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Evaluation Of Bond Strength Of Splinting Material To The Teeth After Thermocycling - An In Vitro Study

Research Article

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Abstract

Introduction: Bond strength can be explained, as the amount of adhesion between bonded surfaces. Splints are used to immobilize traumatized teeth that suffered damage in their structures of support, preventing their constant movement. The most frequently used technique is to use orthodontic stainless steel wire, bonded onto the inside surface of the teeth with composite which acts as a splint. Thermocycling is a laboratory method of exposing dental materials and teeth to temperature ranges similar to those occurring in the oral cavity. The aim of this study is to evaluate the bond strength of splinting material to the teeth after thermocycling.

Materials and Methods: The experiment consisted of three main steps; namely, preparation of the testing samples, thermocycling and measurement of bond strength. 8 pairs of natural maxillary central incisors were splinted in pairs, using stainless steel orthodontic wire. The 8 pairs were divided in two groups; group 1: where the wire is splinted using bulk filled composite (BFC) and group 2: where the wire is splinted using flowable composite. Both groups were splinted in the same manner. 8 pairs were labelled and wrapped in gauze. Each group was put in the thermocycling machine. After completion of thermocycling, INSTRON E 3000 universal testing machine was used to measure the bond strength, by recording the amount of force it takes to detach the splint from the incisors. After recording the data, and obtaining graphs for the same, the data was analysed using SPSS statistical software. Data analysis was done using an independent sample t test and p value was set as 0.05 as level of significance.

Results: In the BFC group, the mean and standard deviation values were 27.5300 and 16.26524. In the flowable composite group, the mean and standard deviation values were 86.2575 and 53.88458. Independent sample t test was done and p value was 0.031 which is less than 0.05, hence statistically significant.

Conclusion: Within the limitations of this study, it can be concluded that the splinting of teeth with orthodontic wire using flowable composite shows higher bond strength than bulk filled composite resin after thermocycling.

Keywords: Splinting; Thermocycling; Bond Strength; Flowable Composite; Bulk Filled Composite; Innovative Measurement.

Introduction

Periodontitis or periodontal disease is reported as an infectious pathology that is caused in dental plaque by a susceptible host and bacterial factors [1]. This causes inflammation which results in disorganisation of periodontal fibres, initiation of bone resorption, and destruction of epithelial cell attachment [2]. Due to this destruction, there is reduced periodontal attachment which causes tooth mobility and migration, which causes the occlusal forces to misalign. Treatment of such a condition depends on the degree of damage to the bone. So, the treatment for teeth that are affected with gingival inflammation and have higher grade of mobility due to higher loss of bone includes a combination of periodontal therapy, occlusal adjustments, and tooth restraints for stability. This can be accomplished by periodontal splinting, which mainly works on the principle of distributing functional and parafunc-

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tional forces. It is a widely accepted treatment for traumatic injuries, and is used to stabilise subluxated, luxated, avulsed and root fractures teeth. The treatment outcome of these injured teeth is determined by the course of healing of the severed periodontal ligament. This helps in reorganising gingival tissues, periodontal fibres and alveolar bone.

Splinting helps in promoting tooth stabilisation and tissue healing by reducing inflammation [3]. There are many ways to do so; wire splinting, acrylic cap splints, acid etched splints, porcelain veneers, trans-alveolar sutures and fiber reinforced composite splints [4]. Most commonly, wire splints and fibre reinforced splints are used. Wire splints involve the use of conventional orthodontic wire, which is held onto the teeth with the help of dental composite [5]. Such a procedure involves multiple steps such as etching, priming and application of adhesive. Avulsion is defined as the complete displacement of the tooth out of its socket with disruption of the fibers of periodontal ligament, remaining some of them adhered to the cementum and the rest to the alveolar bone [6]. This condition is more frequent in young permanent teeth, because the root development is still incomplete. Splint is the device used to support, protect or immobilize in order to avoid possible damage to the pulp and periodontal tissue, which retards the repair of neurovascular bundles and reintegration of periodontal fibers broken by trauma [7]. Splints are used to immobilize traumatized teeth that suffered damage in their structures of support, preventing their constant movement [8]. The literature has shown that after replantation, it is necessary to use splints in order to immobilize the teeth during the initial period, which is essential for the repair of periodontal ligament; the use of semi-rigid splint is more indicated than the rigid one, and long periods of splinting showed that substitutive resorption or ankylosis is an expected complication [9].

