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Improving Composite Resin Performance Through Decreasing its Viscosity by Different Methods

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Abstract: The aim of this work was to present the different current methods of decreasing viscosity of resin composite materials such as (using flowable composites, lowering the viscosity of the monomer mixture, heating composites and applying sonic vibration) and furnish dentists with a basis that can provide criteria for choosing one or another to suit their therapeutic requirements. The four discussed methods proved that lowering composite viscosity improves its handling and facilitates its application to cavities with complicated forms, decreasing time for procedure and improving marginal adaptation. Other properties improved by decreasing composite resin viscosity were controversial between the four methods and affected by other factors such as composite brand and light cure unit.

Keywords: Improving properties, low viscosity, resin composite.

1. INTRODUCTION

In the last decade, growing demands by patients for mercury-free, esthetic restorations have markedly increased the use of direct, light-activated resin composites in restorative dentistry [1].

A major drawback of current composite-based resins is that they contract or shrink during conversion from monomer to polymer. The resin matrix of all composite- based resin restorative materials shrinks volumetrically approximately 10 percent during polymerization [2]. This polymerization shrinkage stresses the adhesive between the tooth and the restorative material, frequently resulting in failure of this bond and marginal infiltration [3].

These problems have activated producers to find solutions and to make either the material or the technique easier to apply and faster to use. The effect of lowering viscosity to improve adaptation of the composite and to improve ease of placement has been shown to be important [4].

Compared with conventional composite resins, these new composite resins with low viscosity boost few advantages: easily applicable to cavities with complicated forms, time required for the filling procedure is short, and excellent in cavity sealing [5, 6].

1.1. Flowable Composites

One of the methods used for decreasing composite viscosity is the development of flowable resin composites. Flowable resin composites; being less viscous material improve the wettability by flowing onto all prepared surfaces creating an intimate union with the micro structural defects in the floor and the walls of the cavity preparation. Moreover, they act as a flexible intermediate layer that helps to relieve stresses during polymerization shrinkage of the restorative resin. These characteristics and a syringe delivery system make them an ideal choice for the use as a liner [7, 8]. Flowable composites achieve their lower viscosity primarily by a reduction in reinforcing filler content and changes in the matrix chemistry [9, 10]. However, it is well known that a decrease in filler content will affect various properties of a hardened composite resin, such as the mechanical strength and curing shrinkage [11]. Against this background, it is important to investigate how to lower the viscosity of a composite resin without decreasing its filler content [12]. Thus far, the most uncomplicated method of decreasing the viscosity of composites is to lower the viscosity of the monomer mixture itself.

1.2. Lowering Monomer Viscosity

The base monomer most widely used commercially is BisGMA (bisphenol A diglycidil dimethacrylate; MW=512 g/mol. Despite its high intrinsic reactivity, the presence of hydroxyl groups on the backbone and the π-π interactions given by the aromatic rings increase the initial viscosity (η=1,200 Pa) to a point that the homopolymer typically does not reach high conversion [13]. For that reason, and also to improve handling characteristics and allow incorporation of higher inorganic filler contents, BisGMA is usually combined with low free viscosity monomers like TEGDMA (triethylene glycol dimethacrylate; MW=286 g/mol, η=0.01 Pa. However, addition of TEGDMA increases water sorption and polymerization shrinkage [14, 15]. To overcome these effects, studies have been directed toward developing low viscosity, more hydrophobic Bis-GMA analogs such as the hydroxyl-free propoxylated Bis-GMA (CH3Bis-GMA) and propoxylated fluorinated Bis-GMA (CF3Bis-GMA), as replacements for TEGDMA in Bis-GMA mixtures [16, 17]. Also, in an attempt to improve properties of methacrylate resins, aldehyde-propanal (propionaldehyde) or diketone-diacetyl (2,3-butanedione) have been added as potential crosslinking agents with appreciable success [18, 19].

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1.3. Heating Composite

Many polymer resins exhibit lower viscosity when they are heated. The theoretical basis for this behavior is that thermal energy forces the composite monomers or oligomers further apart, allowing them to slide by each other more readily. Studies have shown that heating general polymers and resin composites lowers viscosity and thereby improves adaptation [20].

