Shear bond strength fissure sealant based on glass ionomer after topical fluor application: a comparison between sodium fluoride and acidulated phosphate fluoride

Yulie Emilda Akwan, Annisa Listya Paramita*, Fitria Rahmitasari**

** Fakultas Kedokteran Gigi Universitas Hang Tuah Surabaya*

Correspondence: yulie.emilda@hangtuah.ac.id

Received 11 May 2022; 1st revision 14 June 2022; 2nd revision 1 December 2022; Accepted 22 December 2022; Published online 28 December 2022

Keywords:

Fluoride; fissure sealant; glass ionomer cement; shear bond strength

ABSTRACT

Background: *Application of fissure sealants to young permanent teeth is one of the preventive measures for caries in the field of dentistry. Fissure sealants based on glass ionomer cement (GIC) have the advantage of releasing fluoride. Sodium fluoride and acidulated phosphate fluoride (APF) are remineralization agents because they can increase remineralization by altering hydroxyapatite to fluorapatite and this in turn makes fluorine able to increase pH. Fluoride can prevent caries by increasing remineralization of the enamel that has just been demineralized by acids produced by plaque bacteria. The aim of this study is to compare the shear bond strength fissure sealant based on glass ionomer between sodium fluoride and APF topical fluor application*

Method: *This research applied true experimental design with post test only control group design. The 21 maxillary permanent premolars were distributed into 3 groups, namely the control group (K1), the treatment group added 5% sodium fluoride (K2), and the treatment group added 1.23% APF (K3).*

Result: *One Way ANOVA and post hoc LSD analysis test displayed no significant difference in each group. This could be due to the material used as a conditioner prior to the GIC application. The addition of fluoride ions will inhibit the demineralization process of the enamel produced by the application of conditioner. So it does not rule out that it will interfere with the attachment of the GIC material used as a fissure sealant in this research.*

Conclusion: *There was no significant difference in shear bond strength of fissure sealant based on glass ionomer between sodium fluoride and acidulated phosphate fluoride topical application.*

doi: http://dx.doi.org/10.30659/odj.9.2.222-230
2460-4119 / 2354-5992 ©2022 National Research and Innovation Agency

Odonto : Dental Journal accredited as Sinta 2 Journal (https://sinta.kemdikbud.go.id/journals/profile/3200)
How to Cite: Akwan *et al*. Shear bond strength fissure sealant based on glass ionomer after topical fluor application: a comparison between sodium fluoride and acidulated phosphate fluoride. Odonto: Dental Journal, v.9, n.2, p.222-230, December 2022

INTRODUCTION

Dental caries is a microbiological infection of the teeth caused by local factors that cause tooth decay. Caries is caused by various interconnected factors. These factors are the relationship between the host (teeth and saliva), microflora, substrate (food), and time. Pits and fissures on the tooth surface are areas that are at risk for caries, because they are good retention areas for microorganisms. Caries is most often caused by streptococcal that adhere to pits and fissures causing caries within 6 to 24 months. The treatment plan to prevent caries is pit and fissure sealant and topical fluoride application.[1]

Pits and fissures are narrow and deep gaps or recesses found on the occlusal surface of a molar tooth. They are part of the occlusal surfaces of posterior teeth that are more susceptible to caries.[2] Fissure sealant is a treatment for shallow pits and fissures on young permanent teeth that have not been exposed to caries so that the surface area becomes smooth and easy to clean thereby preventing caries.[3] Application of sealant aims to create a thin layer on deep pits and fissures so that debris and bacteria do not easily enter the area.[4] Material glass ionomer as a sealant material has advantages over resin materials, among others, it can be applied when the teeth are still pre-erupted so that the patient's age at the time of application can be younger, it can also release fluoride which prevent caries, and has good biocompatibility.[5]

