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Antibacterial and solubility power differences of luting cement, resin reinforced glass ionomer, bioactive, and resin-based composite in dental restoration

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Abstract

There was still high caries incidence in abutment teeth (30.3%) in fixed denture treatment. One of the important components in luting cements to prevent caries in abutment teeth is the antibacterial and solubility properties of cement materials. This study aims to determine the difference of antibacterial activity and the solubility of three luting cements against *S. mutans*. 3 luting cement materials were RRGI (Fuji plus), Bioactive luting cement (Activa luting) and Resin Based composite (Relyx U200). Each of the materials had 7 samples sized of 5x1.5mm for antibacterial test against *S. mutans* and 15x1mm for solubility test. Data analysis was subsequently performed using an ANOVA test. There was a significant difference between the three luting cement in antibacterial tests against *S. mutans*, while in the solubility test gived no different to each other dental luting cements p = 0.107. Luting cement with the highest antibacterial is bioactive luting because the material can improve more hydroxyapatite and more fluorine against *S. mutans*.

Keywords: antibacterial, luting cement, solubility, S. mutans

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INTRODUCTION

Teeth can be damaged to the point where they can be detached from the gum, this is due to various things including caries, periodontal tissue damage, and trauma (Rosenstiel, Land, Fujimoto, 2016). Tooth loss will affect the function of mastication and facial aesthetics. Hence, it needs to be replaced immediately with artificial teeth, one type of prosthodontic treatment that is commonly known and preferred is fixed denture (GTC) (Rosenstiel, Land, Fujimoto, 2016; Hamad, et al,2016).

In order for a restoration to last long in addition to the required design accuracy, the selection of supporting teeth and adequate preparation also need a special material to glue the fixed restoration as a sealer in the prepared abutment teeth, the material is called luting cement. Luting cement serves as a gap between the supporting teeth or teeth prepared with a fixed crown restoration (Rosenstiel, Land, Fujimoto, 2016; Curtis, & Watson, 2014; Sita, et al. 2014). Therefore, in order to obtain optimal GTC treatment results, a strong cement material with certain characteristics and characteristics such as attachment, physical characteristics and biocompatibility of luting cement material is needed in the mouth, especially on the pulp tissue in the supporting teeth (Heshmat, et al. 2013). A good cement material must also have low solubility to saliva and bacteriocid nature, which has an antibacterial power to minimize the occurrence of secondary caries in the supporting teeth (Mayanagi, et al. 2011; Unosson, et al. 2012).

Lutin cements that exist today, aside from being made of conventional cement and composite resin, are also made from GIC (glass ionomer cement) that is modified with the addition of RMGI (modified glass ionomer resin) and RRGI (reinforced glass ionomer resin) (Rosenstiel, Land, Fujimoto, 2016). Cement material with bioactive compound is also developed, which is a very active compound on the surface of the tooth and can bind firmly to the structure of dental tissue. This material is very helpful in application and increases the resistance of restorative materials to damaged teeth (Dworkin, Gerad, Cheen, 2018).

This study aims to determine the differences in the anti-bacterial power and solubility of available luting cement made from ionomer reinforced glass resin, Bioactive and resin based composte.

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MATERIAL AND METHODS

This research is an experimental laboratory research with a post test only on control group design (Supranto, 2007).This research has been through the ethical eligibility procedure of the Ethics Commission of the Faculty of Dentistry, Universitas Airlangga No: 045/HRECCFODM/V/2018. The researchers took 7 samples from each test material and the research was carried out in the research center of the Faculty of Dentistry, Universitas Airlangga.

The samples were 3 kinds of luting cement material, namely RRGI (Fuji PlusTMGC USA), and bioactive (BioactivaTMluting cement, Pulpdent USA) and Resin Based composite (RelyX ™ U 200 ™ 3M ESPE Germany) which then divided into 2 for the test group of anti-bacterial power and solubility.

To test the antibacterial power (Unosson, et al. 2012), each sample in the form of luting cement is mixed with a ratio of 1:1 into a paste form, placed in a cylindrical aluminum mold container with a diameter of 5 mm and a thickness of 1.5 mm. As for the solubility test the sample was placed in a cylindrical aluminum mold container with a diameter of 15 mm and a thickness of 1 mm (Heshmat, et al. 2013). Then wait until it hardens and is released from the mold container.

Streptococcus mutans was obtained from the Microbiology Laboratory of Universitas Airlangga, Surabaya. Bacterial breeding of S. mutans inside the BHI broth suspension was done with a standard 0.5 McFarland inside a chamber of 37°C for 24 hours. S. mutans inside the BHI suspension broth 0.1 ml was taken and then placed into 7 petri dishes containing trypton yeast cystein (TYC) agar media then levelled using cotton brush stick (McLain Jean, et al. 2016). After being distributed evenly, the agar medium was divided into 3 parts, each section made into a well using an aluminum ring 5 mm in diameter and 1.5 mm high on the surface of the agar media.

