Journal of Biomaterials
2022; 6(1): 1-4
http://www.sciencepublishinggroup.com/j/jb
doi: 10.11648/j.jb.20220601.11
ISSN: 2640-2602 (Print); ISSN: 2640-2629 (Online)

Bond Strength Evaluation of a Self-etching Adhesive and Two Composite Resins to Human Dentin Irradiated with Cobalt-60

Juliana Dorini Amaral[1], Thiago Dorini Sanfins[2], Beatriz Garcia Coutinho[2], Luiz Flavio Kalil Telles[3], Andre Luis Dorini[4, *]

[1]Dorini Dentistry, Itatiba, Brazil

[2]Graduate College, University San Francisco, Bragança Paulista, Brazil

[3]North Riograndense League Against Cancer, Natal, Brazil

[4]Departament of Dentistry, Federal University of Rio Grande do Norte, Natal, Brazil

Email address:

judorini@hotmail.com (J. D. Amaral), thiagodsanfins@gmail.com (T. D. Sanfins), beatriz-garcia-c2011@hotmail.com (B. G. Coutinho), luizflaviokt@hotmail.com (L. F. K. Telles), andredorini@yahoo.com (A. L. Dorini)

[*]Corresponding author

To cite this article

Juliana Dorini Amaral, Thiago Dorini Sanfins, Beatriz Garcia Coutinho, Luiz Flavio Kalil Telles, Andre Luis Dorini. Bond Strength Evaluation of a Self-etching Adhesive and Two Composite Resins to Human Dentin Irradiated with Cobalt-60. *Journal of Biomaterials*. Vol. 6, No. 1, 2022, pp. 1-4. doi: 10.11648/j.jb.20220601.11

Received: September 3, 2021; **Accepted**: March 21, 2022; **Published**: April 14, 2022

Abstract: The aim of this study was to evaluate the bond strength of a self-etching adhesive system on teeth subjected to Co-60 irradiation. Thus, 24 human third molars were selected. Of these, 12 were randomly selected and exposed to total radiation of 1935,588 cGy (corresponding to the effective biological dose of 35 daily cycles of 2000 cGy). The teeth were prepared by removing the occlusal enamel, exposing a flat dentin surface. The Single Bond Universal Adhesive System (3M/ESPE) was applied to each group according to the manufacturer's instructions. Then, two resin increments, of 2 mm each, of composite resins Filtek Z350 XT (3M/ESPE) or Aura (SDI) were added, which were light cured for 20s. There were, therefore, four analysis groups: Aura + irradiated Universal Single Bond (ASBI), Aura + non-irradiated Universal Single Bond (ASBNI), Filtek Z350 + irradiated Universal Single Bond (FZSBI) and Filtek Z350 + irradiated Universal Single Bond (FZSBNI). The samples were sectioned, yielding toothpick-shaped specimens. To evaluate the bond strength, a microtensile test was performed using the EMIC DL - 2000 machine (EMIC, Brazil) with a load cell of 500N and a microtensile speed of 0.5 mm/min. Although the radiation doses applied may cause some structural changes in the dentin, this did not interfere with the bond strength of teeth that were or were not exposed to radiation and that were restored using a self-etching adhesive system. No statistically significant difference was found in the bond strength between the groups, whether comparing the irradiated and non-irradiated groups, or between the different resins used: ASBI (35.76 Mpa), ASBNI (34.32 Mpa), FZSBI (32.20 Mpa) and FZSBNI (38.37 Mpa).

Keywords: Adhesiveness, Radiotherapy, Composite Resins

1. Introduction

Every year approximately 500.000 new cases of head and neck cancer are diagnosed around the world. The choices of treatment include surgery, radiation and the combination surgery/radiation [1].

The intensification of radiotherapy in head and neck cancer brought significant improvements in tumor control and increased the survival rates for those patients. The cases in which radiation is part of the therapy, it may be applied before or after surgery, or even be the only treatment. However, the radiotherapy, besides causing the death of cancer cells it also affects healthy cells, which can lead to complications, a lot of which affect the oral cavity [2].

The most common oral clinical consequences of radiation are: hypo salivation, mucositis, taste loss, lockjaw, osteoradionecrosis and radiation caries. The risk of dental deterioration by sudden onset of rampant caries radiation and osteoradionecrosis are threats throughout the patients' life. Among late collateral effects are included severe and debilitating destruction of teeth associated with the loss of masticatory function, which interferes in the nutritional intake and in the social daily activities of the patient [3].