Topical administration of fluoride is carried out with the aim of preventing the dental caries process. Topical application of fluoride is to coat all parts of the tooth enamel with fluoride so that caries-causing acids cannot penetrate the teeth. The structure of tooth enamel consists of a complex chemical composition with a crystalline group, namely hydroxyl apatite. Fluorine in hydroxyl apatite crystals can reduce solubility to acids and increase the remineralization process so as to prevent caries. The effect of fluorine on bacteria is to inhibit bacterial enzymes that turn bacteria into acids. Fluorine lowers the surface tension of teeth which makes it difficult for bacteria to adhere and form plaque.[7] Fluorine reduces the solubility of enamel to acids, reduces enamel permeability, thereby increasing remineralization. On the surface of the enamel, which is applied fluoride, it is expected that many ions are bound by hydroxyl apatite, especially fluorine ions. With the addition of fluorine, the hydroxyl apatite turns into fluorine apatite so that it becomes resistant to acid.[8] Topical fluoride application consists of various preparations, namely fluoride solution, gel, foam, varnish, toothpaste.[9] Acidulated phosphate fluoride (APF) 1.23% contains phosphoric acid which etches tooth enamel, is chemically stable and easy to find in the market.[10] Sodium fluoride is a topical fluoride preparation consisting of 2% NaF, neutral pH, 9.200 ppm fluorine ion, and can be applied using the Knutson technique. Knutson recommends repeated applications at approximately 3 year intervals to suit the eruption pattern of children. The first application can be made at 3 years of age to protect primary teeth, then at 7 years of age to protect incisors and molars, at 10 years of age to protect canines and premolars and finally at 13 years of age to protect second molars.[11] The advantages of 2% sodium fluoride are good taste, long-term storage, non-irritating to gingival tissue, and no extrinsic staining.[6] Sodium fluoride can be combined with tricalcium phosphate (TCP). Sodium fluoride 5% containing tricalcium phosphate yields 2.26% fluoride. TCP increases fluoride attachment to enamel and dentin and enhances the remineralization process.[12 13] Application of fissure sealant based on glass ionomer material after topical fluoride application is expected to increase fluoride absorption in enamel.[9]

Shear strength is the maximum ability that a material can accept before damage occurs.[14] In consideration of material selection, the most important thing to consider is the attachment of the material to the teeth, so shear bond strength is the test of choice to see how much the material adheres to the teeth. Based on the above background, the researcher wanted to conduct a study on the effect of the shear bond strength of fissure sealants based on glass ionomer after the application of topical fluoride sodium fluoride and APF, which was described above.

The purpose of this study was to compare the shear bond strength of fissure sealant based on glass ionomer after the addition of sodium fluoride and APF topically after polishing.

METHODS

The type of research used is true experimental laboratories where researchers can control the emergence of all variables that can affect the process and results of research. The sampling site and the shear bond strength were carried out at the Dental Materials Laboratory, Universitas Hang Tuah, Surabaya. The samples in this study were permanent premolars, the criteria were no caries, no decalcification, no enamel defects, had been extracted, and without fillings stored in saline solution that resembled physiological fluids.

This research uses tools in the form of a 10 x 10 x 25 mm block mold (length x width x height), a cylindrical mold with a diameter of 4 mm with a height of 4 mm, a paper pad, agate spatle, plastic filling instrument, cement stopper, stopwatch, universal testing machine Shimadzu AGS-1KNX (measuring shear strength), contra angle low speed handpiece, wheel diamond bur, masking tape, glass lab, cement stopper, and brush. The research materials used included 21 maxillary permanent premolars that had been extracted with the criteria of no caries, no decalcification, no enamel defects, never had orthodontic brackets installed, and without fillings, powder and liquid GIC Fuji VII brand GC, heavy body elastomeric impression material (consisting of base and catalyst), pumice, micro applicator, polishing brush, 5% sodium fluoride, 1.23% APF, dentin conditioner, and cocoa butter.