1.4. Sonic Vibration

A new method of restoration relies on more sophisticated instruments that condense the material by vibration. Such devices have been created by several producers and operate according to the same principle: sonic vibration .The principle of this technique assumes that vibration lowers the viscosity of the resin, allowing the material to flow and easily adapt to the cavity walls without air pores, in a similar way as a flowable composite. Thus, a condensable material with increased viscosity can be used similar to a flowable composite, without the disadvantage of high polymerization shrinkage and poor mechanical properties [21].

Our review aimed to disclose that if decreasing viscosity of resin composites through the four mentioned methods has an impact on the performance of the restoration by improving its properties.

2. MATERIALS AND METHODS

With the help of currently available literature, this paper attempted to point out four methods used for decreasing composite viscosity and their ability to improve its properties. The electronic database PubMed was searched for scientific articles on the four methods. The search was carried out between 2004 and 2014 to represent the latest developments in the last 10 years.

The search words low viscosity, flowable composite, low viscosity monomers, preheated composites and sonic vibration were used. The search was done for each method separately. Total 59 papers were selected out of 70 papers. The selection was done on the basis of papers that correlate the selected method of decreasing viscosity to its effect on the performance of restoration. The rejected papers discussed other aspects as well which are not related to the scope of the review. The results of selected studies were presented in Tables **1**, **2**, **3**, and **4**. The papers were listed in the tables with ascending arrangement according to the year of publication.

3. DISCUSSION

Today, improvements in formulations, optimization of properties and the development of new techniques for placement have made the restoration of direct composite more reliable and predictable. Producers tried to decrease the viscosity of dental composite to make either the material or the technique easier to apply and faster to use. Several solutions have been proposed to decrease composite viscosity.

3.1. Flowable Composites

The first way discussed in this review was; using flowable composite Table (**1**) [22-35]. The use of flowable resin composite as an intermediate layer liner when studied for occlusal, cervical and proximal restorations, showed different results. Some authors found this application improves the marginal seal, Olmez *et al.*, 2004 [22] concluded that; a composite lining in a Class II resin composite with margins below the cemento enamel junction may reduce marginal microleakage and voids in the interface and the total number of voids in the restoration. Sadeghi *et al.*, 2009 [28] also concluded that; a layer of flowable materials at the gingival floor of Class II composite restorations may be recommended to improve the marginal seal of a restoration. The same idea was supported by Simi *et al.*, 2011 [32] who concluded that; both resin-modified and flowable composite liners under nano composite restorations result in comparable reduction of micro leakage.

In contrast; others failed to show any benefits from using flowable composite as a liner. Tredwin *et al.*, 2004 [23] found use of a flowable composite liner against cementum/dentin was associated with increased micro leakage. Lindberg *et al.*, 2005 [24] and Pecie *et al.*, 2013 [35] found that the use of flowable resin composite did not rinfluence the interfacial adaptation. Van dijken *et al.*, 2011 [31] also concluded that; the use of flowable resin composite as an intermediate layer did not result in improved effectiveness of the Class II restorations.

Using liner under occlusal restoration was studied by Efes *et al.*, 2006 [26] who found that; the clinical performance of occlusal restorations did not benefit from the additional use of the flowable composite.

Using flowable composite as a liner in class V cavities was studied by Arslan *et al.*, 2013 [34] who stated that; micro leakage is not affected by the application of either conventional or new-generation flowable composite resin as an intermediate material between composite resin and dental substrates. Also, Loguercio *et al.*, 2005 [25] stated that; the use of Filtek Flow as a liner under Filtek Z250 restorations did not improve the clinical performance of class V restorations after 6 and 12 months of evaluation.

When performance of flowable resin materials in non-carious cervical lesions was studied; acceptable clinical performance (except for the retention rates of the Dyract Flow restorations) in non-carious cervical lesions was stated by Celik *et al.*, 2007 [27] with no significant differences were found between the flowable and microhybrid resin materials ($p > 0.05$). The same conclusion was recorded by Kubo *et al.*, 2010 [29] who found that: both types of resin flowable and hybrid resin composite in conjunction with S3 Bond demonstrated an acceptable clinical performance up to 3 years when applied to non-carious cervical lesions with no significant differences.

