Effect of Water Storage on Marginal Adaptation of Different Flowable Composite Restorative Systems Bonded to Dentin Cavities

ShimaaAbd El-Kader Mahsoub, Salah Hassab Mahmoud**, Ashraf Ebrahim***and FatmaAbdallahElerian*****

Abstract:

Objectives: The current study aimed to evaluate & compare the effect of water storage on marginal adaptation of different flowable resin composite restorative systems bonded to dentin cavities.

Materials and Methods: Six different flowable composite restorative systems were used in the current study. A total of 120 human molars was mounted in a small block of a self cure acrylic resin material, The buccal enamel was removed to expose flat dentin surface. A standardized cylindric class V cavities were prepared.The cavities were randomly divided into six groups each n=20, according to the composite restorative system used.Marginal adaptation was evaluated immediatelyand after 6 months of water storage, using a metallographic microscope.

Results: There was a statistically significant difference between the marginal values of tested groups. No significant difference between the marginal values immediately and delayed of tested groups.

Conclusion: Ormocer-based system revealed the bestmarginal adaptation at all testing times.water storage has a negative effect on marginal adaptation of all tested restorative systems.

Introduction

Marginal adaptation still a genuine problem in clinical dentistry that affects the longevity of adhesive restorations. It is obvious that the higher the percentage of continuous margin, the better is the adhesion, thus reflecting quality of adhesive technique and increasing reliability.[1]

The life expectancy of a resin restoration depends on optaining a stress-resistant adhesion between the tooth and restoration. Although composite restorative materials have improved during the past decade, polymerization shrinkage remains their major disadvantage.[2]

Most direct restorative composite have putty like consistency which is desirable for many clinical situations but it have a relatively high modulus of elasticity, high stiffness and consequently increased contraction stress during polymerization. This can lead to either bond failure or fracture of the tooth structure, resulting in microleakage, so there is a need to have a less viscous composite resin for better adaptability with the cavity walls. For this reason, "flowable composite resins" was introduced.[3]

In spite of, their various mechanical properties such as flexural strength and wear resistance have been reported to be generally inferior compared to those of the conventional composites.[4,2], some authors have theorized that because of the low modulus of elasticity and high wettability of flowable composites make this kind of material absorb the shrinkage stress during the polymerization, and thus can act as a stressbreaker and increases their ability to flex with a tooth than stiffer materials, making them suitable to be used with class Class V restorations, and the increased bond strength presented by the flowablecomposites, there may be less polymerization shrinkage.[5]

Bonding of resin composites to acid etched enamel is a well established clinical procedure, while bonding to dentin is far more complex and less reliable.[6,7]Currently developments in chemistry of the adhesives have led to high bond strength capacity with dentin and to restorations with better marginal sealing.[8,9]However laboratory tests have indicated that even after these improvements, the adhesives failed to provide gap free restorations.[10]

MATERIALS AND METHOD

Six light- activated flowable composite restorative systems, shade A2 were used in this study. These materials were ormocer-based composite restorative system (Admira fusion flow/ Admira bond, Voco), a high filler-loaded flowable universal nano-hybrid composite (Grandio flow/ Futura bond M , Voco) , a self adheringflowable composite (Vertise flow, Kerr), a highly filled flowableccomposite (G-aenial flow/G-aenial bond, GC-Amerian), a bulk fill flowable resin composite (Surefil SDR flow/prime&BonduniversalTM, Dentsply), (Filtek Z350XT flow/ Adper single bond, 3M ESPE). Bonding and handling of these systems were carried out according to manufacturer's recommendations.

A total of 120 Sound freshly extracted human molars mounted in a small block of resin material so that it can be held easily, The buccal enamel was removed with a hard tissue microtome (Leica SP 1600), to expose flat dentin surface A standardized cylindric class V cavities were prepared on flat dentin surfaces of all the selected teeth using a #256 tugsten carbide bur (Brasseler USA, Savannah, GA, USA) mounted on a high speed hand piece (SironaT3, Bensheim, Germany) under copious water spray. The preparation will be 3.5mm in mesio-distal diameter, 2mm in occluso-cervical diameter and approximately 1.5mm in depth. Teeth were randomly divided into six groups each of 20 tooth, according to type of flowable composite restorative system used. Marginal adaptation of all teeth of each group n=20 was evaluated immediately after polymerization and after 6months of dark storage in water at 37˚C. Examination of the restoration margins was perfomed under metallographic microscope (Zeiss Axiotech 30 optical microscope) equipped with a

digital video camera (Axiocam, ERc5s) and image analysis software at 200X magnification.