The research procedure was that 21 maxillary permanent first premolars were prepared evenly on the buccal part of the teeth within 2 mm of the enamel surface using a wheel diamond bur. Diamond wheel bur is used to gradually reduce the tooth tissue until the tooth occlusal is flat. Samples were made by using putty impression materials with a base and catalyst ratio of 1:1 mixed by hand until homogeneous and placed in a block-shaped mold. Mold 10 x 10 x 25 mm (length x width x height) to full. The prepared tooth was immediately placed in the mold containing the putty and leveled using a glass lab until the surface of the putty was smooth and level, parallel to the tooth, ensuring that the tooth adhered well to the putty. The putty impression material is waited for to harden and then removed from the mold carefully so as not to damage the sample. Before giving GIC treatment, the samples were stained using pumice then washed and dried first. In the control group (P1): the buccal teeth were not added with topical fluoride, in the treatment group (P2): the buccal teeth were added 5% sodium fluoride after polishing and allowed to stand for 4 minutes measured using a stopwatch, and in the treatment group: the buccal teeth were added 1.23% APF after polishing and allowed to stand for 4 minutes measured using a stopwatch. The buccal surface of the tooth was applied with dentin conditioner for 15-20 seconds using a micro applicator and measured using a stopwatch. After that, rinsed and dried using a rubber chip blower until moist. The sample is then filled with GIC Fuji VII material for fissure sealant with a ratio of powder and liquid according to the manufacturer's rules, stirred on a paper pad by folding until it is homogeneous and has a glossy appearance. The fissure sealant material was taken using a plastic filling instrument and applied to a cylindrical mold with a diameter of 4 mm with a height of 4 mm which was placed just above the tooth sample embedded in the putty. The fissure sealant material is ensured to fill the contents of the mold cavity and is condensed with a cement stopper to avoid trapped air and produce a smooth surface of the fissure sealant material. Fissure sealant material is awaited until setting/hardening. Application of cocoa butter over the entire surface immediately after setting.

Universal testing machine (UTM) can be used to test the shear bond strength. Universal testing machines need to be calibrated before starting according to the manufacturer's instructions. The purpose of calibration is to adjust the use at the time of the shear bond strength and to obtain good standardization. Crosshead is a tool on a universal testing machine that can move up and down. The load is placed on the crosshead, with a cross head speed of 1 mm/min. The button that regulates the use of this tool is located on the load amplifier, the point is to press or pull (load cell selector). The load cell is selected according to the strength of the test material. When running the crosshead, the balance button on the load amplifier must be rotated and adjusted until the number on the load on the crosshead controller shows 0. After showing the number 0, the peak load is pressed until the statistics light is on. The pressure received by the load cell on the crosshead will cause the numbers to change. then the crosshead is set by pressing the speed on the crosshead controller automatically crosshead stops. The maximum force is indicated by the number on the load. This number is then entered into the formula for shear bond strength:[15]

$$\sigma = \frac{F}{A} \times 0{,}09807 \text{ MPa}$$

Description

σ = Shear bond strength (MPa)

F = Force (Kgf)

A = Area (cm^2)

The analysis used in this research is one way ANOVA statistical test. Before determining the statistical test used, it is necessary to know the relationship between unpaired variables, the data scale is in the form of ratios, and the distributed data must be normal and homogeneous. The thing that must be done at the beginning is to find out whether the data is normally distributed or not through the normality test (sig > 0.05). The homogeneity test with Levene's test was carried out after the normality test. If the data is homogeneously distributed (sig > 0.05), then a one-way ANOVA test is performed. The one way ANOVA test resulted in $p<0.05$, it could be continued with the Pos Hoc LSD test.

RESULTS

From the studies that have been carried out, the results of measuring shear bond strength in the control group (without the addition of topical fluoride), treatment group 1 (addition of 5% sodium fluoride after polishing), and treatment group 2 (addition of 1.23% APF after polishing). The results showed that the highest mean result was the sodium fluoride treatment group, and the lowest was the APF treatment group.

Table 1. Results of shear bond strength in 3 treatment groups

			Surface area (mm2)	Shear strength (MPa)	
Group	Sample	Maximal Force (N)	3,14x2mmx2mm	Max force x surface area	Average shear strength (MPa)
Control	1	5.22868	12.56	0.416	1.355659463
	2	12.4946	12.56	0.995	
	3	24.3276	12.56	1.937	
	4	29.311	12.56	2.334	
	5	16.8354	12.56	1.340	
	6	17.2044	12.56	1.370	
	7	13.7879	12.56	1.098	
Treatment 1 (Sodium Fluoride)	1	3.05478	12.56	0.243	1.695342129
	2	31.9276	12.56	2.542	
	3	12.3188	12.56	0.981	
	4	23.986	12.56	1.910	
	5	34.7179	12.56	2.764	
	6	23.2177	12.56	1.849	
	7	19.8317	12.56	1.579	
Treatment 2 (APF)	1	1.83026	12.56	0.146	1.331419017
	2	18.2834	12.56	1.456	
	3	11.7436	12.56	0.935	
	4	20.3996	12.56	1.624	
	5	23.8991	12.56	1.903	
	6	10.0161	12.56	0.797	
	7	30.8863	2.459		