Clinical efficacy of two flowable composite resins used to restore occlusal caries lesions was investigated by Gallo *et al.*, 2010 [30] who observed that marginal discoloration, polishability and marginal adaptation significantly worsened at 36 months and he suggested that they should be limited to small restorations such as preventive resin restorations having isthmus widths of one-quarter or less of intercuspal distance. Bonilla *et al.*, 2012 [33] reached the same conclusion when they studied placing flowable composite as minimally invasive occlusal restorations. Their results showed that a

Table 1. Studies that investigated micro leakage and marginal adaptation of flowable composites.

First author + year	Site of resin application	Tested variables	Conclusion
Olmez, A [22] 2004	Class II composite restorations with the margins below the cemento-enamel junction as a liner	Marginal microleakage and internal voids	The use of flowable resin composites provided a reduction in marginal microleakage and a reduction in some parts of the internal voids or total voids
Tredwin, C.J [23] 2004	Class II cavities as aliner	Micro leakage	Leakage data do not support the use of flowable resin composite linings in Class II resin composite restorations
Lindberg, A [24] 2005	Class II resin composite restorations as a liner	Interfacial adaptation	Neither the use of flowable resin composite liner nor the curing used influenced the interfacial adaptation
Loguercio, A. D [25] 2005	Class V as a liner	Clinical performance over 1 year	The use of Filtek Flow as a liner under Filtek Z250 restorations did not improve the clinical performance of class V restorations after 6 and 12 months of evaluation.
Efes, B.G [26] 2006	Occlusal cavity as a liner	Two –year clinical performance	The clinical performance of occlusal restorations did not benefit from the additional use of the flowable composite.
Celik, C [27] 2007	Non-carious cervical lesions.	Two-year clinical performance	Different types of resin materials demonstrated acceptable clinical performance in non-carious cervical lesions.
Sadeghi, M [28] 2009	Class II as gingival liner	Micro leakage	The groups utilizing flowable liners had significantly less microleakage with no significant difference between utilizing flowable composite or flowable compomer
Kubo, S [29] 2010	Non-carious cervical lesions	Three-year clinical performance	There were no significant differences in the clinical performances between the hybrid and the flowable composite for each variable acceptable clinical performance up to 3 years.
Gallo, J.R [30] 2010	Occlusal as a restoration	Clinical efficacy	Marginal discoloration and marginal adaptation significantly worsened at 36 months.
Van dijken, J.W [31] 2011	Class II restorations as a liner	Long term clinical performance	The use of flowable resin composite as an intermediate layer did not result in improved effectiveness of the Class II restorations
Simi, B [32] 2011	Class II as a liner	Micro leakage	Both resin-modified and flowable composite liners under nanocomposite restorations result in comparable reduction of microleakage.
Bonilla, E.D [33] 2012.	Minimally invasive occlusal restorations.	Micro leakage	Using flowable composite in minimally invasive occlusal restorations might result in undue restoration pitting or degradation.
Arslan, S [34] 2013	Class V restorations as intermediate material	Micro leakage	Micro leakage is not affected by the application of either conventional or new-generation flowable composite resin as an intermediate material between composite resin and dental substrates
Pecie, R [35] 2013	Class II as a liner	Marginal adaptation	The application of flowable composite as a liner may not improve marginal adaptation and is product dependent.

conventional microhybrid composite material, leaked significantly less than all the flowable composite groups. Tiny microscopic bubbles were seen within many of the flowable composite specimens, as were a few voids.

3.2. Lowering Monomer Viscosity

The second discussed way for decreasing composite resin viscosity was decreasing monomer mixture viscosity (Table **2**) [36-42]. Most of the composite resins widely used in restorative dentistry contain the highly viscous monomer 2,2-bis [4-(2-hydroxy-3-methacryloxyprop-1-oxy) phenyl] propane (Bis-GMA) and low-viscosity monomers, used as diluents, in order to achieve high filler loading. In particular, triethylene glycol dimethacrylate (TEGDMA) has been extensively used for such purpose.