A bond strength describes the amount of force required to break the connection between a bonded restoration and the tooth surface with the failure occurring in or near the adhesive/adherens interface [10]. Thermocycling is a laboratory method of exposing dental materials and teeth to temperature ranges similar to those occurring in the oral cavity that could produce adverse consequences as a result of different coefficients of thermal expansion between the tooth structure and the filling material. Through these cycles, thermal stresses could affect the bond strength between the control groups and tested samples [11]. Comparison of these materials (flowable and bulk filled composite) for splinting has not been widely reported. Hence, the aim of this study is to evaluate the bond strength of splinting material to the teeth after thermocycling.

Materials and Methods

The experiment consisted of three main steps; namely, preparation of the testing samples, thermocycling and measurement of bond strength.

Step 1: Preparation of Samples

8 pairs of natural maxillary central incisors were obtained from a tooth dealer. They were splinted in pairs, using stainless steel wire. The 8 pairs were divided in two groups; group 1: where the wire is splinted using bulk filled composite (BFC) (4 pairs) and group 2: where the wire is splinted using flowable composite (4 pairs). Both groups were splinted in the same manner, the teeth samples were etched, coated with bonded agents, and cured with respective composite. Both groups were then attached to an acrylic mold (Figure 1).

Step 2: Thermocycling

8 pairs were labelled and wrapped in gauze. Each group was put in the thermocycling containers and the machine instructions were set. TC 4 SD Mechatronik, Integrated thermocycler was used. The temperatures were set to 60 degrees Celsius as the highest limit and 10 degrees Celsius as the lowest limit. It was also set to record 1000 thermocycling cycles, which roughly replicates 6 months of presence in the oral cavity.

Step 3: Measurement of Bond Strength

After completion of thermocycling, the samples were taken out and dried. INSTRON E 3000 universal testing machine was used to measure the bond strength, by recording the amount of force it takes to detach the splint from the incisors (Figure 2).

Figure 1. Sample preparation.

Figure 2. Bond strength testing using INSTRON E 3000 universal testing machine.

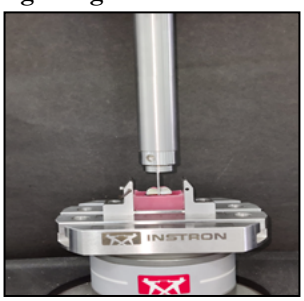
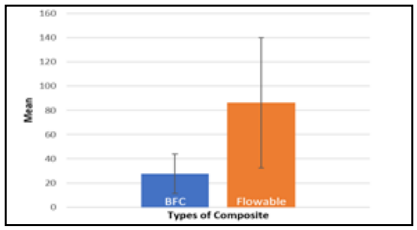


Table 1. Mean, standard deviation and test of significance of bond strength values between group 1 (BFC) and group 2 (Flowable composite).

Composite resin Groups	N	Mean	Std. Deviation	Significance
BFC	4	27.53	16.265	0.031
Flowable	4	86.258	53.885	

Figure 3. The bar graph shows the average mean of the bond strength of the bulk filled composite and flowable composite post thermocycling along with the standard deviations. X axis represents the type of composite and the Y axis represents the mean bond strength. Blue denotes BFC (bulk fill composite) and orange denotes flowable composite. The bond strength of the splinting material in the flowable composite group is higher than that of BFC.



After recording the data, and obtaining graphs for the same, the data was analysed using SPSS statistical software. Data analysis was done using an independent sample t test and p value was set as 0.05 as level of significance.