The tolerance doses of healthy tissue are around 60 Gy, and the sensibility of tumor tissue varies from 30 to 60 Gy. The clinical dose of radiation varies from 40 to 70 Gy, fractioned usually in daily doses ranging from 1,8 to 2 Gy, in a period of four to seven weeks, according to the therapeutic plan [4].

Such doses of radiation may cause direct effects on the hard tooth tissue (enamel and dentin), which may lead to morphological alterations in the tooth and eventually interfere in the way these tissues react to the process of union to adhesive restorative materials [5-11].

Thereby, this article has the goal of evaluating the effect of irradiation with cobalt 60 (Co-60) on the bond strength of a self-etching adhesive on dentin. The null hypothesis tested is that the irradiation does not interfere in the bond strength.

2. Materials and Methods

In this study, 24 third molars were used, which were from the division of surgery and maxilla-facial traumatology of the UFRN Dental Department, through favorable opinion of the ethics committee for research CAEE n° 45188415.7.0000.5537.

The extracted teeth were stored in 0.5% thymol, until the moment they were used, in order to avoid bacterial growth and morphological changes in the substrate. They were washed with water and soap, scraped with periodontal curettes, and brushed with pumice and water, using a Robinson brush at low rotation [12]. After that, they were randomly divided into two main groups, one exposed to radiation and the other one not exposed (control), then subdivided into four groups (n=6), according to the received treatment, as shown in Table 1:

Table 1. *Study groups.*

IRRADIATED		NOT IRRADIATED	
Filtek Z350 + Single Bond Universal (n=6) Z350 XT	Aura + Single Bond Universal (n=6) AURA	Filtek Z350 + Single Bond Universal (n=6) Z350 XT	Aura + Single Bond Universal (n=6) AURA

Randomly, 12 teeth were exposed to irradiation with Co-60 in a telecobalt therapy machine (Theraton 780, Ottawa, Canada) at the Advanced Norte Rio Grandense Oncology Center (Natal, Rio Grande do Norte, Brazil).

According to the International Atomic Energy Agency (IAEA TRS 398), the standard for calibration of the radiation beam is the water [14]. Using the linear squared model, the teeth were immersed in 1,5 cm of distilled water, in an area of 18x27 cm, 80 cm distant from the source for the area 10/10 and 0,5 cm deep, adding up to 70,13 cGy/min. The total time of irradiation was 27,6 minutes, and leading to an only do with a total of 1935,588 cGy. Such dose corresponds to a Biological Effective Dose (BED) which is similar to the one obtained with 35 daily cycles of 2000 cGy [14].

Sense the chosen substrate was dentin, the middle third of the crown enamel was sectioned perpendicular to the long axis through a cut using a diamond disk linked to a precision cutting machine (Struers Minitom, Compenhagen, Denmark) being cooled, thereby exposing a flat surface of dentin [15]. Then, the dentin was planned, using Silicon Carbide sandpaper (Bosch, Gerlingen, German) decreasing grainness 100 and 600, with abundant cooling using water at low speed (100 RPM).

The Adper Single Bond Universal (3M ESPE, St. Paul, Minnesota, USA) adhesive was applied in each group according to the instructions given by the manufacturer. After that, two composite resin increments were added Filtek Z350, color EA2 (3M ESPE, St. Paul, Minnesota, USA) or Aura, color DC3 or DC4 (SDI, Bayswater, Victoria, Australia), with 2 mm, light cured (DB 685; Dabi Atlante, Ribeirao Preto, São Paulo, Brazil) for 20s each, according to the instructions given by the manufacturer. The LED power measured by the radiometer was 1625 mW/cm^2. After the sample pieces were made, the teeth were put in distilled water for 24 hours in a chamber at 37°C.

Three parallel sections to the long axis of the tooth were done in the buccal-lingual direction, and four sections in the mesial-distal direction, creating specimen with a stick form [16].

To evaluate the bond strength, the EMIC DL – 2000 (EMIC, São José dos Pinhais, Parana, Brazil) machine was used with a load cell of 500N, and micro tensile speed of 0,5mm/min [17]. The statistic test that was used to verify the bond strength for the groups tested was ANOVA two factors.

3. Results

Same letters indicate absence of significant statistical differences (á=5%)

Table 2. *Average results of bond strength (MPa) for irradiated and not irradiated groups.*

Treatment	Resin	Bond Strength (MPa)
Irradiated	Z350	32,20 (11,96) ^{A}
	Aura	35,76 (6,75) ^{A}
Control	Z350	38,37 (16,9) ^{A}
	Aura	34,32 (7,5) ^{A}

Table 2 shows that there were no differences in the bond strength of the Aura and Z350 resins to the self-etching adhesive Single Bond Universal, regardless of the teeth being irradiated previously or not.

