Analysis of the Bond Strength of the FL Bond 2 Bioactive Adhesive System Associated with Ozonized Water on Enamel.

Fernanda Rafaela Ribeiro, Caterine Renata Passaglia, Julio Katuhide Ueda, Marcio José Mendonça, Veridiana Camilotti

https://doi.org/10.1590/SciELOPreprints.9345

Submitted on: 2024-07-09
Posted on: 2024-07-15 (version 1)
(YYYY-MM-DD)

Analysis of the Bond Strength of the FL Bond 2 Bioactive Adhesive System Associated with Ozonized Water on Enamel.

Fernanda Rafaela Ribeiro

State University of Western Paraná - UNIOESTE

orcid: https://orcid.org/0009-0001-4963-662X

Caterine Renata Passaglia

State University of Western Paraná - UNIOESTE

orcid: https://orcid.org/0009-0008-0706-5911

Julio Katuhide Ueda

State University of Western Paraná - UNIOESTE

orcid: https://orcid.org/0000-0002-8664-942X

Marcio José Mendonça

State University of Western Paraná - UNIOESTE

orcid: https://orcid.org/0000-0002-6953-7135

Veridiana Camilotti

State University of Western Paraná - UNIOESTE

orcid: https://orcid.org/0000-0002-3004-3939

Abstract

The aim of this study was to investigate the potential of ozonated water as an oxidative cleaning solution to improve the bond strength of a bioactive adhesive system to enamel without prior etching. Forty bovine anterior tooth crowns were used and divided into four groups according to the cleaning solution and storage time: AD24h (cleaning with distilled water, 24 hours of storage), AO 24h (cleaning with ozonized water, 24 hours of storage), AD30D (cleaning with distilled water, 30 days of storage) and AO 30D (cleaning with ozonized water, 30 days of storage). All groups were subjected to the application of the bioactive adhesive system, followed by the manufacture of bioactive bulk fill flow resin composite cylinders (2x2 mm) on the crowns. After each storage period, the samples were evaluated using microshear tests and fracture analysis. The data was statistically analyzed using JAMOVI software, version 1.2.24. The results indicated that there was no statistically significant difference in most of the tooth thirds and groups evaluated, except in the cervical third after 24 hours, where ozonated water showed greater bond strength. This study suggests that ozonized water can potentially benefit the adhesion of bioactive adhesive systems to dental enamel, especially under specific storage and application conditions.

Keywords: Dental enamel. Ozone. Composite resin. Dentistry.

Introduction

The evolution of dental materials and their properties is becoming increasingly evident in dentistry. The quality of selecting a good adhesive system and the correct restorative technique allows the resin composite to be more effective, durable and functional [1]. In order to restore lost natural aesthetics, some various restorative materials and techniques enable long-term clinical success [2].

Resin composite is a restorative material widely used in restorative dentistry, as it provides conservative, relatively low-cost treatment with good aesthetic purposes [3]. However, expectations about these materials leave a lot of room for advances in their mechanical properties, such as failures caused by polymerization-induced stress, polymerization contraction and thermal expansion mismatch, abrasion and wear resistance, toxicity and marginal infiltration [4, 5].

Biomaterials were developed to improve the interaction between the restorative material and the dental structure [6]. The concept behind the development of bioactive restorative materials aims not only to repair lesions in dental hard tissues, but also to incorporate biological properties that prevent the growth of secondary caries, without adversely affecting the host cells [7]. Biocompatibility is based on a material's ability to interact properly with biological structures, without causing a toxic or immunological reaction [8].

Studies on the initial properties of giomers have reported initial mechanical properties that are comparable to those of a resin composite [9]. Giomer has been described as an "intelligent particle", that emerged intending to combine the esthetics and strength of resin composite with the fluoride-releasing capacity of glass ionomer[10].

This material uses glass ionomer technology with a pre-activated S-PRG surface [11]. When in contact with polyacrylic acid, the fluoraminosilicate particles react and are incorporated into the resin, resulting in a continuous release of fluoride. This happens as soon as it interacts with saliva from the oral environment [12-14]. In addition to hindering bacterial adhesion to the tooth [15], the ions act as a buffer, neutralizing the acids produced by these microorganisms [11].

