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Proceeding Paper

Effect of Irrigation with Sodium Hypochlorite on the Bond Strength to Dentin Using Different Bonding Protocols †

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Abstract: The study evaluates the influence of irrigation with sodium hypochlorite on the microtensile bond strength to dentin with different bonding protocols on pre-endodontic restorations. After endodontic opening of restored human molars, teeth were randomly divided into four experimental groups: group 1 was not irrigated and the access was restored, while the other groups were irrigated with sodium hypochlorite. Group 2 was restored, group 3 had the endodontic access walls instrumented, and group 4 had CoJet sandblasting and silane application prior to final restoration. The bond strength after irrigation showed higher values when silicatization is performed.

Keywords: pre-endodontic restorations; sodium hypoclorite; bond strength; dentin

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1. Introduction

Pre-endodontic restorations are widely used to properly plan the rehabilitation treatment of the tooth, before considering endodontic treatment [1–3]. To achieve this goal, it is essential to remove carious tooth lesions, old restorations and/or root canal posts, and to perform an adhesive dentistry prior to endodontic treatment. The primary goal is to achieve an optimal contour of the four walls, improve the structural strength and functionality of the affected teeth, and prevent fractures. It also helps to create better conditions for rubber dam isolation and effective irrigation [2–4]. Another major benefit that contributes to the effectiveness and success of endodontic treatment is the prevention of contamination by microorganisms from the carious lesion, saliva, and blood [2,5].

Root canal disinfection is critical to the success of endodontic treatment, and the use of irrigants such as sodium hypochlorite (NaOCl) is generally recommended [5]. In the case of pre-endodontic restorations, the question arises as to whether endodontic irrigation with NaOCl throughout the entire endodontic procedure affects the integrity of the hybrid layer and the adhesive bond strength of this restoration to dentin. No studies have determined, so far, whether it is necessary to remove pre-endodontic restorations after irrigation with NaOCl, and, if its removal is not necessary, it is important to determine the ideal bonding protocols to achieve an effective seal. The aim of this study was to evaluate the influence of irrigation with NaOCl on microtensile bond strength (μTBS) to dentin, using different bonding protocols on pre-endodontic restorations.

2. Materials and Methods

This study was approved by the Ethics Committee of the Egas Moniz School of Health & Science, Portugal (no. 943) and was performed in accordance with ISO/TS 11405/2015 [6] and the Academy of Dental Materials [7]. Twenty intact human third molars were scaled and cleaned of all debris, stored in a 1% chloramine T (*v*/*v*) solution at 4 °C for one week and kept in artificial saliva at 4 °C until use. Two cross-sections were made of each tooth using a hard tissue microtome (Accutom-50, Struers A/S, Ballerup, Denmark) at low speed, with water refrigeration. Pulp remnants were removed, and the pulp chamber filled with cyanoacrylate glue (Zapit, Dental Ventures of America, Corona, CA, USA). A smear layer was then created by polishing with a 600-grit silicon carbide sandpaper on a polisher with constant refrigeration (Buehler Ltd., Lake Bluff, IL, USA), and the dentin was restored with orthophosphoric acid (Octacid), followed by Optibond FL™ adhesive system (Kerr, Orange, CA, USA), and a nanohybrid composite (Grandio SO—VOCO, GMBH, Cuxhaven, Germany), shade A3, according to the manufacturer's recommendations. An endodontic access cavity preparation (3 × 6 mm) was conducted using a conical truncated diamond drill bur (ISO 504) in a high-speed handpiece (Pana-Max2 (NSK, Tokyo, Japan) under refrigeration. After 24 h, the specimens were randomly assigned to four experimental groups (n = 5). Group 1 (G1) was not irrigated, and the access was restored, while the other groups were irrigated with NaOCl according to the Egas Moniz School of Health & Science protocol. Group 2 (G2) was restored after irrigation. In group 3 (G3), the endodontic access cavity preparation walls were instrumented with a high-speed diamond bur (ISO 504), and group 4 (G4) was treated with CoJet™ (3M, Saint Paul, MN, USA) (30-µm Al_2O_3 coated with SiO_2) followed by silane application, prior to final restoration. A range of 76–84 beams (1 ± 0.2 mm^2) were obtained from each five-teeth group, using a hard tissue microtome (Accutom-50, Struers A/S, Ballerup, Denmark), under constant water refrigeration, and immersed in artificial saliva at 37 °C for 24 h in an incubator (Memmert INE 400, Memmert, Germany) prior to testing. The cross-sectional area of the beams was measured using a digital calliper (MPI/E-101, Mitutoyo, Tokyo, Japan), and then they were fixed to Geraldeli-type jigs. The microtensile bond strength (µTBS) test was performed in a universal testing machine (Shimadzu Autograph Ag-IS, Tokyo, Japan) using a 1 kN load cell at 1 mm/min until fracture.