4. Discussion

This study showed that there was no statistical difference between the irradiated groups and not irradiated, therefore the null hypothesis is accepted.

In other studies, it is reported that patients which received radiotherapy treatment in the head and neck area exhibit a challenging oral cavity, sense they may have high rates of decay, deterioration and failed restorations [19].

In studies done by Mc Comb et al. [18] and Hu et al. [19] they observed that the most common cause for several types of dental restoration failures were the material displacement, but secondary caries was not found on the margins of the restorations that fell off. Those clinical indicators lead us to believe that the mechanic imbrication between the dental surface and the restorative material may be altered, decreasing the retention and consequently reduced longevity of the restoration, apart from the action of secondary caries actions.

Springer et al. [20] reported the radiation may have direct destructive effect on mineralized dental tissue, especially on the enamel-dentin junction, although they were able to prove radiogenic destruction of the collagen only on pulp tissue of human teeth. They also showed that the irradiation does not affect measurably the extent of the mineralized collagen destruction of dental tissue, which may be related to a relatively low protein value present in the dentin and enamel.

According to Walker [21], in his research, the results suggest that the therapeutic irradiation does not significantly affect the susceptibility of teeth to demineralize in vivo. However, his observations do not exclude other possible direct effects of the radiation, with the increased fragility of teeth caused by the protein degradation.

Regarding the micro hardness of dentin, Gonçalves et al. [22] found that the values of micro hardness in diminished after cumulative doses of radiation of 10, 20, 30, 50 and 60 Gy in comparison with not irradiated dentin. Related to the microstructure, in the dentin of non-irradiated teeth, there was an increase in morphological alterations after radiation doses of 30 and 60 Gy, fissures in the dentin structure became evident at amplifications of 10.000 and 20.000. With a cumulative dose of 60 Gy, the dentinal tubules were destroyed. The collagen fibers were gradually fragmented with the increase of the doses of radiation.

The reduced hardness of irradiated dentin appears to not have influence on the bond strength in dentin [23, 24]. Besides that, Fisher et al. [25] was not able to prove in this study an influence of the collapse of the matrix of dentin after irradiation.

Using electronic microscopy, Kielbassa et al. [26] did not find any difference in the specimen of irradiated dentin and non-irradiated. That may be another reason for the findings in our study. Alterations of the hardness, crystalline structure and collagen matrix may not have influence on the bond strength of adhesive systems to dentin.

The data obtained with this research, corroborates with the consulted literature. However, in the limitations of this research, there are other variables that can influence in the process of adhesion, such as the dental substrate and the aging of the restorations. Therefore, additional researches are necessary evaluating other types of substrate and using thermal or mechanical cycling methods, to try to simulate such situations.

5. Conclusion

Although irradiation is known to cause physical changes in dental tissues, based on the results and limitations of this research, it is concluded that irradiation did not change the bond strength to dentin of two composite resins associated with a self-etching adhesive system, with no differences between the radiated and irradiated groups.

References

[1] Bruno CJ, Patricia MR, Erika LM, Renata CL, Andre LC, Mark AS, Addah RF. Oral health status of 207 head and neck cancer patients before, during and after radiotherapy. Clin Oral Investig. 2008; 12: 19-24.

[2] Al-Nawas B et al. Using Ultrasound Transmission Velocity to Analyse the Mechanical Properties of Teeth After In Vitro, In Situ, and In Vivo irradiation. Clin Oral Investig. 2000; 4: 168.172.

[3] Monteiro L, Barreira E, Medeiros L. Osteorradionecrose dos Maxilares. Rev Port de Estomatol Med Dent Cir Maxilofac. 2005; 46: 49-62.

[4] Mohammadi N et al. Evaluation of radiation-induced Class V dental caries in patients with head and neck cancer undergoing radiotherapy. J Dental Res. 2008; 2 (3): 82-84.

[5] Bulucu B, Yesilyurt C, Cakir S, Meydan A D. Influence of radiation on bond strength. J Adhes Dent. 2006; 8: 217-221.

[6] Gernhardt CR, Kielbassa AM, Hahn P, Schaller HG. Tensile bond strengths of four different dentin adhesives on irradiated and nonirradiated human dentin in vitro. J Oral Rehabil. 2001; 28: 814-820.