Therefore, cavity cleaning is essential to maximize adhesive system properties. Ozone is a molecule made up of three oxygen atoms, which form naturally. It protects the Earth's surface and human life from harmful ultraviolet rays [16]. Ozone therapy is a biologically beneficial agent in which oxygen/ozone is supplied as a gas or dissolved in a water or oil base for medicinal purposes, which has therapeutic uses in various dental treatments. When used in conjunction with other treatments, ozone therapy has many benefits[17]. Due to this, ozonated water has been proposed as a method of cavity disinfection before restorative procedures [18]. It has shown several advantages, due to its antioxidant, healing and remineralizing properties, and can contribute to increasing bond strength to dental substrates [19-21]. This study aimed to verify whether using an oxidative cleaning solution, such as ozonized water, can improve the bond strength of a bioactive adhesive system on enamel without prior conditioning.

Methodology

Sample preparation

Forty bovine anterior teeth from a local slaughterhouse were selected, freshly extracted and sectioned at high speed with abundant cooling using a No. 4138 diamond tip (KG Sorensen), separating the crowns from the roots. The crowns were fixed in standardized PVC tubes with acrylic resin, leaving the vestibular surface free. They were then divided into 4 groups:

Group 1: AD 24h - Cavity cleaning with distilled water and storage for 24 hours;

Group 2: AO 24h - Cavity cleaning with ozonized water and storage for 24 hours;

Group 3: AD 30D - Cavity cleaning with distilled water and storage for 30 days;

Group 4: AO 30D- Cavity cleaning with ozonized water and storage for 30 days.

The materials used in each group are shown in Table 1.

Table 1 - Description and composition of the materials used.

Material	Composition	Manufacturer	Mode of use
FL- Bond II – Two-step, self-etching adhesive system.	Primer: Carboxylic acid monomer, phosphinic acid monomer, 6-MHPA, water, solvent and photoinitiator. Adhesive: HEMA, UDMA, TEGDMA, 40% S-PRG-filler particles, photoinitiator.	Shofu, Kyoto, Japan.	Step 1: Dispense the Primer and carefully apply it to the dentin and enamel surfaces, leave for 10 seconds, dry with an oil-free air jet for 5 seconds (Do not rinse) Step 2: Dispense the Bonding Agent and apply a homogeneous layer over the entire surface, light-cure for 10 seconds with halogen light or 5 seconds with LED.
Beautifil Flow Plus F00	Base resin: Bis-GMA resin (15% by weight) /TEGDMA (13% by weight). Filler: Multifunctional glass filler and S-PRG filler based on fluroboroaluminosilicate glass. DL-Camforquinone	Shofu, Kyoto, Japan.	In the case of a deep cavity, proceed in several stages (application/curing) without exceeding 4 mm in thickness at a time. Light cure for 10 seconds with LED light.

*Bis-GMA: bisphenol-A-diglycidyl methacrylate; TEGDMA: triethylene glycol dimethacrylate; 6-MHPA: 6-methacryloxyhexyl 3-phosphonoacetate; HEMA: 2-hydroxyethyl methacrylate; UDMA: urethane dimethacrylate; S-PRG filler: glass ionomer filler pre-reacted on the surface.

Preparation of ozonated water

The 4 ppm7 ozonated water was prepared at a room temperature of 25ºC ± 1.0 ºC and 5 minutes ± 1.0 min before use and used up to 5 minutes ± 1.0 min after preparation, using an ozone generator (Ozone &Life® /O&L3.0RM, São José dos Campos, SP, Brazil) which uses pure oxygen from a cylinder attached to a glass tower (1L/min). The amount of ozone in the water will be measured using direct iodometric titration, as recommended by the International Ozone Association (IOA), which consists of adding 50 ml of potassium iodide solution (KI) 1 N, in previously ozonized water. The chemical reaction that takes place in this procedure results in the oxidation of KI by ozone, promoting the release of iodine (I2), according to the equation O3 + 2 KI + H2O ↔ I2 + 2 KOH + O2. In order to ensure the production of I2, it will be necessary to acidify the medium by adding 2.5 mL of 1 N sulfuric acid (H2SO4) to the KI solution. Then titrate with 0.01 N sodium thiosulfate (Na2S2O3) until the yellowish color of the iodine becomes barely perceptible. Then 1 mL of 1% starch indicator solution is added and the titration is resumed until the blue color of the solution disappears.