Studies have been directed toward developing low viscosity, hydroxyl free, more hydrophobic Bis-GMA analogs. Okamura *et al.*, 2006 [37] evaluated the dental application possibility of producing, experimental composite resins of low-viscosity monomer mixtures using low-viscosity

Table 2. Studies that investigated the decreasing viscosity through monomer changes.

First author + Year	Monomer change	Variables tested	Result
Pereira, S.G [36] 2005	Replace TEGDMA in Bis-GMA mixture with either CH3 Bis-GMA or CF3 Bis-GMA	Mechanical properties	The analogue CH3 Bis-GMA, which allows the preparation of medium-viscosity resins, is a good candidate to replace TEG-DMA in Bis-GMA mixtures.materials with CH3 Bis-GMA diluents showed an enhanced microhardness.
Okamura, H [37] 2006	Experimental composite resins of low-viscosity monomer mixtures of newly developed polyfunctional acrylates	Mechanical and physical properties	Mechanical (i.e., compressive, diametral tensile, and bending) strength of a polymer obtained from one new monomer mixture without fillers was similar to that of a bis-GMA/TEGDMA (2/1 weight ratio) based polymer. In terms of setting shrinkage, the composites consisting of new monomer mixtures exhibited significantly smaller shrinkage than the bis-GMA based composites, and decreased with increase in filler content.
Charton, C [38] 2007	co-monomer bis-GMA /TEGDMA (70/30 and 50/50 % and co-monomer UEDMA/TEGDMA (88.5/11.5 and 66.5/33.5 %)	Shrinkage stresses	The viscosities of the UEDMA bases were exactly the same as those of the bis-GMA ones. Shrinkage stress Statistically, there was a negative correlation between viscosity, Tg and shrinkage stress.
Prakki, A [39] 2008	Combining bis-GMA and TEGDMA, CH(3)bis-GMA or CF(3)bis-GMA, with aldehyde or diketone	Wear, roughness and hardness	The findings correlate with additives ability to improve degree of conversion of some composites/copolymers thereby enhancing mechanical properties. Bis-GMA/TEGDMA and bis-GMA/CH(3)bis-GMA copolymers with additives became smoother after abrasion test.
Prakki, A [40] 2009	Two additives, aldehyde or diketone,to Bis-GMA-based composites containing TEG-DMA, (CH_3Bis-GMA) or (CF_3Bis-GMA).	Mechanical properties	The ability of additives to improve degree of conversion of some composite systems thereby enhancing mechanical properties.
Denis, A.B [41] 2012	Bis-GMA diluted with CH3bis-GMA containing 0, 2, 8, 16 and 24 mol% propionaldehyde	Physical, rheological, and mechanical properties	24 mol% of Propionaldehyde significantly increased comonomer degree of conversion; Increased %DC is known to improve resin mechanical properties such as surface hardness
Prakki, A [42] 2012	Additives of Bis-GMA based copolymers andthat of TEGDMA, CH3Bis-GMA or CF3Bis-GMA.	Water sorption characteristics	Aldehyde and diketone led to increases in the water sorption characteristics of experimental resins.

monomer mixtures of newly developed polyfunctional acrylates. The viscosity of composite pastes with high filler content was markedly lower than that of Bis-GMA based composites. Compressive strengths of composite resins produced using the new monomer mixtures were similar to that of composite resin produced using Bis-GMA monomer mixture. In terms of setting shrinkage, the composites consisting of new monomer mixtures exhibited significantly smaller shrinkage than the Bis-GMA based composites, and decreased with increase in filler content. Such small setting shrinkage might be attributed to the relatively large volume of polyfunctional monomers and the relatively small intermolecular distance.

Pereira *et al.*, 2005 [36] investigated the influence of new diluent agents, diluent ratio and filler content, on relevant mechanical properties of several novel composite resins containing Bis-GMA as resin matrices, and to compare these with the properties of composites based on TEGDMA, a conventionally used diluent. Two Bis-GMA analogues were synthesized combining three monomer mixtures (Bis-GMA/TEGDMA, Bis-GMA/CH3 Bis-GMA and Bis-GMA/CF3 Bis-GMA). Materials with CH3 Bis-GMA showed an enhanced micro hardness VHN. Mean Flexural strength (FS) was higher for matrices containing TEGDMA. Overall, dilution favored FS and VHN but not modulus of elasticity ME.

