Original Article

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Comparison of Effect of C-Factor on Bond Strength to Human Dentin Using Different Composite Resin Materials

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ABSTRACT

Background: The study was planned to assess the use of low shrinkage composites for restoring cavities with high configuration factor (C-factor) which are subjected to high stresses.

Aim: The aim of the study was to evaluate the effect of C- factor on tensile bond strength to human dentin using methacrylate based nanohybrid and low shrinkage silorane composite.

Materials and Methods: In this study 40 non carious human molar teeth were selected and assigned into two main groups - cavity (Class I cavity with high C-factor) and flat group (flat surface with low C-factor). Two different composite materials-methacrylate based and silorane low shrinkage composite were used to restore the teeth. Dentin surface was treated, adhesive application was done and composite was applied as per manufacturer's instructions. Samples were stored in distilled water then subjected to tensile bond strength measurement using universal testing machine.

Results: Statistical analysis was done using Independent sample t-test. The mean bond strength in methacrylate based and silorane composite was significantly higher in flat preparation (Low C-factor) than cavity preparation. The mean bond strength in both cavity (High C-factor) and flat preparation(Low C-factor) was significantly higher in silorane than in conventional methacrylate based composite.

Conclusion: The bond strength of composites to dentin is strongly influenced by C-factor and type of composite resin material used.

Keywords: Bonding, Configuration factor, Polymerization, Shrinkage stress, Silorane composite, Tensilebond strength

INTRODUCTION

Composites are most popular aesthetic restorative material used in dentistry but the major drawback is polymerization shrinkage which leads to undesirable clinical effects. C-factor is an important clinical consideration with regard to polymerization shrinkage, as it has implications on bond strength and bond integrity [1,2]. Studies have shown that with increase in C-factor the bond strength decreases [3,4]. Since there are few studies published in literature evaluating the effect of C-factor on bond strength of low shrinkage composite like silorane, the present study aimed at comparing the effect of C-factor on bond strength of methacrylate based and low shrinkage composite to human dentin.

MATERIALS AND METHODS

The present study was conducted in Department of Conservative Dentistry and Endodontics at Sri Sai College of dental surgery, Vikarabad in 2013. A total of 40 intact, non carious human molars which were extracted for periodontal reasons were selected for the study. They were subsequently debrided and examined to ensure that they were free of defects. They were stored in saline and used within 2 months. The occlusal surfaces of these teeth were ground using a diamond disc until all the occlusal enamel was removed. The prepared teeth were embedded into self-cure acrylic resin such that crowns were exposed.

The teeth were randomly assigned into two main groups: cavity group and flat group. The cavity group represented a high C-factor group with Class I cavities and flat surface group represented a low C-factor group with flattened dentin surfaces. For high C-factor groups, Standardized class I occlusal cavity prearations (length: 4mm; width 4 mm; depth 2.5 mm) were made in each tooth with diamond burs using high speed contra angled hand piece. For low C-factor groups, flat dentin surface was exposed.

In each group samples were again sub divided into 2 groups. Two different types of composite resin materials were used in the study, Tetric N-Ceram representing methacrylate based composite and Filteksilorane representing low shrinkage composite. A total of 4 groups with 10 samples each were formed depending on type of cavity configuration and type of composite used.

Group A– Cavity group restored with methacrylate based composite (Tetric N-Ceram).

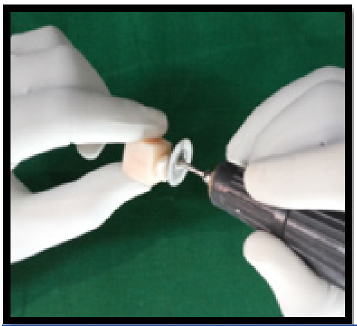
Group B – Flat group restored with methacrylate based composite (Tetric N-Ceram).

Group C – Cavity group restored with low shrinkage composite (Filtek Silorane).

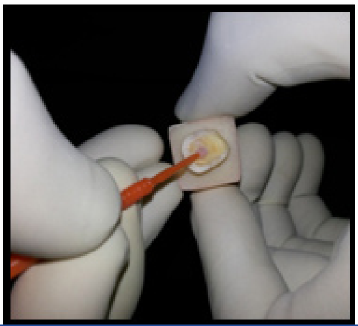
Group D – Flat group restored with low shrinkage composite (FiltekSilorane).

In Group A and Group C – The adhesive application was done in the respective groups as per the manufacturer's instructions.A ligature wire of 26 gauge was taken and one end was twisted and at other end loop was formed. The twisted end was inserted inside the uncured resin. The composite resin was then light cured using LED light curing unit according to the manufacturer's instructions. Following complete curing the adjacent tooth structure which formed the cavity walls was carefully removed using diamond burs under profuse water cooling, finally leaving a resin block with twisted wire bonded to the dentin surface.

