Research Article

Assessment of marginal adaptation of indirect zirconia crown restorations using self-adhesive resin cements modified with polylysine antibacterial particles

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Abstract: The objective of this in vitro study was to evaluate the effect of incorporated polylysine antibacterial particles (PLS) in two different types of adhesive resin cements on marginal adaptation of indirect crown restorations fabricated from IPS e.max ZirCAD (LT block). Material and methods: 32 maxillary first premolar teeth were prepared to receive indirect crown restorations with the following preparation criteria: occlusal-gingival height of 4 mm, 3% axial wall taperness, and a 0.8 mm circumferential chamfer finishing line that was checked with a digital caliper. The prepared teeth were randomly assigned to four main groups (n=8) according to the type of resin cement used to lute indirect restorations: 1) Rely C: cemented with RelyXTM U200 cement, 2) RelyPLS: cemented with RelyXTM U200 cement incorporated by PLS, 3) BrC: cemented with Breeze™ cement and 4) BrPLS: cemented with BreezeTM cement incorporated Breeze™ cement. The teeth were digitally scanned and crown design was performed using Sirona InLab CAD 15.1 software. Each restoration was cemented to its respective tooth and a 230X magnification power digital microscope was used to measure the marginal gap in µm. The data was then analysed statistically; Independent t-test and a paired t-test were used. Result: The results showed that the crowns cemented by RelyC showed significantly lower mean values of the marginal gap compared to BrC (28.969 µm, 31.06 µm), respectively ($p<0.05$) and there were no significant differences in marginal adaptation between the groups cemented with resin cement incorporated with PLS and the other groups cemented with resin cement not incorporated with PLS for both types of cements ($p>0.05$). Furthermore, the results of the paired t-test showed a statistically higher marginal gap after cementation compared to before cementation in all groups ($p<0.05$) Conclusion: Incorporating antibacterial PLS antibacterial particles into resin cements did not adversely affect marginal adaptation of zirconia crowns. A smaller gap was produced with RelyX compared to Breeze cement.

Keywords: polylysine, RelyX™ U200, Breeze™, marginal gap, self-adhesive resin cement.

Introduction

The past decade has proven to be a remarkable period for the advancement of dental materials, marked by remarkable strides in biocompatibility, aesthetic enhancement, and improved material strength. This progress has been particularly pronounced with the growing adoption of zirconia materials and the shift toward metal-free dentistry. A deep understanding of zirconia ceramic chemistry, crystallography, and custom ceramics has paved the way for cutting-edge dental applications. [(1)].

The practitioner should be aware of various elements that influence the long-term performance of full-ceramic restorations long-term performance. To achieve this, prosthetic crowns must have an exact marginal and internal fit, as well as increased mechanical strength, good interfacial adhesion to the veneer material, and the correct luting cement [(2)]. Marginal fitness is influenced by different variables, including the type of CAD-CAM system, the luting cement, the geometry of tooth preparation, the curing procedure, and the technique used to remove excess cement [(3)]. Dental cement is used to ensure the integrity of the restoration and its retention in the tooth preparation or implant abutment. Resin cement has ideal biological, physical, mechanical, and handling qualities for dental cement [4, 5]. The main function is to seal the gap between the prepared tooth and the restoration, minimise microleakage, and prevent the restoration from becoming loose and dislodged [6]. Compared to self-curing resin cement, dual-curing resin cement has improved bond strength and hardness [7]. Self-adhesive resin cements were used to simplify cementation steps, since no additional surface treatment is required for tooth or the restoration is required [8]. Furthermore, dual polymerised resin cements are advisable when the ceramic material is excessively thick or significantly opaque, preventing adequate transmission of polymerising light [4].