Bonding procedure

Next, the FL Bond 2- (SHOFU, Kyoto, Japan) adhesive system was applied to all groups according to the manufacturer's instructions. Three composite resin cylinders were then made in the crowns of each group. A Tygon matrix (Tygon tubing, TYG-030, Saint-Gobain Performance Plastic, Maime Lakes, FL, USA) with an internal diameter of 2 mm and a height of 2 mm was used. The matrix was positioned with the aid of clinical forceps on the surface. Then its interior was filled with Beautifil Flow Plus - F03 composite resin (SHOFU, Kyoto, Japan) in a single increment. Following the manufacturer's recommendations, photoactivation was carried out using a Valo light device (Ultradent Products, South Jordan, UT, USA).

Storage

The specimens were stored for 24 hours and 30 days at 37ºC in saline solution in a bacteriological oven, after which the matrix was removed with a No. 11 scalpel blade and the microshear test was carried out.

Microshear test

The samples were subjected to the micro-shear test on a universal testing machine (EMIC) at a speed of 1mm/min with a 50N load cell. The maximum force applied to the base of the cylinders was 45N, 10% less than the load cell value. The data was transformed into MPa and submitted to statistical analysis.

Fracture analysis

The fractured resin-enamel/dentin interface was analyzed under a stereoscopic loupe at 100x magnification (Olympus SZ40, Japan). The types of failure were classified as:

Adhesive (A): failure at the composite resin-dentin/enamel interface.

Mixed (M): failures at the adhesive/enamel-dentin/composite resin interface, including cohesive failures.

Cohesive in Composite Resin (CC): failure exclusively in composite resin.

Cohesive in Dentin (CD): failure exclusively within dentin/enamel.

Statistical analysis

The results were tabulated and subjected to statistical analysis using JAMOVI software, version 1.2.24. Initially, the data was assessed for the requirement of normal distribution using the Shapiro Wilk test, with a negative result. After analyzing this prerequisite, statistical tests were carried out to assess the existence of statistically significant differences between the groups using the Wilcoxon test ($p < 0.05$).

Results

The results obtained were statistically analyzed using the non-parametric Wilcoxon test ($p < 0.05$).

In general, using ozonated water promoted greater resistance to fracture when subjected to the microshear test for the cervical third at 24 hours compared to using distilled water. For the other thirds, there was no statistically significant difference between the groups at both times.4

In turn, for the intra-group analysis, there was a statistically significant difference for ozonized water between the cervical third in the 24-hour period and the same third in the 30-day period and with the incisal third in the 30-day period, while for distilled water it was possible to observe a difference between the cervical and incisal thirds in the 30-day analysis. The data is shown in Table 2.

Table 2 – Median values and interquartile deviation of micro-shear bond strength (N), according to time, when using ozonized water and distilled water for cavity cleaning before using self-adhesive resin.

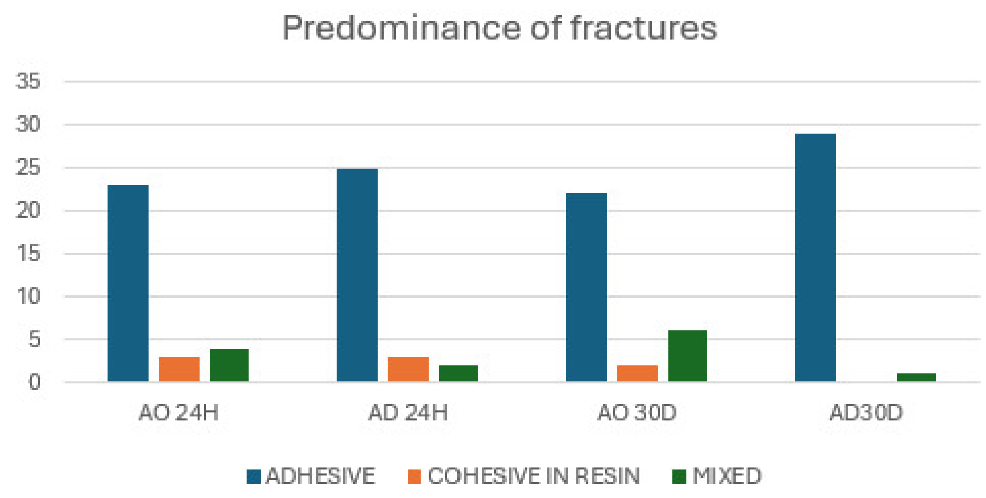
Time		24 hours			30 days	
Dental third	Cervical	Medial	Incisal	Cervical	Medial	Incisal
Destilled water	2.93 (± 1.74) Aab	2.37 (± 1.76) Aab	2.77 (± 2.52) Aab	8.44 (± 8.09) Aa	7.9 (± 9.19) Aab	4.94 (± 9.66) Ab
Ozonated water	8.31 (± 2.16) Ba	8.4 (± 0.76) Aab	8.91 (± 3.31) Aab	7.42 (± 2.39) Ab	6.78 (± 3.49) Aab	6.79 (± 4.33) Ab

*Different lowercase letters in the row = significant differences with $p<0.05$ in the intra-group analysis using the Wicoxon test.