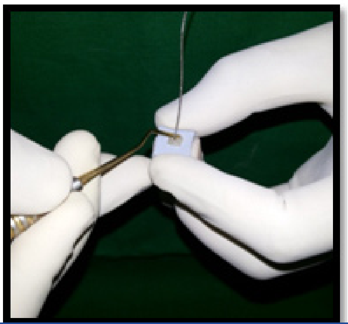
In Group B and Group D- A hollow polyvinyl mould having dimensions similar to that of class I cavity was held on adhesive treated flat surface of specimen and respective composite resin for each group was placed inside the customized mould and condensed. A ligature wire of 26 gauge was taken and one end was twisted and at other end loop was formed. The twisted end was inserted inside the uncured resin. The composite resin was then light cured using a LED light curing unit as per the manufacturer instructions.



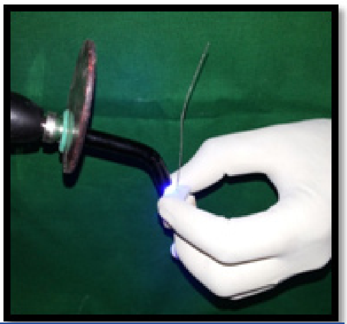
[Table/Fig-1]: Flat Dentin surface exposed



[Table/Fig-2]: Adhesive application

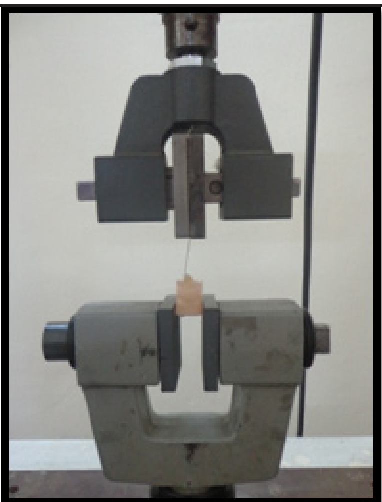


[Table/Fig-3]: Composite packing in mould



[Table/Fig-4]: Light curing

[Table/Fig-5]: Prepared samples



[Table/Fig-6]: Testing bond strength on Universal testing machine

Following complete curing the customized mould was cut and removed leaving the resin block with twisted wire bonded to the dentin surface as shown in the figures [5] [Table/Fig-1-6]. The mould was reused for making other specimens in the same way. A few specimens that showed spontaneous bond failure during removal of mould were discarded and not used in the study.

All the specimens were stored by immersing in water for 24 hours and then subjected to tensile bond strength measurement using an Instron universal testing machine (at Central institute of plastics engineering and technology, Hyderabad) at a cross head speed of 0.5mm/min. The values of bond strength were obtained in MPa. The mean tensile bond strength for each group was calculated and the results were tabulated and statistically analysed using Independent sample t-test.

STATISTICAL ANALYSIS

The statistical analysis was done using SPSS version 17. A p-value of <0.05 was considered statistically significant. Comparison of bond strengths of methacrylate based and silorane composite resin, flat and cavity groups was done using independent sample t-test.

RESULTS

The mean tensile bond strength in methacrylate based (Tetric N Ceram) and Silorane (Filteksilorane) composite was significantly higher in flat surface preparation (Low C-factor) than cavity preparation (High C-factor). The mean tensile bond strength in both cavity (High C-factor) and flat preparation (Low C-factor) was significantly higher in silorane (Filteksilorane) than in methacrylate based composite (Tetric N Ceram) [Table/Fig-7,8].

		Preparation		p-value
		Cavity	Flat surface	
		Mean±SD	Mean±SD	
Composite	Tetric n ceram (methacrylate based)	13.02±2.24	15.89±2.70	0.019; sig
	Silorane (low shrinkage)	19.73±1.82	21.87±2.76	0.05; sig

[Table/Fig-7]: Independent sample t-test for different types of composites

		Composite		p-value
		Tetric n ceram (methacrylate based)	Silorane (low shrinkage)	
		Mean±SD	Mean±SD	
Preparation	Cavity Flat	13.02±2.24	19.73±1.82	<0.001; sig
	surface	15.89±2.70	21.87±2.76	<0.001; sig

[Table/Fig-8]: Independent sample t-test for different types of cavity configurations

DISCUSSION

With the recent improvements in physical, mechanical and aesthetic properties, composites are able to meet the increased demands as choice of restorative materials for aesthetic and functional restoration of anterior as well as posterior teeth [6]. Despite remarkable developments, one of the inevitable drawbacks of composites is shrinkage during free radical polymerization which may be as high as 3% by volume [7,8]. This polymerization shrinkage causes clinical failures of composite resin restorations like poor marginal adaptation, microleakage, secondary caries and cuspal deflection which may result in postoperative sensitivity.

Bonding of restorative material to tooth structure should eliminate any gaps if present. Good adhesion between composite resin and dentin is a crucial factor in increasing the life of restoration. Bonding of composite resins to dentin is influenced by various factors such as cavity configuration, dentin depth, curing behaviour of composites, type of adhesive system and type of composite material. The shrinkage stress generated during curing influences the marginal integrity of the restoration and is in turn affected by the C-factor [9].

