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Effect of Chlorhexidine 2% on the Shear Bond Strength of Different Composite Resins to Dentin

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A B S T R A C T

Currently chemical and technical advances have contributed to increasing resin-dentin bond strength. In this research the influence of chlorhexidine 2% on compressive strength of dental restorative resin composites including P90 (3MCO-90- USA), Z100 (3MCO-USA), Z 350 (3MCO-USA) was studied. 60 intact, noncarious extracted human premolar samples were prepared, and randomly divided into six main groups by regard to the used composite resin and also the usage of chlorhexidine 2% or physiological serum. Also the Dartec Series HC-10 (DARTEC Ltd, Stourbridge, England) shear testing machine was applied. Data were analyzed by Mann-Whitney test and also Kruskal Wallis of SPSS software. The group treated with Z350 (34.49±14.24 MPa) composite resin demonstrated significantly higher shear bond strength values than P90 and Z100 (23.98±5.61 and 18.47±11.46 MPa, respectively) in physiological serum group. Moreover there were significant differences between samples of chlorhexidine group by Kruskal Wallis analysis ($P<0.05$). The Z350 specimens with 42.26± 13.02 MPa, demonstrated higher shear bond strength values than the other groups while the lowest value with 25.31±9.41 MPa, was related to the P90 composite resin. The use of chlorhexidine 2% before acid etching was demonstrated that related bond strengths were more as a compared with those of the controls but not meaningful from the point of statistical views in one composite group.

Introduction

During the last two decades, the dental profession has strived to achieve perfect adhesion of resin composite to tooth substrate, due to decrease micro leakage and restoration stability. Restorative procedures are used to remove the infected dentin and make space for the restorative materials. The successes of these procedures depend on the effective removal of infected dentin, prior to the placement of the restorative material (Hegde, 2008). An endodontic treatment consists of removing all contents of the root canal system before and during shaping (Sharma, 2011). Therefore, chemical and technical advances have contributed to increasing resin-dentin bond strength; however, there are various obstacles that still affect adhesive restorations such as premature loss of bond strength which reduces durability.

Although, irrigation is presently the best method for the removal of tissue remnants and dentin debris during instrumentation, the use of irrigation also provides gross debridement, lubrication, destruction of microbes, and dissolution of tissues (Zamiran, 2013). The irrigants including sodium hypochloride, hydrogen peroxide, a combination of NaOCl and H_2O_2, and chlorhexidine, especially because of substantive antimicrobial properties, have been widely used as in endodontic therapy (Erdemir, 2004). Chlorhexidine molecule is symmetric, consisting of a hexamethylene bridge with terminal 4-chlorophenyl groups (Saunders, 1999). The mechanism of chlorhexidine as a broad-spectrum antimicrobial agent is related to its cationic bisbiquanide molecular structure. The cationic molecule is absorbed to the negatively charged inner cell membrane which causes leakage of intracellular components. At low concentrations it is bacteriostatic. At higher concentrations of chlorhexidine it causes the coagulation and precipitation of cytoplasm and therefore is bactericidal (Matthijs, 2002: Hugo, 1966). Thus, chlorhexidine has an affinity to bacteria, probably because of an interaction between the positively charged chlorhexidine molecule and negatively charged groups on the bacterial cell wall (Lin, 2003). Chlorhexidine is recognized for its antimicrobial substantively. It has been known more effective antimicrobial agent as a compared with sodium hypochlorite substantively low toxicity and no tissue-dissolving properties (Soares. 2008). Different modes of administration such as high and low concentrations of chlorhexidine have been reported to reduce the number of microorganisms in plaque and also saliva for considerable periods of time (Jeansonne, 1994). It has been shown that direct application of chlorhexidine on etched dentine surfaces is more prosperous than smear layer-covered dentine (Fardal, 1986). Therefore the purpose of this study was to evaluate the effect of chlorhexidine digluconate 2% on the bond strength of three composite resins.