The discrepancy of the restoration margin can lead to a demineralization attack due to exposure of dental cement to the oral environment [9, 10]. In addition, it may lead to food accumulation and difficulty optimising good oral hygiene. Due to this difficulty, plaque could more easily form around the restoration margin and bacteria can reach the tooth-cement interface more easily, changing the equilibrium of the oral environment and starting secondary caries. However, the position of the subgingival margin or other host-related variables can increase the risk of secondary caries even when the marginal gap is clinically acceptable. Some researchers consider a marginal gap value of less than 120 μm to be clinically acceptable [11], while others consider it to be less than100μm [12]. Furthermore, the appropriate value is still believed to be between 20 and 75 μm [13]. Finally, we can say that the most common cause of restoration failure and its replacement is secondary caries [14, 15].

The interior surface of the restoration plays an important role, making indirect restorations such as crowns, inlays, onlays, and bridge cementation indispensable [16]. Due to the significant role that residual bacteria under restorations and plaque formation around restoration margins play in the failure of indirect restorations, there is strong demand for a luting cement that has antibacterial properties. Unfortunately, the currently available luting cement lacks any antibacterial activity. However, very limited efforts to incorporate antibacterial properties into luting cement [17].

Polylysine (PLS) has recently been introduced in dentistry as an alternative antibacterial agent. As its higher compatibility with eukaryotic cells can address the limited biocompatibility of some other antibacterial agents [18], it is widely used due to its broad antimicrobial spectrum [19]. PLS is generally considered a safe (GRAS) natural polypeptide that is edible, biodegradable, water-soluble, and non-toxic. I is widely used as a food preservative and to encourage cell adhesion in eukaryotic cell cultures. PLS is safely broken down in the body to produce lysine, an essential amino acid [20]. Furthermore, it was used in medicine as an interferon inducer, medication delivery vehicle, gene delivery vehicle, and coating material for bioelectronics [21]. In 2017, Lygidakis N. developed a smart compound incorporated with PLS particles with different concentrations and found that this combination at a concentration of 2% was capable of preventing *Streptococcus mutans* at all inoculum densities [22]. Another study in 2020 studied the antibacterial effects of ε-polylysine against oral *Streptococcus mutans* and *Porphyromonas gingivalis* in liquid medium on biofilm-dentin samples. The results indicated satisfactory antibacterial efficacy against the two species [23].

As far as is known at the time of writing of this article, no previous studies have incorporated PLS as antibacterial particles into luting resin cement. Therefore, the present study aims to evaluate the marginal fitness of the restoration of complete zirconia crown restorations cemented with antibacterial resin cements modified with PLS particles (before and after cementation). Therefore, the present study aimed to develop new resin cements with antibacterial properties and to evaluate the marginal fitness of the full zirconia crown cemented with modified resin cements (pre- and post-cementation). The first null hypothesis stated that the marginal fitness of the zirconia crowns would not be affected by the addition of PLS to resin cements, while the second hypothesis stated that the fitness would not be affected by the type of resin cement.

Materials and Methods

This present study used two specific types of self-adhering resin-based self-adhesive dental cements, namely Breeze™ self-adhesive resin dental cement (Pentron Clinical Technologies LLC in the USA) and 3M™ RelyX™ U200 (3M ESPE, Germany) as they possess entirely different chemical compositions (Table 1).

Table 1: Description, composition and manufacturers of the materials used in this study

Materials	Description	Composition	Manufacture	Batch numbers
RelyX™ U200 Automix	Self-adhesive Dual-cure	-Methacrylate monomers containing phosphoric acid groups Methacrylate monomers - Monomers Alkaline (basic) fillers -Silanated fillers -Initiator components Stabilisers -Rheological additives Pigments	(3M ESPE, Germany) 3M Deutschland GmbHThe author said:	(LOT NO. 8278778)
Breeze™	Self-adhesive Dual-cure	-Mixture of BISGMA, UDMA, TEGDMA, HEMA, & 4-MET resins, silane-treated -Barium borosilicate glasses -Silica with initiators, stabilisers and UV absorbers, -Organic and/or inorganic pigments, opacifiers	Pentron Clinical Technologies, LLC 68 North Plains Industrial Road Wallingford, CT USSA 06492	BATCH NO8060808The author said:
Polylysine		$(C_6H_{12}N_2O)_n$	ZHENGZHOU BAINAFO Bainofa Bioengineering LTD-China	BATCH NO20210901The author said:
Zirconia	IPS e.max ZirCAD LT	Zirconium oxide (ZrO_2) 88.0-95.5, yttrium oxide (Y_2O_3) > 4.5% – ≤ 6.0%, Hafnium oxide (HfO_2) 5.0%, aluminium oxide (Al_2O_3) ≤ 1.0%, Other oxides ≤1.0%	Vivadent, Schaan, Liechtenstein	