RESULTS

regardless of the type of composite system used and time of examination either immediate or delayed, no statistically significant difference were found between these frequencies (*P* value >0.05).

Regarding other tested parameters (MG, DM, MI), one way ANOVA test showed that there was a statistically significant difference among the tested groups (P<0.001) immediately after polymerization and after 6months , post-hoc tukey test showed that Admira fusion flow exhibited the lowest value of marginal gap width followed by Vertise flow with no statistically significant difference between them, followed by Grandio flow and G-aenial flow and also no statistically significant difference between them, followed by SDR flow, while Z350XT exhibited the highest value of marginal gap width.

Regarding the effect of water storage, the ***Student's t-test(Paired)*** showed that there was no statistically significant difference between the tested parameters immediately after polymerization and after 6 months of water storage (P>0.05).

Table 1: Results of immediate and delayed marginal index of tested composite restorative systems MI (MG*DM)/100

	Admira fusion flow	Grandio flow	Vertise flow	G-aenial flow	SDR-Flow	Z-350XT Flow	P^g
Immediate	.83±14 [a]	1.41±31 [b]	.90±21 [a]	1.59±34 [b]	2.17±37 [c]	3.96±40 [d]	<0.001*
6 Months	.89±.08 [a]	1.62±.38 [b]	1.02±.17 [a]	1.79±.30 [b]	2.36±.24 [c]	4.23±.52 [d]	<0.001*
P^t	0.066	0.07	0.064	0.058	0.065	0.067	

Data expressed as mean±SD

SD: standard deviation P:Probability significance when <0.05

Test used: One way ANOVA followed by post-hoc tukey for P^g (different letters indicate significant difference between groups)& Student's t-test(Paired) for P^t

Fig(1) Micrograph showing MG width of Admira fusion flow

DISCUSSION

Marginal adaptation still a genuine problem in clinical dentistry that affects the longevity of adhesive restorations. It is obvious that the higher the percentage of continuous margin, the better is the adhesion, thus reflecting quality of adhesive technique and increasing reliability.[1]

Water has an important role in the chemical degradation of composite materials, resulting in both hydrolytic reactions and swelling of the material. In that respect, the water sorption and solubility behaviour of composite materials and its effect on marginal adaptation is of great interest. Water uptake in composite materials mainly takes place in the resin matrix.[11]

In the present study, the wall-to-wall polymerization shrinkage was measured directly using optical microscopy. This method is preferred over using scanning electron microscopy on replicas of cast specimens because it is much simpler and quicker. In addition, this method of evaluation was made directly on the original specimen, not on replicas.It eliminates impression, casting, and high-vacuum arti-facts associated with the replica technique.[12]

The results of the present investigation showed that no tested composite/adhesive systems exhibited complete gap-free restorations.This could be due to high polymerization shrinkage of flowable composites, all the low-viscosity resins contain TEGDMA. The presence of this diluent monomer favours the reduction in viscosity that characterizes the material, on the other hand, higher concentrations of these monomers have a negative effect on polymerization shrinkage because of the smaller size of the molecule. And bonding of restorative systems to dentin which has considerably high organic content, the wet tubular microstructure, and the presence of a smear layer

have been too unfavorable.This is in agreement with other studies.[1,2,13]

Among the studied composite systems,methacrylate- based nanofilledflowable composite restorative system showed the lowest frequency of gap free restorations, which may be attributed to the resin matrix composition that affects polymerization shrinkage as well as the low bonding efficiency of its adhesive. In addition, high concentration of diluent monomer (TEGDMA)in the resin matrix may also affect shrinkage. It was reported that higher TEGDMA/bis-GMA ratios in methacrylate-based composites resulted in higher contraction stress values due to increased volumetric shrinkage, as a result of enhanced conversion, this coincide with previous syudy[14]

On the other hand, the ormocer-based restorative system, showed the highest frequency of gap free restorations, this could be attributed to the larger size of monomer molecule of ormocer-based systems that may reduce polymerization shrinkage resulting in a higher frequency of gap free restorations compared with the methacrylate-based systems. These findings coincide with the results of a previous study.[2,15]

