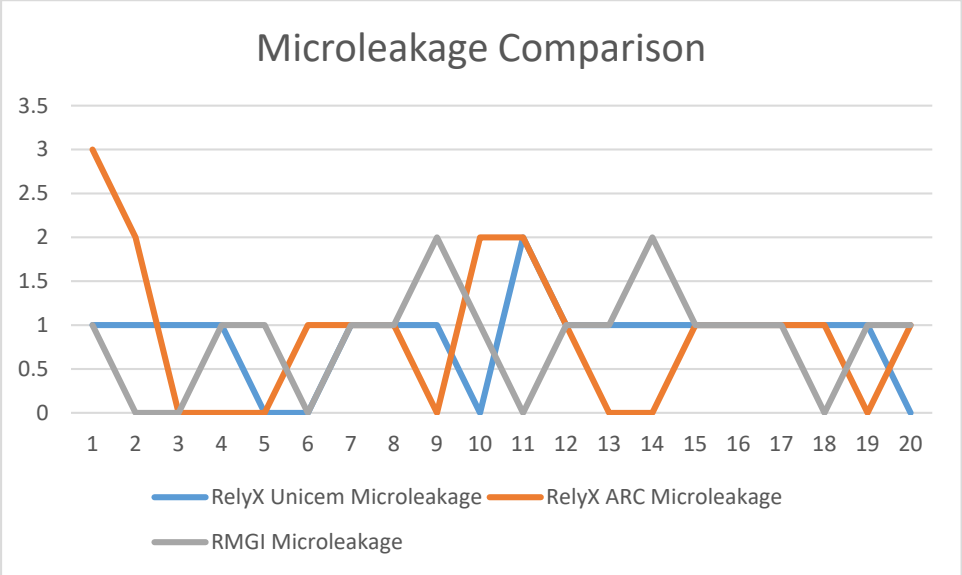


Chart 5. Comparision of all cements microleakage after cementation



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