Incorporation of PLS in resin cement

To initiate the PLS incorporation powder (2%), the initial step involved accurate weighing of the powder by digital balance (AE ADAM AFA-210LC) with a precision of 0.1 mg, as depicted in Figure 1A. Following this, base and catalyst components were dispensed separately. Subsequently, the premeasured amount of PLS powder was divided into two equal portions; the first portion was introduced to the base (of either resin cements) while the second portion was introduced to the catalyst, then each mix was mixed separately and thoroughly using a Zhermack mixing machine to achieve the intended 2% concentration [23, 24]. As illustrated in Figure 1B, the resulting paste was then transferred to a 5ml disposable syringe and placed vertically on a vibrator to remove trapped air bubbles. Subsequently, each paste was reintroduced into its original container by expelling the material through a specially designed connector, shown in Figures 1C and 1D.

Each barrel was left upright for 5 minutes to allow the paste to settle, as demonstrated in Figures 1E and 1F. Subsequently, the two containers were combined to be ready for use, as described in reference [25]. It is worth noting that all mixing procedures were carried out in a dark room to prevent unintentional cement polymerisation.

Tooth preparation and study design:

This research received approval from the Research Ethics Committee of the College of Dentistry, University of Baghdad, Iraq, with the reference number 502-10/3/2022. The sample size was determined using G* power. 3.1.9.7 (Programme written by Franz-Faul, University of Kiel, Germany) (26) With study power = 95%, probability alpha error = 0.05 two-sided, effect size of F is 0.4 (large effect size), two measurements and four groups, under all these conditions, the sample size is 32 samples (8 samples each group). Effect size F is small =0.1, medium=0.25, large=0.4.

Thirty-two intact human maxillary first premolar teeth were selected, which were extracted for orthodontic purposes from patients aged 18-22 years. These teeth exhibited a similar size and shape. Each tooth was individually embedded in a custom-made cuboid rubber mould measuring 3 cm in height, 1 cm in width, and 1 cm in length. The mould was filled with cold-cured acrylic. To ensure precise alignment, a dental surveyor was employed to confirm that each tooth was parallel to the horizontal plane of the mold. The teeth were placed 2 mm cervical to the cementoenamel junction, corresponding to the level of the supporting alveolar bone, within cold-cure acrylic resin (Premacryl Plus, Spofadental, Jicin, Czech Republic). The teeth were randomly divided into four groups, each consisting of 8 teeth. These groups were classified according to the type of resin cement used to attach the restorations. The crown groups were cemented using the following resin cements: RelyX™ U200 cement (RelyC), RelyX™ U200 cement (RelyPLS), Breeze™ cement (BrC) and PLS-incorporated Breeze™ cement incorporated with PLS (BrPLS).

Full coverage crown preparation

The teeth were prepared using a high-speed air turbine handpiece (NSK PANA-MAX, Kanuma, Japan). To ensure parallelism standardisation, a custom dental surveyor (Paraline, Dentaurum, Leipzig, Germany) was employed to hold the handpeice [27]. A permanent colour marker was used to draw a 1mm coronal to the cementoenamel junction, representing the intended finishing line.