Testing the antibacterial power of luting cement against S. mutants growth(McLain Jean, et al. 2016).: Each well in the petri dish contained the media for TYC and S. mutans, Luting cement samples made from resin based composite, bioactive and ionomer reinforced glass resin which have been printed and hardened. This was done in the same way with the other 6 petri dishes

Then the 7 petri dishes were put into the C0 incubator$_2$ with a temperature of 37°C for 24 hours. The inhibition zone was measured using a calipers to the accuracy of 0.05 in millimetres, measured by taking the distance between two perpendicular lines that cross the midpoint of the well containing test material, then a third line is drawn between the two lines that form an angle of 45^0, each sample was measured 3 times in the same inhibition zone according to the measurement guidelines. (Widiyasa, 2013; Prasanthi, 2014).

Table 1. The mean value and standard deviation of antibacterial power (inhibition zone) of RRGI luting cement, bioactive, and resin based composite against *S. mutans*.

Luting cement	N	R	SB
RRGI	7	0.35671	0.137085
Bioactive	7	4.27329	0.794413
Resin Based composite	7	0.08286	0.049727
Total	21		

n = number of samples n
R = Average (mm2)
SB = Standard Intersection

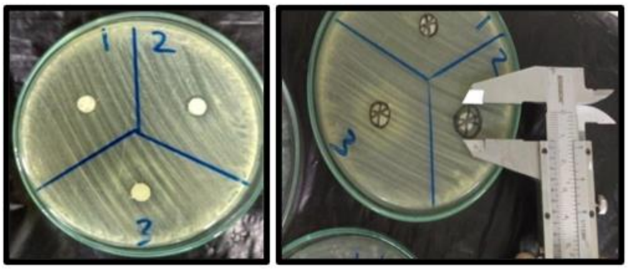

Fig. 1. Test material in petri dish and measurement of inhibition

In the solubility test of luting cement, each sample that has been prepared is put in for 24 hours, after 24 hours, each sample was weighed, and its initial weight was measured. The sample was then soaked in a tube containing saliva for 7 days in a sterile sealed container and stored in an incubator at 37°C.

After 7 days the sample was removed from the tube then washed and cleaned under running water, then measured and weighed after soaking (m_2) then dried in a desiccator for 24 hours, after drying the samples were weighed to get the final weight (m_3). The solubility of the test material is obtained from calculations according to ISO 4049: 2009 (International Organization for Standardization 2009). (E) by reducing the initial weight (m_1) minus the final weight (m_3) divided by the volume (v) of the test material in units of μg / mm^3.

Analysis of research data was done using SPSS statistical test version 16.00 (2007). Data analysis was done using parametric statistical tests using ANOVA to determine differences in anti-bacterial power and solubility of luting cement. If significant differences are obtained then testing was done using a test Multiple Comparison of HSD (Tukey test)

RESULTS

The results of the luting cement antibacterial power test were obtained in the form of zone of inhibition against *Streptococcus mutans* as listed in **Table 1**.

In **Table 1** the mean value of the biggest semen lutting inhibition zone is Bioactive luting cement, followed by luting cement reinforced glass ionomer resin (RRGI) and the lowest average inhibition zone is composite resin.

From the ANOVA test, the p value = 0.0000 ($p <0.05$), this shows that there are significant differences

Table 2. Multiple Comparison Tukey HSD Test Results for antibacterial power of luting cement on *Streptococcus mutans*

Luting Cement	RRGI	Bioactive	Resin Based composite
RRGI		.000*	.527
Bioactive	.000*		.000*

Note: * There are significant differences

Table 3. The average value and the standard intersection of solubility of luting cement made from RRGI, Bioactive and Resin based composite

Material	N	R	SB
RRGI	7	.0396	.02705
Bioactive	7	.0080	.02137
Resin Based composite	7	.0237	.02950

N = Number of samples
SB = Standard Deviation
R = Average (µg / mm^3)

in the antibacterial power between the three luting cements studied then to determine the differences in anti-bacterial power between the three luting cement materials, Multiple Comparison of HSD was done using the Tukey Test and can be seen in **Table 2**.

In **Table 2**, a comparison between luting cement and RRGI is shown with Bioactive luting cement having a value of p = 0.000 ($p < 0.05$), this indicates a significant difference between the two groups. Likewise, in testing the anti-bacterial power between bioactive luting cement with resin-based composite there is a significant difference between the two luting cement because it has a value of p = 0.000 ($p < 0.05$). **Table 2** also shows the comparison between RRGI with Resin based composite with a value of p = 0.527 ($p > 0.05$) which means that the antibacterial power between the two groups of luting cement there is no significant difference.

In research on the solubility test of luting cement made from ionomer reinforced glass resin (RRGI), bioactive and resin based composite the results obtained in the form of the average value of the solubility of the three materials of luting cement examined for saliva (**Table 3**).