The means of microtensile bond strength were obtained for each group, considering the beam as the experimental unit for the inferential analysis. Since normality and homoscedasticity were verified, a one-way ANOVA test was applied, followed by Tuckey's HSD ($\alpha = 0.05$), using IBM SPSS Statistic v.27.0 software (IBM, SPSS Inc., Armonk, NY, USA).

3. Results

The means and standard deviations of microtensile bond strength are represented in Table 1. The microtensile values ranged between 40.6 (±32.1) MPa, in G1, and 53.6 (±23.8) MPa, in G4. ANOVA revealed statistically significant differences for µTBS mean values among groups ($p = 0.001$). Further statistical analysis using Tukey's HSD showed that the microtensile mean values for G3 and G4 were significantly higher ($p < 0.05$) than those of G1.

Table 1. Descriptive statistics of the microtensile bond strength (µTBS) according to experimental groups.

Experimental Groups	*n*	Beams	Mean ± Standard Deviation
G1	5	78	40.6 ± 32.1
G2	5	84	45.3 ± 23.0
G3	5	78	50.9 ± 20.5
G4	5	76	53.6 ± 23.8

4. Discussion

Pre-endodontic restorations are often performed prior to endodontic treatment and help to create suitable conditions for endodontic treatment, but there is still no consensus on whether to maintain or remove the pre-endodontic restoration for the final rehabilitation of the tooth [8,9]. At the end of the endodontic treatment, a better bond strength of the final restoration to the dentin walls increases the marginal sealing, the mechanical resistance to masticatory stress, and the durability of the restorations for the long-term clinical success of the restorative treatment [10,11].

Firstly, it is important to understand whether irrigation with NaOCl affects the bond strength. In the present study, the microtensile strength of G1 (without irrigation) and G2 (with irrigation) did not show significant differences. This finding is consistent with the results of two meta-analysis in 2018 [10,12], and the mechanisms of action of NaOCl on dental adhesion can explain this. NaOCl dissolves the exposed collagen network and creates a mineralized layer of dentin to which resin material can adhere, increasing the bond strength to dentin through a deproteinization process. This allows direct adhesion between adhesive resin and dentin without the hybrid layer that is usually created [1].