The teeth were subsequently given a chamfer finishing line as part of the indirect crown restoration process [11]. The tooth preparation process was divided into two main phases: axial reduction and occlusal reduction. For the axial reduction, each axial wall was shaped with a 3-degree taper angle that matches the bur's taper being used. This resulted in two opposing walls with a combined 6-degree total convergence angle. Initial preparation involved the use of a round end tapered diamond fissure bur guide pin (No. 6856-21, Komet, Germany) to create a 0.5mm depth finish line. Subsequently, the preparation continued with a round diamond fissure bur (6856-314 016, Komet, Germany) to achieve the desired depth of 0.8mm. The final refinements in preparation were carried out using a round-end diamond fissure bur (8856-314 016, Komet, Germany). The reduction in occlusal surface was standardized using a Rugby ball bur (No. 806-314 039, Olident, Germany), resulting in a prepared axial height. The dimensions of the completed tooth preparation were verified with a digital caliper with an accuracy equal to a hundredth of a millimeter (0.01mm).

Digital workflow and zirconia full crown fabrication

In the digital process for creating a full zirconia crown, we utilised a CEREC Omnicam digital intra-oral scanner (CEREC-Omnicam, Dentsply-Sirona, Bensheim, Germany) to scan the samples. Crown restoration design was accomplished using Sirona InLab 15.1 software (Dentsply-Sirona), followed by milling with the InLab MC X5 milling machine (Dentsply-Sirona) using e.max ZirCAD material.

Pre-cementation marginal gap measurement

Each crown was placed on its respective tooth under a standard static load of 5 Kg (50 N) using a specially designed screw-holding device with a load sensor. This load was used to replicate a seating force during crown cementation to simulate the average bite forces produced by the jaw during measurement. The marginal gap was determined using the direct view method, assisted by a digital microscope (Dino-Lite Pro, AnMo Electronics Corp., New Taipei, Taiwan). Images capturing the marginal fit were obtained at a 230X magnification. Four reference points were marked on the surface of each tooth, covering the buccal, palatal, mesial, and distal aspects. Two of these reference points were precisely positioned at the midpoint of each surface, while the other two were spaced 1mm apart [28]. Subsequently, image processing was carried out using DinoCapture software version 2.0, developed by AnMo Electronics Corp. Subsequently, the processed images were subjected to analysis using ImageJ 1.50i, a software tool developed by the National Institutes of Health in Bethesda, USA. This analysis was performed to calculate the mean pre-cementation gap value for each sample (Figure 2).

Cementation of zirconia crown and post-cementation assessment

The cementation procedure began by injecting cement onto the inner surface of the crown using a disposable mixing tip, ensuring a uniform and thin layer of cement. To maintain consistency, half of each crown was cement-filled. The crown was initially seated by applying manual pressure to ensure complete seated. Subsequently, a vertical static force of 5 kilogrammes (approximately 50 Newtons) was exerted for 6 minutes using a custom-made specimen holding device. This process was devised to replicate the biting force experienced during clinical cementation [29]. To replicate the cushioning effect provided by a cotton roll during clinical cementation, a piece of rubber material was placed at the end of the vertical arm of the holding device to ensure a uniform load distribution on the occlusal surface of the crown restoration. Finally, for BrC and BrPLS, each surface of the sample was exposed to 40 seconds of light curing, while RelyC and RelyPLS received 20 seconds of curing, according to the manufacturer's instructions. After cementation, the samples were allowed to sit on a bench for one hour and subsequently stored in distilled water at 37 ° C for 24 hours [30]. The marginal gaps were then measured at the same precementation sites.

Figure 1: Steps the preparation of modified resin cement protocol: (A) weighing of the PLS powder, (B) transfer of the cement paste (base or catalase) and mixing with the PLS powder, (B) mixing of resin cement (base or catalase) using the mixing machine (C)transfer the modified resin cement to the original Breeze resin cement (D) transfer the modified resin cement to the original barrel of RelyC resin cement barrel upright 5 min to allow the paste to settle for RelyC (F) BrC.