Adding additives to the Bis-GMA monomer that decreased viscosity was studied by Prakki *et al.*, 2009 [40] where two additives, propionaldehyde/aldehyde or 2,3-butanedione/diketone, was added. Degree of conversion (DC %), flexural strength (FS), modulus of elasticity (E), modulus of resilience (R) and diametral tensile strength (DTS) were determined. Incorporation of additives led to an increase in DC%, FS and E for Bis-GMA/TEGDMA and Bis-GMA/CH (3) Bis-GMA systems. R-values for all systems were unaffected by addition of additives. They had no significant effect on DC% or mechanical properties of Bis-GMA/CF (3) Bis-GMA. Same conclusion reached by the same authors [39] when they tested wear, roughness and hardness as affected by the two additives and concluded that; incorporation of additives led to improved W and H values for bis-GMA/TEGDMA and bis-GMA/CH_3bis-GMA

Table 3. Studies that investigated the effect of preheating resin composites on micro leakage in class II and V, degree of conversion, mechanical properties, polymerization shrinkage, hardness and marginal adaptation.

First author + Year	Temperature	Variables tested	Results
Aksu, M.N [43] (2004).	130°C	Micro leakage in Class II composite	Preheating of the composite investigated resulted in significantly less micro leakage at the cervical margin compared to the control or the use of the corresponding flowable resin.
Darnoch, M [44] 2005	Between 3°C and 60 °C	Monomer conversion and duration of light exposure	Pre-heating composite prior to photoactivation provides greater conversion requiring reduced light exposure than with room-temperature composite.
Wagner, W.C [45] 2008	54.4°C	Micro leakage in Class II composite restorations	Preheating the composite resulted in significantly less micro leakage at the cervical margins compared to the flowable liner and control.
Walter, R [46] 2009	37°C, 54°C, or 68°C	Polymerization shrinkage	Preheating composite to relatively high temperatures (54°C or 68°C) to increase its flow and adaptation causes an increase in volumetric shrinkage
Lohbauer, U [47] 2009	Between 10°C. and 68 °C.	Degree of conversion	Pre-heating of resin composites does not increase degree of conversion over time. Polymerization shrinkage as a function of pre-heating temperatures exhibited a linear correlation after 5 min, but no statistically different behavior after 24 h.
Lucey, S [48] 2010	60 °C	Pre-cured viscosity and post-cured surface hardness	Pre-heating resin composite reduces its pre-cured viscosity and enhances its subsequent surface hardness.
Fróes-Salgado, N.R [49] (2010)	68 °C	Marginal adaptation (MA), degree of conversion (DC), flexural strength (FS), and polymer cross-linking (PCL)	The pre-heated composite showed better MA than the room-temperature groups. Composite pre-heating and energy density did not affect the DC, FS and PCL.
Tantbirojn, D [50] 2011	68°C	Hardness and postgel shrinkage	Preheating of the composites only slightly increased hardness values and did not negatively affect postgel shrinkage.
Deb, S [51] 2011	22 °C and 60 °C.	Flow and marginal adaptation	Pre-warming of the composites studied enhanced flow as observed by measuring film thickness and did not significantly affect other properties.
Dos Santos, R.A [52] 2011	23°C, 54°C and 60°C	Micro leakage in Class II cavities restored with dental composite	Preheating the resin composite did not improve the micro leakage means when high-irradiance LED was used; however, it decreased the micro leakage means when a QTH with low irradiance was used.
Nada, K [53] 2011	37°C and 54°C	Mechanical properties	Pre warming significantly improved surface hardness and bulk properties of the composites; however, this improvement was significant in only some of the tested materials.
Karaarslan, E.S [54] (2012)	37°C, 54°C and 68°C	Micro leakage in Class V cavities	No significant differences among the preheated groups.

systems, additives had no significant effect on the W and H changes of bis-GMA/CF_3bis-GMA, also concluded that; Bis-GMA/TEGDMA, bis-GMA/CH_3bis-GMA copolymers with additives became smoother after abrasion test.