The present study compared three protocols prior to definitive restoration. The results showed that the microtensile strength of G3 and G4 was significantly higher than that of G1 (with no irrigation), and there were no differences between G2, G3, and G4 (with irrigation). However, the results of the three protocols appeared to show a tendency to increase bond strength (G4 > G3 > G2). Bonstein [13] compared a protocol of instrumentation of composite walls with another protocol of sandblasting the walls with aluminum oxide particles. The first protocol showed higher values because silane was applied after instrumentation with a drill and not in the second protocol. The CoJet^{TM} system (3M, St. Paul, MN, USA), which uses silica-coated alumina particles of the order of 30 μm, is indicated for composite repairs [14]. In addition to the sandblasting effect, the incorporation of silica into the substrate to be bonded contributes to a surface available for chemical bonding through the application of the silane [15,16]. Silane is a bifunctional molecule that acts as a binder and adhesion promoter and is chemically involved in the bonding of various restorative materials [14]. This makes the surface hydrophobic, leading to an improvement in the wettability of the composite [17]. Most studies show that the application of silanes helps to increase the bond strength compared to a simple application of the adhesive [18]. Similar results to our study were found in previous articles which concluded that sandblasting the surface with silica-coated alumina particles was a promising technique with higher bond strength values [19,20]. This can be explained by the action that the abrasive jet exerts on the substrate through its particles. By increasing the surface temperature and creating surface roughness through the impact of the alumina particles, micromechanical retention is increased. In addition to the increase in micromechanical retention, it was concluded that the application of silane to the access walls increased the bond strength by increasing the chemical adhesion, consistent with other studies [13,21].

5. Conclusions

Within the limitations of this in vitro study, irrigation with sodium hypochlorite does not affect the bond strength to dentin. The bond strength of the pre-endodontic restoration to dentin after endodontic irrigation reveals higher values when an adhesive protocol based on silicatization of the endodontic access walls is used.