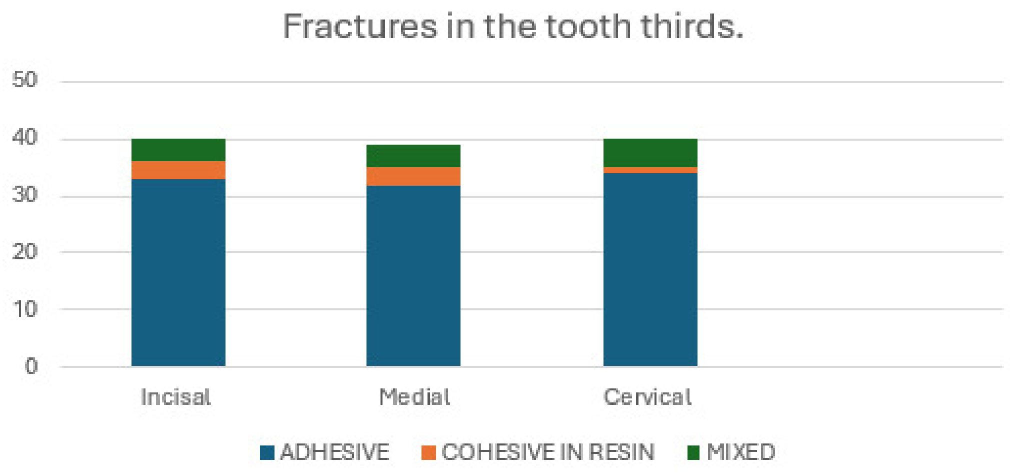
**Different capital letters in the column = significant differences with $p<0.05$ in the inter-group analysis using the Wicoxon test.

Regarding the classification of the type of fracture, the predominant fracture was adhesive, with a significant difference when compared to the others. The second most common type was mixed, followed by cohesive in resin. The type of cohesive fracture in dentin was not observed during the analysis. Data on the types of fracture in each group is shown in Graph 1.

Graph 1 – Predominance of fractures.



Graph 2- Types of fractures in tooth thirds.



Discussion

Ozone acts as an oxidizer, which has led to its use in the medical and dental fields. Ozone has unique properties, which is why it has a wide range of applications. These properties include antimicrobial, immune stimulating, antihypoxic, vasodilating, detoxifying and biosynthetic. In addition, ozone is a powerful repair agent for pulp tissue and is completely biocompatible [22]. Despite having interesting properties for its use, some studies suggest that ozonized water may interfere with the bond strength of long-term restorations [23].

Confirming part of the hypothesis of this study, ozonated water as a cavity-cleaning solution improved enamel bond strength in the cervical third during the 24-hour storage period. However, in other dental thirds and at other storage times, no significant differences were observed. Regarding the use of ozonized water as a cavity cleaning agent, these findings corroborate almost entirely with the studies by Detogni, et al. [24]

(2023) and Cardoso, et al. [25] (2023) who observed that the use of ozonized water did not interfere with the bond strength of bulk fill flow resins. According to Cangul, et al. [26] (2020), the use of ozone before the restorative procedure significantly increased the bond strength of adhesive agents. These findings may be promising, as they contradict the results of the study by Bilgili, et al. [27] (2022), which revealed that the use of ozone decreased the bond strength values of a universal adhesive in dentin, justifying that this difference could be explained due to the presence of oxygen residues after the use of ozone that would affect polymerization. These differences in results can be explained by the methodological differences used in the studies, such as the form of ozone application (gas, ozonated water or oil) and the difference in concentration.

Another factor that may have corroborated the higher bond strength values in enamel in the cervical region is the use of the FL-Bond II adhesive system (Shofu, Kyoto, Japan), since the composition of this self-etching adhesive contains monomers that are able to chemically and mechanically bond the adhesive interface to the dental substrate. Li, et al. [28] (2019) demonstrated that the addition of dimethylaminohexadecyl methacrylate (DMAHDM) and amorphous calcium phosphate particles, a biomaterial, promoted antibacterial activity and increased interfacial durability in adhesive systems.