The same conclusions was reached by Denis *et al.*, 2012 [41] who evaluated the physical, rheological, and mechanical properties of Bis-GMA diluted with CH3bis-GMA containing 0, 2, 8, 16 and 24 mol% propionaldehyde. It has been reported that the viscosity of propionaldehyde is 3 × 10–5 Pa.s and its incorporation into comonomers significantly lowers the viscosity of CH3bis-GMA-based resins. The present findings revealed that the incorporation of propionaldehyde into the experimental resins gradually increased % DC as the mol % of the additive increased.

Prakki *et al.*, 2012 [42] tested the effect of additives on the water sorption characteristics of Bis-GMA based copolymers and composites containing TEGDMA, CH3Bis-GMA or CF3Bis-GMA. Water sorption and desorption were evaluated in a desorption-sorption-desorption cycle. Water uptake (%WU), water desorption (%WD), equilibrium solubility (ES; µg/mm³), swelling (f) and volume increase (%V) were calculated using appropriate equations. All resins with additives had increased %WU and ES. TEGDMA-containing systems presented higher %WU, %WD, ES, f and %V

Table 4. Studies that investigated the effect of sonic vibration on depth of cure, marginal micro leakage, and mechanical performance.

First author + Year	Vibration device	Variables tested	Conclusion
Yapp, R [55] 2011	Sonic fill	Depth of cure of several composite restorative materials	Sonicfill is adequately cured at the maximum recommended depth when cured with the Demi curing light
Eunice, C [56] 2012	SonicFillTM (Kerr/Kavo	Marginal micro leakage in class v	SonicFill TM only has the advantage of better clinical handling, reducing labour time no influence in con-cerning microleakage
Ilie, N [57] 2013	SonicFill, Kerr;	Mechanical performance of seven bulk-fill RBCs	The significant highest flexural strengths were measured for SonicFill
Poggio, C [58] 2013	SonicFill (Kerr)	microleakage in "deep" Class II composite restorations with gingival cavosurface margin below the CEJ	Significant prevalence of Score 0 (no dye penetration) was reported both for Groups 4 (SonicFill) and 5 (Grandio),
Alrahlah, A [59] 2014	SonicFill™.	Depth of cure of bulk fill resin composites through using Vickers hardness profiles (VHN).	SonicFill exhibited the highest VHN SonicFill and Tetric EvoCeram Bulk Fill had the greatest depth of cure among the composites examined.

values, followed by resins based on CH3Bis-GMA and CF3Bis-GMA. Aldehyde and diketone led to increases in the water sorption characteristics of experimental resins.

Charton *et al.*, 2007 [38] showed different results about monomer viscosity when he investigated Influence of glass transition temperature Tg, viscosity and chemical structure of monomers on shrinkage stress in light-cured dimethacrylate-based dental resins. The large differences in stress values for the pairs with the same viscosity, showed that; it is not the viscosity in itself which has a dominating influence on stresses (via the DC). They concluded that; whatever the viscosity, the UEDMA-based matrices developed higher shrinkage stresses than the Bis-GMA homologues.

3.3. Heating Composite

The third discussed method in this review was preheating composite before photo activation (Table **3**) [43-54]. Chair side warming of composite resins before photo polymerization is one of the recent trends in their application.

Daronch *et al.*, 2005 [44] concluded that; pre-heating composite prior to photo activation provides greater conversion requiring reduced light exposure than with room-temperature composite. Different results were reached by Lohbauer *et al.*, 2009 [47] and Fróes-Salgado *et al.*, 2010 [49].

The first one concluded that; pre-heating of resin composites does not increase degree of conversion over time. It can be clinically beneficial, due to a superior marginal adaptation. The second one reached the same conclusion when he studied the effect of composite pre-polymerization temperature and energy density on the marginal adaptation (MA), degree of conversion (DC), flexural strength (FS), and polymer cross-linking (PCL) of a resin composite. He concluded that: Pre-heating the composite prior to light polymerization did not alter the mechanical properties and monomer conversion of the composite, but provided enhanced composite adaptation to cavity walls.