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References

1. Abuhaimed, T.S.; Neel, E.A.A. Sodium Hypochlorite Irrigation and Its Effect on Bond Strength to Dentin. *BioMed Res. Int.* **2017**, *2017*, 1930360. [CrossRef] [PubMed]
2. Kameyama, A.; Saito, A.; Haruyama, A.; Komada, T.; Sugiyama, S.; Takahashi, T.; Muramatsu, T. Marginal Leakage of Endodontic Temporary Restorative Materials around Access Cavities Prepared with Pre-Endodontic Composite Build-up: An in Vitro Study. *Materials* **2020**, *13*, 1700. [CrossRef] [PubMed]
3. Heydrich, R.W. Pre-Endodontic Treatment Restorations. A Modification of the "donut" Technique. *J. Am. Dent. Assoc.* **2005**, *136*, 641–642. [CrossRef] [PubMed]
4. Hargreaves, K.M.; Berman, L.H. *Cohen's Pathways of the Pulp*, 12th ed.; Elsevier: Amsterdam, The Netherlands, 2020.
5. Kshirsagar, S.; Aggarwal, S.; Mukhtar, A.; Gupta, P.; Rai, V.; Chawla, M. Pre Endodontic Build-up of a Grossly Destructed Tooth: A Case Report. *Int. J. Sci. Study* **2015**, *2*, 11.
6. *ISO/TS 11405:2015*; Dentistry—Testing of Adhesion to Tooth Structure. International Organization for Standardization: Geneva, Switzerland, 2015.
7. Armstrong, S.; Breschi, L.; Özcan, M.; Pfefferkorn, F.; Ferrari, M.; Van Meerbeek, B. Academy of Dental Materials Guidance on in Vitro Testing of Dental Composite Bonding Effectiveness to Dentin/Enamel Using Micro-Tensile Bond Strength (MTBS) Approach. *Dent. Mater.* **2017**, *33*, 133–143. [CrossRef] [PubMed]
8. Arashiro, F.N.; Figueiredo, J.L.G.; Guerisoli, D.M.Z.; Pereira, K.F.S.; Silva, P.G.; Yoshinari, G.H. Evaluation the Influence of Endodontic Irrigants on Bond Strength to Superficial Dentin of Bovine Teeth and Scanning Electron Microscope Analysis. *Rev. Odontol. Bras. Cent.* **2010**, *19*, 314–318.
9. Kharouf, N.; Pedullà, E.; La Rosa, G.R.M.; Bukiet, F.; Sauro, S.; Haikel, Y.; Mancino, D. In Vitro Evaluation of Different Irrigation Protocols on Intracanal Smear Layer Removal in Teeth with or without Pre-endodontic Proximal Wall Restoration. *J. Clin. Med.* **2020**, *9*, 3325. [CrossRef] [PubMed]
10. Hardan, L.; Bourgi, R.; Cuevas-Suárez, C.E.; Zarow, M.; Kharouf, N.; Mancino, D.; Villares, C.F.; Skaba, D.; Lukomska-Szymanska, M. The Bond Strength and Antibacterial Activity of the Universal Dentin Bonding System: A Systematic Review and Meta-Analysis. *Microorganisms* **2021**, *9*, 1230. [CrossRef] [PubMed]
11. Fortin, D.; Swift, E.J.; Denehy, G.E.; Reinhardt, J.W. Bond Strength and Microleakage of Current Dentin Adhesives. *Dent. Mater.* **1994**, *10*, 253–258. [CrossRef] [PubMed]
12. Bohrer, T.C.; Fontana, P.E.; Lenzi, T.L.; Soares, F.Z.M.; Rocha, R.D.O. Can Endodontic Irrigating Solutions Influence the Bond Strength of Adhesives to Coronal Dental Substrates? A Systematic Review and Meta-Analysis of In Vitro Studies. *J. Adhes. Dent.* **2018**, *20*, 481–494. [PubMed]
13. Bonstein, D.G. Evaluation of Varied Repair Protocols Applied to Aged Composite Resin. *J. Adhes. Dent.* **2005**, *7*, 41–49. [PubMed]
14. Matinlinna, J.P.; Lung, C.Y.K.; Tsoi, J.K.H. Silane Adhesion Mechanism in Dental Applications and Surface Treatments: A Review. *Dent. Mater.* **2018**, *34*, 13–28. [CrossRef] [PubMed]
15. Valente, L.L.; Sarkis-Onofre, R.; Gonçalves, A.P.; Fernández, E.; Loomans, B.; Moraes, R.R. Repair Bond Strength of Dental Composites: Systematic Review and Meta-Analysis. *Int. J. Adhes. Adhes.* **2016**, *69*, 15–26. [CrossRef]
16. Gutierrez, N.C.; Moecke, S.E.; Caneppele, T.M.F.; Perote, L.C.C.C.; Batista, G.R.; Huhtalla, M.F.R.L.; Torres, C.R.G. Bond Strength of Composite Resin Restoration Repair: Influence of Silane and Adhesive Systems. *J. Contemp. Dent. Pract.* **2019**, *20*, 880–886. [PubMed]
17. Fuentes, M.V.; Escribano, N.; Baracco, B.; Romero, M.; Ceballos, L. Effect of Indirect Composite Treatment Microtensile Bond Strength of Self-Adhesive Resin Cements. *J. Clin. Exp. Dent.* **2016**, *8*, e14–e21. [CrossRef] [PubMed]
18. Fornazari, I.A.; Brum, R.T.; Rached, R.N.; de Souza, E.M. Reliability and Correlation between Microshear and Microtensile Bond Strength Tests of Composite Repairs. *J. Mech. Behav. Biomed. Mater.* **2020**, *103*, 103607. [CrossRef] [PubMed]
19. Costa, T.R.F.; Ferreira, S.Q.; Klein-Júnior, C.A.; Loguercio, A.D.; Reis, A. Durability of Surface Treatments and Intermediate Agents Used for Repair of a Polished Composite. *Oper. Dent.* **2010**, *35*, 231–237. [CrossRef] [PubMed]
20. Celik, C.; Cehreli, B.S.; Bagis, B.; Arhun, N. Microtensile Bond Strength of Composite-to-Composite Repair with Different Surface Treatments and Adhesive Systems. *J. Adhes. Sci. Technol.* **2014**, *28*, 1264–1276. [CrossRef]
21. Bona, A.D.; Borba, M.; Benetti, P.; Cecchetti, D. Effect of Surface Treatments on the Bond Strength of a Zirconia-Reinforced Ceramic to Composite Resin. *Braz. Oral Res.* **2007**, *21*, 10–15. [CrossRef] [PubMed]