Results

The table 1 shows the mean, standard deviation and significance values of bond strength comparison between bulk fill composite and flowable composite group after thermocycling. In the BFC group, the mean and standard deviation values were 27.5300 and 16.26524. In the flowable composite group, the mean and standard deviation values were 86.2575 and 53.88458. Independent sample t test was done and p value was 0.031 which is less than 0.05, hence statistically significant. (Figure 3).

Discussion

As observed in the above results, the bond strength exhibited by the group 2 that is flowable composites is higher than that of bulk filled composite. This means that bulk filled composites have lower bond strength and hence there may be a risk of detachment of the periodontal splint if masticatory forces exceed the threshold. This finding coincides with a study that hypotheses about the flowable composite having lower bond strength than other types of composites. Many methods can be used for the stabilisation and fixation of dentoalveolar injuries [12]. Tooth splinting should be easy to apply, inexpensive and easy to remove without damaging the dental hard tissue. They should not traumatise the teeth or surrounding tissues and should not interfere with the occlusion, dental hygiene or endodontic treatment if mandatory [13]. Most importantly, they should be primitive in restoring the original anatomical tooth position and ensure adequate fixation over the immobilisation period, achieving rigidity or flexibility, according to the type of trauma [14].

In a study conducted by Tina Puthen Purayil, the bond strength of two splinting materials (orthodontic wire and Ribbond) were compared using three adhesive systems, namely CA ester, self-adhering flowable composite and conventional flowable composite. A total of 120 human central incisors were selected, embedded in blocks of rapid polymerising self-cure acrylic resin with two teeth each. The specimens were divided into six groups with ten specimens each. Group I-Orthodontic wire bonded with CA, Group II-Orthodontic wire bonded with flowable composite Group III-Orthodontic wire bonded with Vertise flow, Group IV-Ribbond bonded with CA, Group V-Ribbond bonded with flowable composite and Group VI-Ribbond bonded with Vertise flow [15]. The adhesive force in newtons to debond the splinting material was measured in tension using a universal testing machine. The force at which the splint system failed was noted. The study showed that the bond strength with the orthodontic wire groups was significantly less compared with Ribbond groups $p < 0.05$. Among the adhesives, CA demonstrated lower bond strength value as compared to Vertise flow and flowable composite $p < 0.05$. Through this experiment, it was concluded that orthodontic wire groups demonstrated significantly lower bond strength compared to ribbond groups. Among the adhesives CAs showed significantly lower bond strength compared to Vertise flow and conventional flowable composite. Our team has extensive knowledge and research experience that has translated into high quality publications [16-28, 29-35]. In comparison, the present study has also included the process of thermocycling, which challenges the bond strength in a more realistic way. It conditions the samples to an environment similar to that of the oral cavity, hence leading to more accurate and appropriate results. The results of the present study conclude that flowable composites have a higher bond strength than bulk filled composites, post thermocycling, our study is first of its kind and novel. The limitations of the study include a small sample size, only 2 types of composites usage and adhesive systems of the same company. The experiment can be conducted at a larger scale in order to observe the results more accurately. Adhesive systems of different brands should also be tested in order to obtain a universal result as well.

Conclusion

Within the limitations of this study, it can be concluded that the splinting of teeth with orthodontic wire using flowable composite shows higher bond strength than using bulk filled composite after thermocycling. This means that it will have higher durability and function in the oral cavity.