Table 3 shows the highest average solubility is RRT, while the smallest average solubility is bioactive. The ANOVA test for the solubility of luting cement material obtained p value = 0.107 ($p > 0.05$), then in the research of the solubility test on the three luting cement materials concluded there was no significant difference, which means that the three luting cement materials have relatively the same solubility.

DISCUSSION

There is a higher antibacterial power in luting cement made from bioactive, possibly because there are bioactive compounds added to the composition. Bioactive material contains ion matrix resin, a shock-absorbing resin component and bioactive glass fillers which shows chemical and physical properties resembling natural teeth, so that with the presence of hydration that can lead to a formation of hydroxyapatite bonds on the surface of the cement tooth is able to increase the strength of attachment to the teeth. Bioactive component also plays a role in ion exchange so that when the pH is low and a demineralization process releases Calcium and Phosphate ions from the tooth surface which will exchange with fluoride ions in saliva, this process makes the bioactive component assists the regulation of ions and is able to produce (release and bind) calcium ions, phosphate and fluoride continuously (Dworkin, Gerad, Cheen, 2018).

A bioactive cement has the advantage of releasing calcium compounds, phosphates and fluoride and also can absorb ions or compounds from saliva and then can release it back continuously and simultaneously (Pameijer, 2013). The fluoride content can inhibit bacterial growth and colonization of *S. mutans*. The mechanism of bacterial growth restriction is due to the release of fluoride ions which inhibits the formation of the enzyme glycolytic enolase, the proton-extruding ATP-ase that takes place in the mitochondria, thus affecting the metabolism of bacteria such as phosphate acid, pyroposphatase, peroxydase and catalase. (Dworkin, Gerad, Cheen, 2018; Unosson, et al. 2012). The presence of glicolitic enolase enzymes, which decreases the amount phosphoenolpyruvate (PEP), was also reduced, these compounds play a role in the transport of glucose into bacterial cells in the process of glycolysis and intracellular synthesis in the bacterial body.[6] In addition to inhibiting this, fluoride ions also inhibit glucan and can produce acids so that there is an increase in stress due to acids formed and glucose deficiency in the body of bacterial cells (Unosson, et al. 2012).

Meanwhile, the results of antibacterial power is not different in RRGI with resin based composite Although both of the luting cement materials produce low pH and also have fluoride ion content, due to the conventional application process and mixing technique, it is possible to make an inaccurate comparison of the composition of the luting cement so that the fluorine content of RRGI and resin based composition can shrink or decrease.

The results of research on luting cement solubility found that there was no significant difference between the three materials studied, this means that they have the same average solubility value. Even so, RRGI has a higher average solubility value than the other three ingredients, this resembles the results of research conducted by Gerdolle et al. (2008), who mentioned that Fuji plus is one of the luting cement made from Reinforced Glass Ionomer ResinRRGI with the highest solubility compared to other luting cements studied (composite and compomer resin).

The result of the average solubility value that does not differ much is possible because the three materials studied are the latest generation of luting cement which has a resin compound. It can provide an umbrella effect and be able to protect the material from loss due to being submerged in water and prevent the taking of excess liquid through termination calcium polyacrylate chain (Anusavice, Shen, Rawls, 2012).

The materials used in dentistry either in the form of cement or restoration materials have water or saliva solubility (International Organization for Standardization, 2009). Therefore, ISO sets the threshold value of the solubility of a safe material equal to ≤7.5μg/mm^3. Saliva has a composition of 99.42% in the form of water and the level of acidity of the saliva (pH) will have a considerable influence on materials in dentistry. This includes luting cement which is applied to attach fixed restorations to prepared supporting teeth. In research by Heshmat (Heshmat, et al. 2013). It was found that there was no significant difference between immersion in water or acidic liquid on the solubility of luting cement made from glass ionomer resin compared to resin cement. The results of this research showed that luting cement which was soaked with saliva pH 6.9-1.11 concluded that the glass ionomer resin luting cement had greater solubility than composite resin luting cement.

Things that can affect the size and solubility of a luting cement material include: the content of luting material, particle size of cement, the shape of the surface area produced from the luting cement and the type and method of hardening of the luting cement (Heshmat, et al. 2013). At the time of polymerization of each cement has a different variable degree to the solubility of a material, this depends on the microscopic and molecular structure resin, in addition there is polymerization of free radicals in the resin which can result microleakage¸ this is common in the hardening of cement made from composite resin by using light cure.

Hardening with dual cure on luting cement made from bioactive serves to reduce the effect microleakage because of the stages self cure the material contained therein will more easily bind to the structure of the teeth thereby reducing stress on the pulp due to the heat generated from light cure, despite the self cure procedure that requires a longer time than if the material was hardened using light cure.

CONCLUSION

The highest luting cement which has antibacterial power against *S. mutans* is made from bioactive. RRGI and Resin based have anti-bacterial power that is not much different, but both are lower than bioactive. While the solubility of luting cement against saliva of the three materials was not different. This can be caused by the three ingredients containing resin which provides an umbrella effect.

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