Also the self-adhering systemshowed comparable results to ormocer-based system This finding may relate to the chemical composition, adhesive's technology of the self-adhering flowable composite resin restorative material with GPDM to etch dentin, HEMA bonding agent, and featuring nano-sized amorphous silica and glass fillers. Its sole formula is both hydrophilic and of low pH value. This resin bonds chemically and micromechanically to the tooth structures. the chemical bond is between the phosphate groups of a GPDM monomer and micromechanically, it is between the polymerized monomers of the self-adhering flowable composite resin and the collagen fibers and smear layer, they become incorporated into the dentin surface, enhancing both dentin bonding and sealing ability.as showed in previous studies.[16,17]

After 6 months of water storage, no significant change in the frequencies of GF restorations for all tested composite restorative systems, this could be due to the hygroscopic expansion was not enough to compensate for polymerization shrinkage. These findings coincide with the results obtained from a previous studies.[2,18,19] that investigated polymerization shrinkage and hygroscopic expansion of contemporary posterior resin based filling materials and reported that shrinkage was not compensated by hygroscopic expansion. On the other hand these findings disagree with other studies[20,21]reported that water sorption causes gap reduction by hygroscopic expansion seen in the scanning electron microscope (SEM) as the volume increased, and disagree with another study[11] that showed an increase in water sorption, which was clearer with methacrylate based composite restorations, chemical reaction between filler particles and water can result in mass increase of the dental composite material.

Regarding the other determined marginal adaptation parameters(MG, DM and MI). The ormocer-based, self adhering composite restorative system gave the best results at all testing periods, followed by the highly filled composites (Grandio, G-aenial), followed by SureFill SDR while the methacrylate-based (z350XT) exhibited the worest. This is probably because of the unique low shrinking matrix of ormocer composite material, lower modulus of elasticity(ME) of ormocer –based, self adheringflowable composite than that of the highly filled composies(Grandio, G-aenial), this low (ME) allow the material toflow during polymerization and compete with the stress development, helping to maintain the marginal seal of the restoration. These findings coincide with the results obtained from a previous study.[22] In addition to the hydrophilic monomers of self-adhering flowable composite that enhances its wettability to dentin surface and ensure bonding with hydrated dentin surface, subsequently improves its marginal adaptation.Our findings reach agreement with other laboratory study[23] that revealed that the self-adhesive flowable composite revealed superior sealing ability under aging condition.On the other hand these findings not agreed with previous study[24] that reported when Comparing to the control group, Dyad Flow showed lower bond strength to median dentin.

High filler loaded systems showed higher values of (MG, DM, MI) compared to ormocer –based, self adhering systems, this may be attributed to high ME, increased its viscosity thus impair its ability to flow during polymerization, which may lead to marginal discrepancies and subsequent microleakage. This is in agree with Peutzfeldt and Asmussen et al,[25] showed that the increased fluidity of composite resin makes it to adhere better to the cavity wall.

After 6 months of water storage, there was no significant difference between results of the MG width, DM, and MI. Although all tested systems not significantly affected by water storage, the ormocer composite system provided the least affected system. The relatively high stability of ormocer-based restorations compared with methacrylate-based ones could be attributed to the large size of monomer molecules of ormocer composite that reduces polymerization shrinkage and at the same time reduces leaching of the monomers.Ormocers have a different matrix but share similar filler particles and a coupling mechanism with conventional composite resins.This was in accordance with the previous studies[26,2]

On the other hand these findings not agreed with another study formed by A.U.J.YAP et al,[27] that found a decrease in marginal gap widths over time with most materials, this could be due to difference in water storage time, the examination of maximum marginal gap width between the material and the dentine wall was determined at 24 h, 1 week, 2 weeks, 3 weeks and 4 weeks, but in the present study MG width was determined immediately after polymerization and after 6 months of water storage and the materials used were different from that used in the current study.

Since marginal adaptation with dentin was significantly affected by the type of restorative system and was not significantly affected by water storage, we could partially reject the null hypothesis. Although the results obtained from this study may not be directly extrapolated to the clinical situation, they provide some information regarding the performance of the restorative systems evaluated.

Conclusion

Ormocer-based system revealed the bestmarginal adaptation at all testing times.water storage has a negative

effect on marginal adaptation of all tested restorative systems.

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