[7] Grötz KA, Duschner H, Kutzner J, Thelen M, Wagner W. Histotomographystudies of direct radiogenic dental enamel changes. Mund Kiefer Gesichtschir. 1998; 2: 85-90.

[8] Jansma J, Borggreven JM, Driessens FC, Gravenmade EJ. Effect of X-ray irradiation on the permeability of bovine dental enamel. Caries Res. 1990; 24: 164-168.

[9] Pioch T, Golfels D, Stachle HJ. An experimental study of the stability of irradiated teeth in the region of the dentinoenamel junction. Endod Dent Traumatol. 1992; 8: 242-244.

[10] Pioch T, Stotz S, Buff E, Duschner H, Staehle HJ. Influence of different etching times on hybrid layer formation and tensile bond strength. Am J Dent. 1998; 11: 202-206.

[11] Silva ARS, Alves FA, Antunes A, De Goes MF, Lopes MA. Patterns of demineralization and dentin reactions in radiation-related caries. Caries Res. 2009; 43: 43-49.

[12] Mobarak EH, El-Badrawy W, Pashley DH, Jamjoom H. Effect of pretest storage conditions of extracted teeth on their dentin bond strengths. The J Prosthet Dent. 2010; 104: 92-97.

[13] Internacional Atomic Energy Agency - http://www.iaea.org/

[14] Khan FM, Gerbi BJ. Treatment planning in radiation oncology. 2011. Philadelphia, USA.

[15] Reis A, Zander-Grande C, Kossatz S, Stanislawczuk R, Manso A, Carvalho RM, Lo-guercio AD. Effect of mode of application on the microtensile bond strength of a self-etch and etch-and-rinse adhesive system. Oper Dent. 2010; 35: 428-435.

[16] Saboia VP, Nato F, Mazzoni A, Orsini G, Putignano A, Giannini M, et al. Adhesion of a two-step etch-and-rinse adhesive on collagen-depleted dentin. J of Adhes Dent. 2008; 10: 419-422.

[17] Sadek F T, Castellan CS, Braga RR, Mai S, Tjäderhane L, Pashley DH, et al. One-year stability of resin-dentin bonds created with a hydrophobic ethanol-wet bonding te-chnique. Dent Mater. 2010; 26: 380-386.

[18] Mc Comb D, Erickson RL, Maxymiw WG, Wood RE. A clinical comparison of glass ionomer, resin-modified glass ionomer and resin composite restorations in the treatment of cervical caries in xerostomic head and neck radiation patients. Oper Dent. 2002; 27: 430-437.

[19] Hu JY, Chen XC, Li YQ, Smales RJ, Yip KH. Radiation-induced root surface caries restored with glass ionomer cement placed in conventional and ART cavity preparations: Results at two years. Aust Dent J. 2005; 50: 186-190.

[20] Springer IN, Niehoff P, Warnke PH, Bocek G, Kovacs G, Suhr M, Wiltfang J, Açil Y. Radiation caries-radiogenic destruction of dental collagen. Oral Oncol. 2005; 41: 723-728.

[21] Walker R. Direct Effect of Radiation on the Solubility of Human Teeth In Vitro. J Dent Res. 1975; 54: 901.

[22] Gonçalves LMN, Palma-Dibb RG, Paula-Silva FWG, Oliveira HF, Nelson-Filho P, Silva LAB, et al. Radiation therapy alters microhardness and microstructure of enamel and dentin of permanent human teeth. J Dent. 2014; 42: 986-992.

[23] Kielbassa AM, Beetz I, Schendera A, Hellwig E. Irradiation effects on microhardness of fuoridated and non-fuloridated bovine dentin. Euro J Oral Sci. 1997; 105: 444-447.

[24] Kielbassa AM, Wrbas K-T, Dornfeld B, Hellwig E, Schade-Brittinger C. In vitro and in situ studies of the effect of tumor radiotherapy on the development of caries in human dentin. Deutsche Zahna Èrztliche Zeitschrift. 1999; 54: 31.

[25] Fisher B, Morgan RE, Phillips GO, Wardale HW. Radiation damage in calcium phosphates and collagen: an interpretation of ESR spectra. Radiat Res. 1971; 46: 229-235.

[26] Kielbassa AM, Schaller H-G, Hellwig E. Qualitative observations of in situ caries in irradiated dentin. A combined SEM and TMR study. Acta Medicinae Dentium Helvetica. 1998; 3: 161-168.