From the results of tabel 1 above, it can be seen that the highest average shear strength is the sodium fluoride treatment group, and the lowest is the APF treatment group.

Table 2. Shapiro-Wilk Tes Results

		Shapiro-Wilk		
	Group	Statistic	df	Sig
Shear strength	Control	.971	7	.909
	Sodium Fluoride	.958	7	.802
	APF	.990	7	.993

Data analysis continued with normality test. The normality test used Saphiro-Wilk because the sample < 50. From the results of table 2, it can be seen that each group has a significance value of >0.05 so that researchers can conclude that there is a normal distribution of data distribution in each group.

Table 3. Test of Homogeneity of Variations

Levene Statistic	df1	df2	Sig.
.401	2	18	.676

Data analysis was continued using homogeneity tests using the Levene test. The data is said to be homogeneous when the significance value of p>0.05. From the results of table 3, it can be seen that the value of p = 0.676 > 0.05 means that the data in this group is homogeneous. The distribution of data is normal and homogeneous so that the assumptions of parametric tests are met.

Table 4. One Way ANOVA test

Shear strength	Sum of Squares	df	Mean Square	F	Sig.
Between groups	.580	2	.290	.498	.616
Within Groups	10.484	18	.582		
Total	11.064	20			

Different tests were carried out with one way ANOVA and post hoc LSD. From the results of table 4, the one-way ANOVA test showed p= 0.16 value > 0.05 means that there is no significant difference from the three groups.

Table 5. Post Hoc Test LSD Shear strength LSD

Group	Group	Mean Difference (I-J)	Std. Error	Sig.	95% confidence interval Lower Bound	Upper Bound
Control	Sodium fluoride	-.33971	.40793	.416	-1.1968	.5173
	APF	.02429	.40793	.953	-.8328	.8813
Sodium fluoride	Kontrol	.33971	.40793	.416	-.5173	1.1968
	APF	.36400	.40793	.384	-.4930	1.2210
APF	Kontrol	-.02429	.40793	.953	-.8813	.8328
	Sodium fluoride	-.36400	.40793	.384	-.1.2210	.4930

The final statistical test stage was the post hoc LSD test which was carried out to obtain further results of the differences between the 2 groups. In this case, the groups to be tested were the control group and the sodium fluoride treatment group after polishing, the control group and the APF treatment group after polishing, the sodium fluoride application group after polishing and the APF application group after polishing. From table 5, the results of significance are known for all groups p > 0.05, meaning that there is no significant difference.