Regarding bond strength values, the smaller internal diameter and height of the Tygon matrix may have influenced the results. Since this size reduction may have influenced the force exerted on the load cell, resulting in the lower values found [29].

As for the types of fractures observed after the microshear test, there was a predominance of adhesive fractures in both groups and all tooth thirds, followed by mixed and cohesive resin fractures; in this study, no type of cohesive resin fracture was observed. By remaining on the surface of dental tissues, oxidizing substances such as ozone, hydrogen peroxide and carbamide peroxide can negatively affect the monomer chain that grows during adhesive polymerization [30 – 32.] The studies by Qeblawi et al. [33] (2015) and Ahn et al. [34] (2020) suggest that, in the shear strength test, the distribution of stresses in the bond area and the differences in the elastic properties of the materials can lead to significant changes in fracture patterns.

However to a lesser extent, resin cohesive failures were also found in this study, especially in the incisal and middle thirds. The oxidizing action of ozone can interfere with the prismatic structure of the dental substrate, so the neutralization of acidic monomers is reduced and the residual acidity affects the setting reaction and, consequently, the polymerization of the materials [35]. The non-neutralization of monomers increases water sorption, solubility and hygroscopic expansion stress [36]. Factors that may explain the pattern of cohesive fractures in resin.

Given the limitations of this study, further laboratory tests and clinical trials are therefore necessary to confirm the data obtained in this in vitro study. Further studies on the use of ozonated water in dentistry are needed to prove its efficacy and to determine protocols for using ozone.

Conclusion

It can be concluded that ozonized water obtained the best bond strength results on enamel in the cervical third during the 24-hour storage period. In the other storage periods and tooth thirds, there were no significant differences in enamel bond strength.

Author´s contribution

Author 1: project administration, writing and review, investigation, Author 2: writing and editing, Author 3: resources, Author 4: supervision, Author 5: conceptualization, original draft, supervision.

Conflicts of interests

All authors have read the final version of the manuscript and declare that there is no conflict of interest.

References

1. Watts DC. The quest for stable biomimetic repair of teeth: Technology of resin-bonded composites. Dent Mater J. 2020 Jan 31;39(1):46-51. doi: 10.4012/dmj.2019-201
2. Spezzia S. Oral rehabilitation with the use of facets. Revista Fluminense de Odontologia. *2019; 52*, 1413-2966.
3. Barcelos LM, Borges MG, Soares CJ, Menezes MS, Huynh V, Logan MG, et al. Effect of the photoinitiator system on the polymerization of secondary methacrylamides of systematically varied structure for dental adhesive applications. The quest for stable biomimetic repair of teeth: Technology of resin-bonded composites. Dent Mater. 2020 Mar;36(3):468-477. doi: 10.1016/j.dental.2020.01.020
4. Boaro LC, Pereira Lopes D, de Souza ASC, Lie Nakano E, Ayala Perez MD, Pfeifer CS, et al. Clinical performance and chemical-physical properties of bulk fill composites resin -a systematic review and meta-analysis. Dent Mater. 2019 Oct;35(10):e249-e264. doi: 10.1016/j.dental.2019.07.007
5. Dias AGA, Magno MB, Delbem ACB, Cunha RF, Maia LC, Pessan JP. Clinical performance of glass ionomer cement and composite resin in Class II

restorations in primary teeth: A systematic review and meta-analysis. J Dent. 2018 Jun;73:1-13. doi: 10.1016/j.jdent.2018.04.004