Statistical data analysis

Statistical analysis involved the application of both independent t-tests (for comparison between different cement groups) and paired t-tests (for comparisons before and after cementation). Before these analyses, the normality of the data was assessed using the Shapiro–Wilk test, revealing that all groups exhibited a normal distribution ($p > 0.05$). IBM SPSS version 26.0 software (IBM Corp., Chicago, IL, USA) was used for these analyses and statistical significance was determined at a significance level of 0.05.

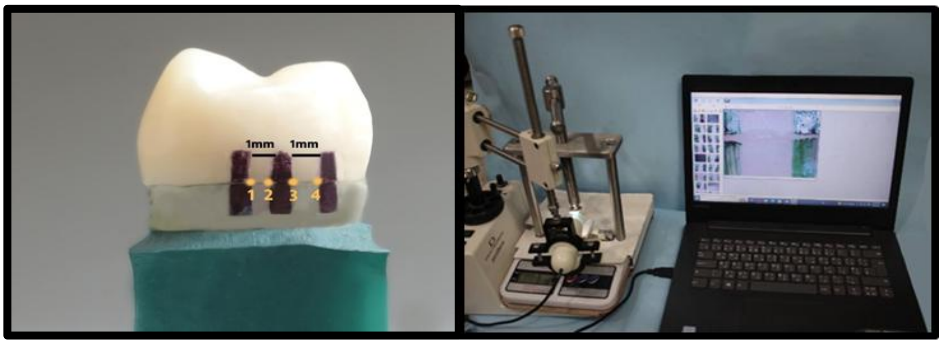

Figure 2.: Marginal gap measurement (A); Points of measurement. (B): Digital microscope attached to the computer

Results

The Shapiro-Wilk test was used to determine the normality of the data distribution before and after cementation. This test showed that the data were normally distributed (p>0.05). The mean, standard deviation, minimum, and maximum values of the vertical marginal gap (in µm) of the groups, before and after cementation, are shown in Table (2). The lowest mean values of the marginal gap (20.45 µm, 19.86 µm) were recorded for RelyC and RelyPLS resin cement, while BrC and BrPLS resin cement recorded the highest mean values (21.45 µm, 21.65 µm) respectively, and the same scenario was observed for the marginal gaps.

It is evident, as shown in Table (2) and based on the results of the student's t test, that the incorporation of PLS in either cement did not have a statistically significant impact on the marginal adaptation of zirconia crowns. This is true for both cements and both before and after crown cementation measurements. Additionally, it is clear that after crown cementation, the marginal gaps increased significantly for all cement groups; this was confirmed by the results of the paired t-test. When comparing the two types of cement, the t-test revealed that the cemented crowns with the control RelyX cement produced a lower gap value compared to the Breeze control Breeze cement, although no significant differences were found between both cements incorporated cements.

Table 2: Descriptive and statistical tests of the marginal gaps in µm among groups**.**

Group	Conc.	Pre				Post					
		Min.	**Max.**	**Mean**	**±SD**	**Min.**	**Max.**	**Mean**	**±SD**	**Paired t- test**	**P value**
RelyC and RelyPLS	**RelyC**	17.200	22.990	20.454	2.147	27.060	31.510	28.969	1.683	7.527	0.000
	RelyPLS	19.000	20.800	19.868	0.657	26.800	32.356	29.973	1.862	14.198	0.000
	t- test		0.738				1.132				
	P value		0.472				0.277				
BrC and BrPLS	**BrC**	20.600	22.800	21.450	0.836	27.220	33.000	31.069	1.803	14.323	0.000
	BrPLS	19.200	23.260	21.653	1.353	29.110	35.380	32.279	2.452	12.149	0.000
	t- test		0.360				1.125				
	P value		0.724				0.280				
Comparisons between Two cements											
	Control cements	**t- test**	1.223	P value	0.242		t- test	2.408	P value	0.030	
	PLS incorporated cements	**t- test**	3.357	P value	0.061		t- test	2.118	P value	0.053	

Discussion

A PLS concentration of 2% was chosen for this study based on the results of previous out-mentioned studies [24]. In this study, 2% PLS was incorporated into resin cements, with the aim of providing the highest antibacterial action of resin cements without affecting other properties of the luting cement [24].