DISCUSSION

Topical fluoride application is a caries prevention treatment performed every 6 months by dentists. Fluorine is used to prevent caries. The mechanism of action of fluorine on hydroxyl apatite crystals is to decrease the solubility of acids, reduce the occurrence of demineralization, and increase the remineralization process. The effect of fluorine on bacteria is to inhibit the metabolism of plaque bacteria which can ferment carbohydrates through the conversion of hydroxyl apatite in enamel to fluorine apatite.[16] The application of ionomer sealant material to young permanent teeth is an action taken as a preventive treatment for dental caries by shallowing deep fissures and pits.[17] The ideal sealant material should have a long lasting retention ability, a low solubility of oral fluid resistance, adequate biocompatibility with the oral cavity tissue, and easy to apply.[18] Researchers used a GIC-based sealant because it can be applied when the teeth are still pre-erupted so that the patient's age at application can be younger, can release fluoride where one of the benefits of fluorine is to prevent caries, and has good biocompatibility.[5] The addition of a remineralizing agent such as topical fluorine can enhance remineralization. Remineralizing agents work by remineralizing carious lesions by replacing lost minerals in the tooth structure, such as calcium and phosphate. Studies conducted in vitro and in vivo have shown that remineralizing agents are useful in the treatment of white spots, early childhood caries, tooth erosion and dentin hypersensitivity.[19] Researchers used fluorine gel containing 1.23% APF and sodium fluoride varnish preparations tri-calcium phosphate, where the Ca3+, PO42-, and F components in this varnish are protected and do not bond with each other. Application 5% sodium fluoride with TCP on enamel in contact with saliva will activate fluoride ions and calcium ions, thereby increasing the enamel hardness. The purpose of the application of sodium fluoride containing TCP is to increase tooth remineralization so that it can change the composition of the enamel.[20] Fluoride varnish have the characteristic to suit enamel surface and the extended duration of fluoride contact to the surface improve fluoride uptake. The varnish has been clinically proven to prevent dental caries both in children and adults.[21] The varnish has the benefit of preventing demineralization and protecting teeth from the development of white spot lesion.[22] In considering of the selection of dental restorative materials, the most important thing to consider is the attachment of the restorative material to the tooth, so shear bond strength is the test of choice to see how much the restorative material adheres to the tooth.

This research was conducted to find out comparison of the shear bond strength of the fissure sealant glass ionomer-based sodium fluoride 5% tri-calcium phosphate after polishing. From the results of this study, it can be seen that the average value of shear strength in the treatment group with the addition of sodium fluoride was higher than the control and APF groups. This is because sodium fluoride 5% contains tri-calcium phosphate with a content of 2.26% or 22,600 ppm fluorine ion and functionalized tri-calcium phosphate (fTCP). Hybrid materials made by combining beta tri-calcium phosphate and sodium lauryl sulfate or fumaric acid produce Tri-calcium phosphate. Combined beta tri-calcium phosphate and sodium lauryl sulfate yield functional calcium and free phosphate. This mixture is beneficial to increase the attachment of fluoride to the enamel and dentin, increasing the remineralization process. TCP is in contact with saliva and teeth causing damage to the protective barrier. Sodium fluoride containing TCP can form hydroxyapatite by accelerating hydrolysis. Hydroxyapatite produced from the hydrolysis process has a higher fluoride absorption potential than hydroxyapatite with conventional methods.[13]

In the LSD post hoc statistical test, it was known that the p of all groups was > 0.05 so that it can be seen from this study that the results were not significant difference in shear bond strength between the control group, the APF treatment group and the sodium fluoride treatment group. The results of the different test showed that the difference was not significant ($p > 0.05$) so that statistically, it did not provide a significant difference in results. From these results, it can be concluded that the bond between the tooth enamel structure and fissure sealant glass ionomer. The bond between tooth enamel and glass ionomer sealants requires a conditioner. After the application of topical fluoride, the researchers used a conditioner, in the form of 10% polyacrylic acid. Conditioner was applied to pits and fissures for 20 seconds according to the manufacturer's instructions, then the surface that had been conditioner rinsed with water and dried. The use of conditioner is expected to be able to increase the interaction between the tooth and the restorative material. The definition conditioner is an acidic substance used to remove the smear layer as well as materials that can reduce the adhesion between the glass ionomer and the teeth for example pellicle, organic saliva, plaque, blood, where at certain concentrations these materials can increase the demineralization process of the enamel surface and dentin.[23] In a study conducted by Sungkar (2014), the application of dentin conditioner at 20 seconds had already resulted in the demineralization of the dentinal tubules, causing the loss of phosphate and calcium ions needed in the GIC adhesion mechanism to the dentinal structure. The decrease in calcium and phosphate ions causes the amount of calcium and phosphate ions in the tooth structure that is exchanged with ions in the GIC to decrease so that the shear strength decreases. If there is demineralization of the enamel/dentin, it results in the loss of calcium and phosphate ions which are required for the adhesion mechanism of the GIC to the tooth structure. Based on the above theory, the addition of fluoride ions will hinder the demineralization process in the enamel produced by the application of conditioners.[23] This does not rule out the possibility of interfering with the attachment of the glass ionomer cement material used as a fissure sealant in this study. However, further research on the impact of fluoride application on the efficiency of the conditioner needs to be done.