6. Lalzawmliana V, Anand A, Roy M, Kundu B, Nandi SK. Mesoporous bioactive glasses for bone healing and biomolecules delivery. Mater Sci Eng C Mater Biol Appl. 2020 Jan;106:110180. doi: 10.1016/j.msec.2019.110180
7. Wuersching SN, Högg C, Kohl L, Reichl FX, Hickel R, Kollmuss M. Leaching components and initial biocompatibility of novel bioactive restorative materials. Dent Mater. 2023 Mar;39(3):293-304. doi: 10.1016/j.dental.2023.01.008
8. Kus-Liśkiewicz M, Fickers P, Ben Tahar I. Biocompatibility and Cytotoxicity of Gold Nanoparticles: Recent Advances in Methodologies and Regulations. Int J Mol Sci. 2021 Oct 11;22(20):10952. doi: 10.3390/ijms222010952
9. Tsujimoto A, Barkmeier WW, Takamizawa T, Latta MA, Miyazaki M. Depth of cure, flexural properties and volumetric shrinkage of low and high viscosity bulk-fill giomers and resin composites. Dent Mater J. 2017 Mar 31;36(2):205-213. doi: 10.4012/dmj.2016-131
10. Rusnac ME, Gasparik C, Irimie AI, Grecu AG, Mesaroş AŞ, Dudea D. Giomers in dentistry - at the boundary between dental composites and glass-ionomers. Med Pharm Rep. 2019 Apr;92(2):123-128. doi: 10.15386/mpr-1169
11. Spinola MDS, Moecke SE, Rossi NR, Nakatsuka T, Borges AB, Torres CRG. Efficacy of S-PRG filler containing varnishes on enamel demineralization prevention. Sci Rep. 2020 Nov 4;10(1):18992. doi: 10.1038/s41598-020-76127-w
12. Colceriu Burtea L, Prejmerean C, Prodan D, Baldea I, Vlassa M, Filip M, Moldovan M, Moldovan ML, Antoniac A, Prejmerean V, Ambrosie I. New Pre-reacted Glass Containing Dental Composites (giomers) with Improved Fluoride Release and Biocompatibility. Materials (Basel). 2019 Dec 3;12(23):4021. doi: 10.3390/ma12234021
13. Francois P, Fouquet V, Attal JP, Dursun E. Commercially Available Fluoride-Releasing Restorative Materials: A Review and a Proposal for Classification. Materials (Basel). 2020 May 18;13(10):2313. doi: 10.3390/ma13102313
14. Harhash AY, ElSayad II, Zaghloul AGS. A comparative *in vitro* study on fluoride release and water sorption of different flowable esthetic restorative materials. Eur J Dent. 2017 Apr-Jun;11(2):174-179. doi: 10.4103/ejd.ejd_228_16
15. Shimizubata M, Inokoshi M, Wada T, Takahashi R, Uo M, Minakuchi S. Basic properties of novel S-PRG filler-containing cement. Dent Mater J. 2020 Dec 3;39(6):963-969. doi: 10.4012/dmj.2019-317
16. Domb WC. “Ozone Therapy in Dentistry: A Brief Review for Physicians.” Interventional Neuroradiology: 2014 20 (5): 632–36. doi:10.15274/INR-2014-10083
17. Lubojanski A, M Dobrzynski, N Nowak, J RewakSoroczynska, K Sztyler, W Zakrzewski, et al. “Application of Selected Nanomaterials and Ozone in Modern

Clinical Dentistry." Nanomaterials (Basel, Switzerland): 2021: 11 (2): 259. doi:10.3390/nano11020259

18. Coelho A, Amaro I, Rascão B, Marcelino I, Paula A, Saraiva J, Spagnuolo G, Marques Ferreira M, Miguel Marto C, Carrilho E. Effect of Cavity Disinfectants on Dentin Bond Strength and Clinical Success of Composite Restorations-A Systematic Review of In Vitro, In Situ and Clinical Studies. Int J Mol Sci. 2020 Dec 31;22(1):353. doi: 10.3390/ijms22010353

19. Hubbezoğlu I and Oğuzhan A. The Efficacy Of Four Cavity Disinfectant Solutions And Two Different Types Of Laser On The Micro-Shear Bond Strength Of Dentin Adhesives. Cumhuriyet Dental Journal*: 2018;* 21: 9-17. doi:10.7126/cumudj.389990

20. Gökçen EY, Aksoy M, Orhan AI, Ozçelik B, Oz FT. Assessment of the effectiveness of ozone theraphy and an antibacterial bonding agent on the cavity disinfection of deciduous teeth: An in vivo study. Cumhuriyet Dental Journal: 2019; 22, 442– 450. doi: 10.7126/cumudj.642787

21. Cangul S, Adiguzel O, Unal S, Ertugrul MO, Gumes S, Unal S, et al. The effect of the Different Cavity Desinfectant on the Bonding Strengh of Non- Linght Curing Adhesive Agent. International Biological and Biomedical Journal: 2019; 5, 04-07.