Materials and Methods

60 intact, non-carious extracted human premolars were kept for 48 h in 0.2% thymol solution then stored at 4ºC in physiological saline solution until analyzing. The teeth were then mounted in cold cured acrylic resin. The teeth were placed, with the buccal surfaces upward, just above the surface of the embedding medium. Immediately before the preparation of the test specimens, the underlying superficial dentin was exposed by mounting the buccal surfaces on a metallurgical polishing wheel and wet grinding. The teeth were then randomly divided into six main groups. The first three groups were covered by the physiological serum (Iran Company) and the second three groups were covered by the chlorhexidine 2 % (Ultradent-USA) for 10 days in 37 Cº.

In groups 1 and 4, samples were coated by P90 (3MCO-90- USA) composite resin, according to the manufacturer’s instructions.

In these groups the dentin surface was air-dried and cured by LED light curing unit (Apoza-turbo-Taiwan) for 10 seconds followed by gentle air dispersion and light curing for 20 seconds with a light curing unit. P90 was placed immediately after the application and curing of P90 adhesive bond and was dispensed from the syringe into the prepared cavity by a flat plastic instrument using A2 color. Each increment was cured individually with a light curing unit for 20 seconds. Then the plastic instrument was cut and separated. In order to the factory recommendation of Z100 (3MCO-USA), groups 2 and 5 which was covered by physiological serum and chlorhexidine 2 %, were etched with a 37% phosphoric solution gel (Ultra-etch-USA). Then washed for 20 seconds by distilled water and dried. Single bond (3M ESPE, USA) was applied in a thin layer on the dentine surfaces, dried and light-cured for 20 seconds. The other part of preparation was repeated same as the group 1 and 4. The composite resin of Z350 (3MCO-USA) was utilized in the case of groups 3 and 6 and its sample preparation was as Z100.

The Dartec Series HC-10 (DARTEC Ltd, Stourbridge, England) shear testing machine was used. Strain rate was set to 1 mm/s for 10 seconds (Toolkit 96 software). This was considered as the distance needed to break the 0.5 mm sample. Bond strength refers to the force per unit area required to break the bond between the adhesive material and dentin. The shear bond strengths of the specimens were calculated and expressed in megapascals (MPa).

Data were analyzed using SPSS release 21.0 software (SPSS, Chicago, IL, USA). The Mann-Whitney test as a non-parametric equivalent to the independent samples t-test, and also kruskal wallis were applied. All tests were done at a 0.05 level significance.

Result and Discussion

The mean values for the shear bond strengths of all groups are presented in Table 1. Analysis of the present data indicates that chlorhexidine application as an antimicrobial agent has no negative effect on the bond strength of resin to dentin. By Kruskal Wallis analysis all specimens showed significantly different shear bond strength values in physiological serum ($P<0.05$). The group treated with Z350 (34.49±14.24 MPa) composite resin demonstrated significantly higher shear bond strength values than P90 and Z100 (23.98±5.61 and 18.47±11.46 MPa, respectively). Moreover there were significant differences between chlorhexidine group samples too ($P<0.05$). The Z350 specimens with 42.26± 13.02 MPa, demonstrated higher shear bond strength values than the others while the lowest value with 25.31±9.41 MPa, was related to the P90 composite resin.

Statistical data analysis revealed that, although the interactions of factors including the physiological serum and chlorhexidine did not have any significant effect by Mann-Whitney test ($P>0.05$) (Table 2), the type of composite had a significant effect on the shear bond strength ($P<0.05$) (Table 1). On the other word, no differences between chlorhexidine application and the physiological serum group were found in the same composite resin types.

The typical reported dentin bond strengths for adhesive resins are 20 to 30 MPa, although they can be much higher depending on the testing methods (Schwartz, 2006). There are various limitations in dentin bonding materials which are related to polymerization shrinkage. For resin bonding the root canal system has an unfavorable geometry (Tay, 2005).