Based on the research of Sundari et al (2018), the glass ionomer Fuji VII used looks more viscous physically. The thicker the glass ionomer sealant, the more difficult it is for the sealant to flow in deep and narrow pits and fissures. This can affect the adhesion of the glass ionomer to the enamel surface. Thick sealant material will result in poor adhesion.[5]

The shear bond strength between the GIC material and the teeth also depends on the release of fluoride from the GIC material. The release of fluoride from GIC is a complex process that is influenced by intrinsic factors including the formulation or method of mixing powder and liquid, the ratio of powder and liquid, the shape of the sample made,mixing time, solubility or porosity of the material, temperature, surface polishing area, method of treatment and is also influenced by extrinsic factors which include the type and pH of storage media, ambient temperature, research design, and research analysis methods. Some of the mechanisms responsible for the release of fluoride from GIC materials are surface loss, diffusion through pores and cracks in the filling material, and bulk diffusion. [24 25]

In this study, the results obtained from the analysis of shear bond strength in each treatment group were very fluctuating. This can be due to several factors that cannot be controlled during the manufacture of research samples, including the strength of condensation during the application of GIC materials and the application time of GIC materials varies. However, it does not mean that the researcher does not control at all at the time of making the sample. Researchers still control the w:p ratio according to the manufacturer's recommendations for each sample. Factors that affect the mechanical properties include the shear bond strength of GIC, namely the method of mixing materials that can minimize porosity, the way of manipulating the material by means of powder and liquid until the setting phase occurs, the ratio between powder and liquid, viscosity, and homogeneity of the material. In addition, the factor that affects the strength of the GIC material is the porosity. Porosity in the sample can occur due to improper mixing of powder and liquid GIC so that air is trapped in it. This will affect the attachment between the GIC material and the tooth.

CONCLUSION

Based on the result, it can be concluded that there was no significant difference in shear bond strength of fissure sealant based on glass ionomer between sodium fluoride and APF topical fluor application.

ACKNOWLEDGMENTS

Alhamdulillah, we are grateful to Allah SWT for the completion of a comparative study on theshear bond strengthof fissure sealants based on glass ionomer after the addition of APF (Acidulated Phosphate Fluoride) and Sodium Fluoride topically after polishing. We would like to thank our institution Universitas Hang Tuah, Surabaya which funded our research, as well as all related parties who supported this research.

REFERENCES

1. Casamassimo, P.S., Fields, H.W., McTigue, D.J. and Nowak, A., 2012. Pediatric dentistry-pageburst e-book on vitalsource, infancy through adolescence, 5: Pediatric dentistry-pageburst e-book on vitalsource. Elsevier Health Sciences
2. Bachtiar Z.A., Putri R.A.,. Penatalaksanaan Fissure Sealant pada Gigi Anak (Laporan Kasus). TALENTA. 2018. 1(1): 207-213.
3. Kaur S, Kaur M.. Retention of Pit and Fissure Sealants Used by Two Different Techniques: A Comparatively Study. Internasional Journal of Applied Dental Sciences. 2018. 4(4):70-72.
4. Pawarti P, Fathiah F. Perbedaan Topical Fluoride Application dan Fissure Sealant dalam Mencegah Karies Pada Gigi Molar Satu. Jurnal Vokasi Kesehatan. 2017 Jul 31;3(2):98-102.
5. Sundari I, Diansari V, Julianti E.. Perbandingan Tingkat Kebocoran Mikro Antara Resin Komposit Dan Glass Ionomer Cement Sebagai Bahan Penutupan Fisura (Evaluasi In-Vitro Setelah Satu Bulan Aplikasi). Cakradonya Dental Journal. 2018; Oct 4;10(2):121-8.
6. Sirat NM.. Pengaruh Aplikasi Topikal dengan Larutan NaF dan SnF2 dalam Pencegahan Karies Gigi. Jurnal Kesehatan Gigi. 2014; 2(2): 224.
7. Annisa, Ahmad I.. Mekanisme Fluor Sebagai Kontrol Karies pada Gigi Anak. Journal of Dental Association. 2018; 1(1): 63. 10.
8. Limeback H. Comprehensive Preventiv Dentistry. Oxford: WileyBlackwell. 2012.
9. Dean, J. A., Avery, D. R., & McDonald, R.E. Dentistry for the child and adolescent 9th ed. Maryland Heights, Missouri: Mosbey Elsevier co. 2011.
10. Mount, G. J., Hume, W. R., Ngo, H. C., & Wolff, M. S. (Eds.). Preservation and restoration of tooth structure. John Wiley & Sons. 2016.
11. Yagiela JA, Dowd FJ, Jhonson BS, Mariotti AJ, Neidle EA. Pharmacology and Therapeutics for Dentisry 6th Edition. 2011. St.Louis: Mosby. p.725
12. Bayrak S, Tuloglu N, Bicer H, Tunc ES. Effect of Fluoride Varnish Containing CPP-ACP on Preventing Enamel Erosion. 2017.Hindawi.; 2-5.
13. Cochrane NJ, Shen P, Yuan Y, Reynolds EC. Ion Release From Calcium and