C-Factor is considered to be an important factor that can affect the developing stresses when cavities are restored with resin composite materials. Feilzer et al., defined it as ratio of bonded to unbounded surface of restorations [1]. Whenever the configuration factor is high it means that bonded surfaces are more. The reduction of free surface area limits the flow of the shrinking composite material, depriving the materials ability to change its shape and restrict relaxation of developed stresses. In addition, the shrinking materials will pull the opposing walls of cavity closer together, thereby increasing the stresses generated at the bonded walls, ultimately affecting the integrity and bond strength at the interface of restoration and cavity wall [1,2]. So in the present study two different cavity configurations were considered for comparison, a class I cavity representing high C-Factor (5) and flat surface representing low C-Factor (0.2).

Conventional composites like Tetric N Ceram have methacrylates in their composition which upon polymerization cause significant amount of volumetric shrinkage during curing. Recently a low shrinkage composite commercialized as Filtek silorane (3M ESPE) was introduced. The term Silorane hybrid derives from combination of its chemical building blocks that contain siloxane and oxirane structural moieties, which open up on polymerization to bond to other monomers. The polymerization of silorane composite is brought about by oxirane ring opening that causes volumetric expansion, this to some extent compensates the shrinkage that occurs during bonding [10]. Weinmann et al., compared silorane composite with four methacrylate based composites Filtek Z250, Filtek P60, Tetric ceram, Spectrum TPH and confirmed that silorane based commercial composite showed less than 1% of total volumetric shrinkage compared to 2-2.5% for BisGMA based composites [11,12]. So in the present study two different composite materials were used for comparison namely Filteksilorane representing low shrinkage composite and Tertic N Ceram representing a methacrylate based nanohybrid composite.

The results of the present study showed that tensile bond strength of the cavity group measured were 13.02 and 19.73 MPa for methacrylate based and silorane composite against the flat group which was 15.89 and 21.87 MPa for methacrylate based and silorane composite respectively. Statistical analysis showed that tensile bond strength of flat group was significantly higher than cavity group irrespective of type of composite used which clearly indicates that C-factor has played a major role in influencing the tensile bond strength. These findings were in conformity with the studies conducted by Yoshikawa et al., Choi et al., Shirai et al., Armstrong et al., where the effect of cavity configuration on bond strength of two resin composite in different cavity configurations was evaluated and revealed that bond strength decreases with an increase in C-factor [3,7,13,14]. Another factor which can also reduce the bond strength is dentin depth. Deep dentin has high water content than superficial dentin due to larger diameter and number of tubules per unit area. This water may dilute the organic solvents of some bonding systems, causing monomers to leave the soluble phase and form resin globules in water. As deeper cavities are prepared, both cavity configuration and effect of dentin depth may combine to result in lower bond strengths to the cavity floor [3].

The results of the study also reveals that there was a statistical difference in mean bond strength between two types of composite resin materials i.e., bond strength in both cavity and flat preparations was significantly higher in low shrinkage composite (Filteksilorane) compared to methacrylate based composite (Tetric N Ceram). This is attributed to the reason that epoxy ring opening of the silorane composite during polymerization produces volume expansion, which can partially offset the contraction resulting from simultaneous formation of covalent bonds and the reduction in space between adjacent molecules [11,15-17]. Additionally, in contrast to radical polymerization reaction that forms parallel chains and significant reduction in volume with increased chain length, the cationic ring opening polymerization of a multifunctional monomer such as silorane results in a network formation that is accompanied by minimal reduction in volume [11,16].

Similar results have been reported in a study by Annelis van Ende et al., where the tensile bond strength of silorane composite was found To be higher when compared with methacrylate based composite Filtek Z100 [18]. In another study by Annelis van Ende et al., it was found that the bond strength of low shrinkage composite was much better when layering technique was used especially in cavities with high C-factor [19]. Contrary to the above study, El- sahn et al., in his study compared the microtensile bond strength of low shrinkage composite (Filteksilorane) with methacrylate based composite Filtek Z250 and found that an increase in C-factor did not decrease the bond strength of low shrinkage composites [20]. This can be explained by the fact that low shrinkage composites revealed less shrinkage stress, and this can be attributed to the difference in composition and chemistry of its polymerization reaction [21].

LIMITATIONS OF THE STUDY

However, the study has certain limitations like size of the sample, thermocycling of the prepared samples was not done and only two different types of composites and two different types of cavity configurations were compared. Therefore further studies should be conducted comparing more than two different types of composite resins, cavity configurations and composite placement techniques.

CONCLUSION

So from the present study it was concluded that the cavity configuration and type of resin composite could strongly influence the tensile bond strength to the dentin of cavity walls. Thus when a composite restoration is planned, one must investigate the effects of cavity configuration factor, dentin depth, method of placement, curing behaviour of composite and type of composite being used on bond strength to expedite the interpretation of nature of adhesion within the prepared cavity. Therefore from present study it can be considered that low shrinkage composites can be a definitive alternative for restoring cavities with high C-factor by counteracting the deleterious effects.

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