Estimation of the vertical marginal gap is considered the most frequent method used to measure the precision of the fitness of the restoration [31]. To determine the mean marginal value as reported in earlier studies, the mean marginal gaps of each sample (3, 32) were calculated. In this investigation, this was done rather than dividing the findings to appreciate the design as a whole. The direct view technique is used, since it is a popular and conservative method that requires less time and has fewer chances of errors compared to other indirect methods [32].

The standardisation of the crown fabrication process (tooth preparation, scanning, design, and milling, along with the use of IPS e.max ZirCAD LT blocks) contributed to the statistically insignificant differences observed in the marginal gap before cementation. In this study, the marginal spacer was set 'to zero' using a CAD/CAM system, while the radial and occlusal spacers were set to 100" µm starting 1mm above the margin. The marginal gap values in this study are less than 40 µm, as previously mentioned, the clinically acceptable marginal gap data value of less than 120 µm is clinically acceptable [11], while others consider that it should be less than100µm [12]. Furthermore, the appropriate value is still believed to be between 20 and 75 µm [13]. although significant differences were found between the groups in this study. All data on the marginal gap were within clinically acceptable limits.

It is important to note that measuring crown marginal gaps before cementation is not practical because the cementation process significantly influences the outcome [33]. When the cement crown was placed on the prepared tooth and pressure was applied, there was no space for excess cement to escape through the cervical margin. Resin cement increased viscosity too rapidly to flow toward the cervical area and extrude from the margins of the crown, this will create the problematic discharge of excess cement and hydraulic pressure that will push the cement upward, this will result in a large amount of luting cement to accumulate on the occlusal surface of the prepared tooth that could interfere with proper crown restoration after the cementation procedure [33, 34].

Therefore, the result showed significant differences between precementation and postcementation for all groups. This finding is consistent with studies by Abdullah and Ibraheem, 2017[35], Al-Hawwaz and Ibraheem, 2018[36], Abdulla and Majeed, 2020[33] who found that the cementation process caused an increase in the discrepancy of the vertical marginal gap, the hydraulic pressure that forms during cementation may be the cause, pushing the cement higher [37].

Compared to Breeze, RelyC exhibited a lower post-cementation marginal gap. This result could be attributed to the lower viscosity of RelyC, a characteristic believed to be influenced by factors such as the amount of filler, the type of filler particles, the composition of the resin matrix, and polymerization degree [38]. The percentage by volume is 52%, while in RelyC it is 43%. Therefore, this may lead to the film thickness of RelyC being lower than that of BrC [39]. From this result, the first null hypothesis was rejected.

The results of the study showed that the addition of antibacterial particles with PLS did not significantly increase the marginal gap after being incorporated into both cements; this negligible effect may be attributed to the fact that the PLS added to bo both cements was small enough to cause a dramatic effect on film thickness, coincided with the results of Mansi et al.,2023 which found that 2%PLS did not effect on the film thickness of resin cement. Therefore, the null hypothesis was accepted since the addition of PLS did not affect the marginal fitness of the marginal fitness of the zirconia crown [24]. The filler has a role in the properties of resin cements, increasing the filler load may affect different properties(film thickness, setting time, water sorption, and solubility) [24].