Deb *et al.*, 2011 [51] evaluated if pre warming of composites would influence the flow and enhance marginal adaptation and, he stated that; pre-warming of the composites studied enhanced flow as observed by measuring film thickness and did not significantly affect other properties.

Micro leakage as affected by preheating was discussed with two different points of view. The first one correlated composite preheating to the reduction in micro leakage in class II composite. Wagner *et al.*, 2008 45 and Aksu *et al.*, 2004 [43] supported this view, the first one compared micro leakage in Class II composite restorations prepared using: preheated resin composite, and unheated composite and found no statistical differences among materials at the occlusal margin. However, at the cervical margin, the preheated samples showed statistically lower micro leakage than the controls and all other treatments. The second study also stated that; preheating of the composite investigated resulted in significantly less micro leakage at the cervical margin compared to the control or the use of the corresponding flowable resin. The other point of view by Dos Santos *et al.*, 2011 [52] who found that; the decrease in micro leakage in Class II cavities restored with preheated dental composite happened when a QTH with low irradiance was used but, not improved when high-irradiance LED was used. Karaarslan *et al.*, 2012 [54] also tested the micro leakage as affected by preheating composite and found no significant differences among the preheated groups.

Mechanical properties and polymerization shrinkage for preheated composite were tested with varied results. Walter *et al.*, 2009 [46] studied whether temperature affects the polymerization shrinkage of composite resin and concluded that: Preheating composite to relatively high temperature 54c or 88 c to increase its flow and adaptation causes an increase in volumetric shrinkage. This result was opposed by Tantbirojn *et al.*, 2011 [50] who evaluated the effect of composite preheating and light-curing duration on hardness and postgel shrinkage and stated that; preheating of the composites only slightly increased hardness values and did not negatively affect postgel shrinkage.

Lucey *et al.*, 2010 [48] tested the pre-cured viscosity and post-cured surface hardness for the preheated composite and stated that; pre-heating resin composite reduces its pre-cured viscosity and enhances its subsequent surface hardness. This conclusion was supported by Nada *et al.*, 2011 [53] who found that the effect of pre polymerization warming on composites' mechanical properties, is material dependent; pre warming significantly improved surface hardness and bulk properties of the composites; however, this improvement was significant in only some of the tested materials.

3.4. Sonic Vibration

The last discussed method was sonic vibration (Table **4**) [55-59]. Up to now, little independent studies assessed the vibration technique, also some data offered by the producers of such devices being available.

Microleakage was investigated by two studies the first by Eunice *et al.*, 2012 [56] who stated that; the sonic system has no effect concerning microleakage. The second study by Poggio *et al.*, 2013 [58] on contrast proved that sonic fill composites showed the lowest microleakage values when compared with other groups tested micro leakage in "deep" Class II composite restorations with gingival cavosurface margin below the CEJ.

Alrahlah *et al.*, 2014 [59] studied post-cure depth of cure of bulk fill resin composites through using Vickers hardness profiles (VHN), they stated that SonicFill exhibited the highest VHN, also sonic fill and Tetric EvoCeram bulk fill had the greatest depth of cure among the composites examined. Ilie *et al.*, 2013 [57] also studied the mechanical performance of seven bulk-fill RBCs and he stated that; the significant highest flexural strengths were measured for SonicFill.

Yapp *et al.*, 2011 [55] found that; sonic fill adequately cured at the maximum recommended depth when cured with Demi curing light set to yield a saw tooth when used according to manufacturer's direction for use.

CONCLUSION

No benefits from the additional use of the flowable composite as a liner for interfacial adaptation and micro leakage. Lowering monomer viscosity by replacing TEGDMA in Bis-GMA/diluent mixtures with CH3 Bis-GMA, or CF3 Bis-GMA consequently improves degree of conversion DC, polymerization shrinkage (PS) and handling properties. Additives are able to improve degree of conversion of some composite systems thereby enhancing mechanical properties. Preheating composite reduces viscosity and increases flowability, which facilitates better adaptation to cavity walls; this reduces micro leakage and results in superior marginal adaptation. Condensation of composite resins can be faster achieved by using vibrating instruments. Vibration decreases the viscosity of the material and facilitates its flow within the preparation irregularities with better adaptation of the material to the cavity walls.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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