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References

[1]. Ramesh A, Varghese SS, Jayakumar ND, Malaiappan S. Chronic obstructive pulmonary disease and periodontitis–unwinding their linking mechanisms. J. Oral Biosci. 2016 Feb 1;58(1):23-6.
[2]. Thamaraiselvan M, Elavarasu S, Thangakumaran S, Gadagi JS, Arthie T. Comparative clinical evaluation of coronally advanced flap with or without platelet rich fibrin membrane in the treatment of isolated gingival recession. J Indian Soc Periodontol. 2015 Jan;19(1):66-71.
[3]. Oikarinen K. Functional fixation for traumatically luxated teeth. Dent Traumatol. 1987 Oct;3(5):224-8.
[4]. Hensten-Pettersen A, Jacobsen N. Perceived side effects of biomaterials in prosthetic dentistry. J Prosthet Dent. 1991 Jan 1;65(1):138-44.
[5]. STASSLER H. Stabilization of the natural dentition in periodontal cases using adhesive restorative materials. Perio Insight. 1997;4:4-10.
[6]. Oikarinen K. Tooth splinting: a review of the literature and consideration of the versatility of a wire-composite splint. Endod Dent Traumatol. 1990 Dec;6(6):237-50.Pubmed PMID: 2094598.
[7]. Strassler HE. Aesthetic management of traumatized anterior teeth. Dent Clin North Am. 1995 Jan 1;39(1):181-202.
[8]. Croll TP. Bonded composite resin/ligature wire splint for stabilization of traumatically displaced teeth. Quintessence Int. 1991 Jan 1;22(1):17-21.
[9]. Negri MR, Panzarini SR, Poi WR, Sonoda CK, Manfrin TM, Vendrame dos Santos CL. Use of a cyanoacrylate ester adhesive for splinting of replanted teeth. Dent Traumatol. 2008 Dec;24(6):695-7.Pubmed PMID: 19021667.
[10]. Bearn DR. Bonded orthodontic retainers: a review. Am J Orthod Dentofacial Orthop. 1995 Aug 1;108(2):207-13.
[11]. Bitter K, Meyer-Lueckel H, Priehn K, Kanjuparambil JP, Neumann K, Kielbassa AM. Effects of luting agent and thermocycling on bond strengths to root canal dentine. Int Endod J. 2006 Oct;39(10):809-18.
[12]. Von Arx T, Filippi2 A, Buser3 D. Splinting of traumatized teeth with a new device: TTS (Titanium Trauma Splint). Dent Traumatol. 2001 Feb;17(4):180-4.
[13]. Manfrin TM, Poi WR, de Mendonça MR, Cardoso LC, Massa Sundefeld ML, Sonoda CK, et al. Analysis in vitro of direct bonding system with cyanoacrylate ester and orthodontic wires. Dent Traumatol. 2009 Apr;25(2):229-32.Pubmed PMID: 19290906.
[14]. Giachetti L, Scaminaci Russo D, Baldini M, Bertini F, Steier L, Ferrari M. Push-out strength of translucent fibre posts cemented using a dual-curing technique or a light-curing self-adhering material. Int. Endod. J. 2012 Mar;45(3):249-56.
[15]. Purayil TP, Chakravarthy A, Ginjupalli K, Ballal NV. Evaluation of bond strength of splinting materials to the teeth using three adhesive systems-an in vitro study. Saudi J. Oral Sci. 2015 Jul 1;2(2):94.
[16]. Ramesh A, Varghese S, Jayakumar ND, Malaiappan S. Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study. J Periodontol. 2018 Oct;89(10):1241-1248.Pubmed PMID: 30044495.
[17]. Paramasivam A, Priyadharsini JV, Raghunandhakumar S, Elumalai P. A novel COVID-19 and its effects on cardiovascular disease. Hypertens. Res. 2020 Jul;43(7):729-30.
[18]. S G, T G, K V, Faleh A A, Sukumaran A, P N S. Development of 3D scaffolds using nanochitosan/silk-fibroin/hyaluronic acid biomaterials for tissue engineering applications. Int J Biol Macromol. 2018 Dec;120(Pt A):876-885.Pubmed PMID: 30171951.
[19]. Del Fabbro M, Karanxha L, Panda S, Bucchi C, Doraiswamy JN, Sankari M, et al. Autologous platelet concentrates for treating periodontal infrabony defects. Cochrane Database Syst Rev. 2018;(11): CD011423.