In this study, the introduction of a newly modified resin cement formulation with antibacterial PLS filler with exceptional, no effect on marginal adaptation can open the scope to clinical application since they have the advantage of providing antibacterial properties of cements especially when the restoration margin subgingivally with limits cleaning and can be considered as a potential risk factor for secondary caries, An antibacterial cement can improve the long-term success of the crown cement by inhibiting secondary caries [(40).] However, it is important to acknowledge certain limitations in the methodology employed in this study. First, the application of cement to crowns during the cementation process was not standardised due to the challenge of standardising pressure with varying cement viscosities. Second, this study primarily provides insights into the vertical marginal discrepancies achievable under controlled in vitro conditions with zirconia crowns. Furthermore, crowns were not subjected to artificial ageing processes such as thermocycling and cyclic loading, which could offer more information on the clinical performance of the restorations. It is essential to note that these in vitro measurements may not necessarily reflect the clinical environment. Consequently, more research is needed to investigate the implications of such marginal discrepancies for the longevity of dental restorations.

Conclusion

In the present study, the mean values of the marginal gap of the crowns in all groups (before and after cementation) were within the clinically acceptable limit. In the scope of this investigation, it was observed that modification of the resin cement with the addition of antimicrobial PLS particles did not produce a substantial influence on the extent of the the marginal gap of zirconia crowns more than the marginal gap of the zirconia crown cemented with self-adhesive resin cement was less than the groups cemented with Breeze self-adhesive resin cements. In light of these in vitro results, it is conceivable to propose that PLS modified cements may be promising for use in the future due to their antibacterial sw.

Conflict of interest

The authors have no conflicts of interest to declare.

Author Contributions

Conceptualisation, ZM and AM.; methodology, ZM investigation AM writing—original draft preparation, ZM, and A.M; writing—review and editing, AS: All authors have read and agreed to the published version of the manuscript.

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Informed consent

Informed consent was obtained from all individuals or their guardians included in this study.

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تقييم التكيف الهامشي لترميمات تيجان الزركونيا غير المباشرة باستخدام أسمنتات راتنجية ذاتية اللصق معدلة بجزيئات البولي ليسين المضادة للبكتيريا

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المستخلص:

الهدف من الدراسه المختبريه هو دراسه تاثير جزيئات البوليليسين المضادة للبكتيريا المدمجة في نوعين مختلفين من الأسمنت الراتنجي ذاتية اللصق على التكيف الهامشي لترميمات تيجان الزركونيا غير المباشرة .لمواد والطرق: تم تحضير 32 سنًا من الضواحك الأولى العلوية من أجل ترميمات التاج غير المباشرة بأبعاد السن المحضر النهائي (ارتفاع البعد المحوري 4 مم وسماكة خط التشطيب المحيطي 0.8 مم) والتي تم التاكد منها باستخدام جهاز الفرجال الرقمي. تم اخذ طبعات رقمية لجميع النماذج المحضرة وتم تصميم التيجان بالحاسوب ومن ثم تم عمل التيجان من مادة الزركونيا. تم توزيع الأسنان مع تغليفات التيجان الخاصة بها إلى أربع مجموعات رئيسية (العدد = 8). تم لصق مجموعات من التيجان باستخدام RelyPLS-RelyXU200 وأسمنت Breeze (BrC) بالاضافه الي (BrPLS) Breeze™. تم تثبيت كل ترميم على السن الخاص به، وتم استخدام مجهر رقمي بقوة تكبير 230 لقياس الفجوة الهامشية بالميكرومتر ثم تحليل البيانات إحصائيا باجراء اختبار شابيرو وذلك لتحديد الحالة الطبيعية لتوزيع البيانات قبل وبعد التثبيت (ع > 0.05). تم استخدام اختبار المستقل Tو المقترن.T لمقارنة النتائج اوضحت النتائج قيما منخفضه بشكل ملحوض للفجوه الهامشيه للمجاميع المثبته باستخدام RelyC و RelyPLSمقارنه بالBrC و BrPLSكما اظهرت النتائج انه لاتوجد فروق ذات دلاله احصائيه بين المجاميع التي تحتوي علي البوليلايسين والتي لاتحتوي على البوليلايسين .الاستنتاج: تعديل الأسمنت الراتينجي باستخدام البوليلايسين ليس له دور معنوي سلبي في التكيف الهامشي