Fluoride Containing Dental Varnishes. Australian Dental Journal. 2014.; 59: 100-105.

14. Powers, J. M., & Sakaguchi, R. L. Craig's Restorative Dental Materials. (P. Rudolph & J. Pendill, Eds. 12th ed. 2006.St. Louis, Missouri: Mosby Elsevier.
15. Anusavice, K. J., Shen, C., & Rawls, R. H.. Phillips' Science of Dental Materials 12th ed. 2013. St. Louis, Missouri: Mosby Elsevier.
16. Ekky Berliana; Wardani, Istien; Juniar, Eriza. Efektivitas Topikal Aplikasi Fluoride Menggunakan Ekstrak Teh Hijau Dibandingkan Dengan Sodium Fluoride Pada Gigi Sapi. DENTA Jurnal Kedokteran Gigi, 2015, 9.2: 155.
17. Gunjal S, Nagesh L, Raju HG. Comparative Evaluation Of Marginal Integrity of Glass Ionomer And Resin Based Fissure Sealants Using Invasive and Non-invasive Techniques: An In Vitro Study. 2012. Indian Journal of Dental Research; 23: 320-325.
18. Erry HW, Ardinansyah A. Perbedaan Efektifitas Retensi Dan Preventif Karies Bahan Pit Dan Fissure Sealant. ODONTO: Dental Journal. 2019 Dec 30;6(2):125-33.
19. Joshi, S. R., Gowri Pendyala, D., Mopagar Viddyasagar, D., Padmawar, N., Nara, A., & Joshi, P.. Remineralizing agents in dentistry: A review. 2018
20. Ekandini, Elfa Rushdah, Et Al.. Kadar Calcium Dan Fluoride Pada Gigi Insisive Sulung Setelah Aplikasi Topikal Sodium Fluoride 5%+ Tricalcium Phosphate (In Vitro). 2015. Phd Thesis. Universitas Airlangga.
21. Dewiyani S, Paath SL, Febrianti F. Comparison Fluoride Concentration In Saliva Between Fluoride Varnish And Glass Ionomer Cement. ODONTO: Dental Journal. 2022 Jul 26;9(1):28-33.
22. Apriani A, Mandalas HY, Khoe W. Saliva Acidity Level Toward Application Casein Phosphopeptide-Amorphous Calcium Phosphate For Children Aged 8-9 Years. ODONTO: Dental Journal. 2021 Dec 22;8(2):91-6.
23. Sungkar, Suzanna. Peran Kondisioner Pada Adhesi Bahan Restorasi Semen Ionomer Kaca Dengan Struktur Dentin (Tinjauan Pustaka). 2014.Cakradonya Dental Journal, , 6.2: 699-705.
24. Attar N, Turgut MD. Fluoride Release And Uptake Capacities Of Fluoride-Releasing Restorative Materials. Oper Dent; 2003.28:395-402.
25. Preston AJ, Agalamanyi EA, Higham SM, Mair LH. The recharge of esthetic dental restorative materials with fluoride in vitro-two years' results. Dent Mater 2003;19:32-37.