Table.1 The mean values (MPa) for the shear bond strengths of studied groups

Group	Composite	Number	Average	SD	*P*-Value (Kruscal wallis)
Physiological Serum	P90	10	23.98	5.61	0.006
	Z100	10	18.47	11.46	
	Z350	10	34.49	14.24	
Chlorhexidine	P90	10	25.31	9.41	0.016
	Z100	10	27.38	19.07	
	Z350	10	42.26	13.02	

Table.2 Interactions of factors including the physiological serum and chlorhexidine

No	Composite	Factor	Number	Average	SD	P-Value (Mann-Whitney)
1	P90	Serum	10	23.98	5.61	0.704
2		Chlorhexidine	10	25.31	9.41	
3	Z100	Serum	10	18.47	11.46	0.217
4		Chlorhexidine	10	27.38	19.07	
5	Z350	Serum	10	34.49	14.24	0.219
6		Chlorhexidine	10	42.26	13.02	

In addition, deterioration of the resin bond with time is another restriction (Hashimoto, 2000, Hashimoto, 2001). On the other hand, the completeness of resin infiltration into the demineralized dentin is one of the most important elements in the strength and stability of the resin dentin bond.

It is worthy to note that chlorhexidine is a metalloproteinase (MMP) inhibitor that can arrest degradation of the hybrid layer, since fluid movement between the hybrid layer and unaffected dentin speeds the degradation of the bond if the resin does not completely infiltrate (Pashley, 2004; Suppa, 2005). Chlorhexidine is a broad spectrum antiseptic with pronounced antimicrobial effects and has been shown to be effective in reducing cariogenic bacteria and the use of chlorhexidine, even in very low concentrations, strongly inhibited the inherent collagenolytic activity of mineralized dentin (Hebling, 2005).

As mentioned before, this study showed that chlorhexidine application in concentrations of 2% before acid etching affect on the strength of dentin bonding system. Regarding the other related studies the use of chlorhexidine after acid-etching, initial bond strengths is comparable to those of the controls (Soares, 2008). The beneficial effects of chlorhexidine on the preservation of dentin bond strength as an MMP inhibitor when applied before bonding and without further rinsing was established by Carrilho et al (2010). In this case, the naked collagen fibrils were exposed to chlorhexidine that was then sealed into the fibrils by adhesive resins, leading to better preservation of the collagen fibrils (Soares, 2008).

In contrast, the results in this study are contrary to the results obtained by Shafiei et al (2010) which claimed that although chlorhexidine 2% does not have any effect on self-adhesive cement, but it can diminish the loss of bonding effectiveness over time associated to etch-and-rinse and self-etch cements. In the mentioned study chlorhexidine 2% did not affect the bond strengths of three resin cements including Panavia F2.0, Variolink II, and RelyX Unicem after 24 h.

The combination of composite resins and the ability to bond to dentinal surfaces have forever changed the way that restorative dentistry is practiced. Dentin tubular pattern, region of dentin, presence of smear layer and erosion-abrasion can influence the bond strength of adhesive systems on dentin (Campos, 2009). Furthermore, dentin surface preparation, dentin age, measurement techniques such as the mode of load application, material properties such as elastic modulus, and also the size of the specimen tested are the most important factors in the differences between bond strength values found in the dental literature (Van Noort, 1991).

In the serum group there were significantly different results among Z100, Z350 and P90 composites. The results showed that the bond strength of Z 100 was lower than Z 350 and P90 (*P*-value <0.05). Z100 as a hybrid composite possesses an average particle size of 1 µm. The average size of the ground glass particles ranges between 0.01 µm and 3.5 µm and it takes up about 66% by weight of the total filler loading. On the other hand, Z350 composite is a nano hybrid composite with an average particle size of 0.6- 10 µm and its total filler loading is 63.3%. Both of these composites are bonded to dentin using the same bonding agent from the fifth generation. The only difference between these composites is related to their filler characteristics. On the other word, it seems that smaller fillers and the presence of a superior polymer matrix coupled with a favorable combination of aggregated zirconia-silica cluster filler with highest density have positive effect on the bond strength of Z350. Different bonding agents generation is the main reason of variety between Z100 (5^{th} generation) and P90 (6^{th} generation).

Conclusion

Within the limitations of this study, the use of chlorhexidine 2% before acid etching was more effective as a compared with those of the controls. Analysis of the present data indicates that chlorhexidine 2% application as an antimicrobial agent has no negative effect on the bond strength of resin to dentin. Additionally, further studies need to be conducted to analyze the effects of different concentration of chlorhexidine solutions, the association of these solutions to self-etching adhesive systems and the influence of chlorhexidine application on bonding stability over time.

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