22. Alpan AL, Bakar O. Ozone in Dentistry [Internet]. Ozone in Nature and Practice. InTech; 2018. Available from: doi.org/10.5772/intechopen.75829

23. Akturk E, Bektas OO, Ozkanoglu S, Akin EGG. Do Ozonated Water and Boric Acid Affect the Bond Strength to Dentin in Different Adhesive Systems?. Nigerian Journal of Clinical Practice 22(12):p 1758-1764, December 2019.doi: 10.4103/njcp.njcp_281_19

24. Detogni AC, Silva MP, Sinhoreti MAC, Ueda JK, Camilotti V. (2023). Influence of ozonated water prior to the use of two universal adhesive systems on the binding resistance of bulk fill flow composite resins: in vitro study. Revista Foco v.16.n.8, e2758, p.01-16. doi: 10.54751

25. Cardoso PM de F, Vanolli R da S, Ribeiro FR, Mendonça MJ, Camilotti V Effect of time and dental substrate on the bond strength of a universal adhesive system: in vitro study. Rev odontol UNESP [Internet]. 2023;52:e20230005. Available from: https://doi.org/10.1590/1807-2577.00523

26. Cangul S, Erpacal B, Adiguzel O, Sagmak S, Unal S, Tekin S. Does the Use of Ozone as a Cavity Disinfectant Affect the Bonding Strength of Antibacterial Bonding Agents? Science & Engineering: 2020.doi: 10.1080/01919512.2020.1746633.

27. Bilgili CD, Dundar A, Barutcugil C. Effect of Cavity Disinfection Protocols on Microtensile Bond Strength of Universal Adhesive to Dentin. Odovtos-Int J Dent Sc. 2022;24(3):91-102.doi: 10.15517/ijds.2022.50966

28. Li Y, Hu X, Ruan J, Arola DD, Ji C, Weir MD, Oates TW, Chang X, Zhang K, Xu HHK. Bonding durability, antibacterial activity and biofilm pH of novel adhesive containing antibacterial monomer and nanoparticles of amorphous calcium phosphate. J Dent. 2019 Feb;81:91-10.doi: 10.1016/j.jdent.2018.12.013

29. Garcia RN, Galli AH, Gomes BO, Piva JP, Laus L, Borghetti N, Becker R, Zanella R, Duarte VAPS, Fernandes SX. Bond strength of all-in-one adhesives in different substrates. *Revista Salusvita, 2016;* 35*, 27-40.*

30. Mirzaei M, Shafei F, Niakan S. Effect of Bleaching on Shear Bond Strength of Composite Resins to Bovine Enamel Using Three Bonding Agents. J Iran Dent Assoc 2013; 25 (2) :101-108.

31. Rodrigues PCF, Souza JB, Soares CJ, Lopes LG, Estrela C. Effect of Ozone Application on the Resin-Dentin Microtensile Bond Strength. Operative Dentistry. 2011; 36 (5):537–44. doi:10.2341/10-062-L

32. Arslan, S., A.R. Yazici, J. Gorucu, A. Ertan, K. Pala, Y. U. Antonson, and D.E. Antonson. 2011.Effects of Different Cavity Disinfectants on Shear Bond Strength of Silorane-Based Resin Composite. The Journal of Contemporary Dental Practice 12 (4):279–86. doi:10.5005/jpjournals-10024-1047

33. Qeblawi DM, Campillo-Funollet M, Muñoz CA. In vitro shear bond strength of two self-adhesive resin cements to zirconia. J Prosthet Dent. 2015 Feb;113(2):122-7. doi: 10.1016/j.prosdent.2014.08.006.

34. Ahn JJ, Kim DS, Bae EB, Kim GC, Jeong CM, Huh JB, Lee SH. Effect of Non-Thermal Atmospheric Pressure Plasma (NTP) and Zirconia Primer Treatment on Shear Bond Strength between Y-TZP and Resin Cement. Materials (Basel). 2020 Sep 5;13(18):3934. doi: 10.3390/ma13183934.

35. Vrochari AD, Eliades G, Hellwig E, Wrbas KT. Water sorption and solubility of four self-etching, self-adhesive resin luting agents. J Adhes Dent. 2010 Feb;12(1):39-43. doi: 10.3290/j.jad.a17539.

36. Manso AP, Carvalho RM. Dental Cements for Luting and Bonding Restorations: Self-Adhesive Resin Cements. Dent Clin North Am. 2017 Oct;61(4):821-834. doi: 10.1016/j.cden.2017.06.006.