[20]. Paramasivam A, Priyadharsini JV. MitomiRs: new emerging microRNAs in mitochondrial dysfunction and cardiovascular disease. Hypertens. Res. 2020 Aug;43(8):851-3.
[21]. Jayaseelan VP, Arumugam P. Dissecting the theranostic potential of exosomes in autoimmune disorders. Cell Mol Immunol. 2019 Dec;16(12):935-6.
[22]. Vellappally S, Al Kheraif AA, Divakar DD, Basavarajappa S, Anil S, Fouad H. Tooth implant prosthesis using ultra low power and low cost crystalline carbon bio-tooth sensor with hybridized data acquisition algorithm. Comput Commun. 2019 Dec 15;148:176-84.
[23]. Vellappally S, Al Kheraif AA, Anil S, Assery MK, Kumar KA, Divakar DD. Analyzing relationship between patient and doctor in public dental health using particle Memetic multivariable logistic regression analysis approach (MLRA2). J. Med. Syst. 2018 Oct;42(10):1-7.
[24]. Varghese SS, Ramesh A, Veeraiyan DN. Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students. J Dent Educ. 2019 Apr;83(4):445-50.
[25]. Venkatesan J, Singh SK, Anil S, Kim SK, Shim MS. Preparation, characterization and biological applications of biosynthesized silver nanoparticles with chitosan-fucoidan coating. Molecules. 2018 Jun;23(6):1429.
[26]. Alsubait SA, Al Ajlan R, Mitwalli H, Aburaisi N, Mahmood A, Muthurangan M, et al. Cytotoxicity of different concentrations of three root canal sealers on human mesenchymal stem cells. Biomolecules. 2018 Sep;8(3):68.
[27]. Venkatesan J, Rekha PD, Anil S, Bhatnagar I, Sudha PN, Dechsakulwatana C, et al. Hydroxyapatite from cuttlefish bone: isolation, characterizations, and applications. Biotechnol Bioprocess Eng. 2018 Aug;23(4):383-93.
[28]. Vellappally S, Al Kheraif AA, Anil S, Wahba AA. IoT medical tooth mounted sensor for monitoring teeth and food level using bacterial optimization along with adaptive deep learning neural network. Measurement. 2019 Mar 1;135:672-7.
[29]. PradeepKumar AR, Shemesh H, Nivedhitha MS, Hashir MM, Arockiam S, Maheswari TN, et al. Diagnosis of Vertical Root Fractures by Cone Beam Computed Tomography in Root Filled Teeth with Confirmation by Direct Visualization-A Systematic Review and Meta-Analysis. J Endod.. 2021 May 11;47(8):1198–214.
[30]. Ramani P, Tilakaratne WM, Sukumaran G, Ramasubramanian A, Krishnan RP. Critical appraisal of different triggering pathways for the pathobiology of pemphigus vulgaris-A review. Oral Dis. 2021 Jun 21.
[31]. Ezhilarasan D, Lakshmi T, Subha M, Deepak Nallasamy V, Raghunandhakumar S. The ambiguous role of sirtuins in head and neck squamous cell carcinoma. Oral Dis. 2021 Feb 11.Pubmed PMID: 33570800.
[32]. Sarode SC, Gondivkar S, Sarode GS, Gadbail A, Yuwanati M. Hybrid oral potentially malignant disorder: A neglected fact in oral submucous fibrosis. Oral Oncol. 2021 Jun 16:105390.Pubmed PMID: 34147361.
[33]. Kavarthapu A, Gurumoorthy K. Linking chronic periodontitis and oral cancer: A review. Oral Oncol. 2021 Jun 16:105375.
[34]. Vellappally S, Al-Kheraif AA, Anil S, Basavarajappa S, Hassanein AS. Maintaining patient oral health by using a xeno-genetic spiking neural network. J. Ambient Intell. Humaniz. Comput.. 2018 Dec 14:1-9.
[35]. Aldhuwayhi S, Mallineni SK, Sakhamuri S, Thakare AA, Mallineni S, Sajja R, et al. Covid-19 Knowledge and Perceptions Among Dental Specialists: A Cross-Sectional Online Questionnaire Survey. Risk Manag Healthc Policy. 2021 Jul 7;14:2851-2861.Pubmed PMID: 34262372.