Microleakage and Shear Punch Bond Strength in Class II Primary Molars Cavities Restored with Low Shrink Silorane Based versus Methacrylate Based Composite using Three Different Techniques

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Objectives: *This in vitro study aimed to evaluate the gingival microleakage in class II cavities in primary molars restored with a low shrink silorane resin composite (Filtek P90) or a nanohybride composite resin (Filtek supreme XT) using three different techniques, (total bonding, closed or open sandwich techniques) lined by nano-filled resin modified glass ionomer cement RMGIC (Ketac N100). Additionally, the shear punch bond strength between the two types of composite and KN100 was also examined.* ***Study design:*** *For microleakage test, two standardized class II slot cavities were prepared in proximal surfaces of 60 sound extracted primary molars which were divided into 2 groups of 30 each according to the type of composite. Each group was subdivided into 3 groups (n = 10) according to the restorative technique used. The restored teeth were examined for microleakage after immersion in 2% methylene blue dye using stereomicroscope at 20 X. Microleakage scores among the groups were compared using Kruskal Wallis test followed by pair wise Mann Whitney U test at P ≤ 0.05. Thirty disc specimens were prepared for determining the shear punch bond strength between the two composite materials and the KN100. Specimens were divided into 5 groups (n = 6) according to the adhesive protocol. The differences in mean bond strength values in MPa between groups were statistically analyzed using ANOVA followed by pair wise Tukey Post hoc test at P ≤ 0.05.Mode of failure was also evaluated for all groups.* ***Results:*** *Both the silorane resin and nano-composite resin showed superior marginal seal with the total bonding technique compared to closed and open sandwich techniques. The recorded mean shear punch bond strength values showed no statistical significant difference between the two resin composites without or with their adhesive bonding systems when bonded to the nano-ionomer. All specimens showed cohesive mode of failures except for silorane resin with Adper Easy Bond Self Etch Adhesive (AEBSEA) which showed adhesive mode of failure.* ***Conclusions:*** *The best marginal seal was obtained with the total bonding technique using both resin composites. The shear punch bond strength between KN100 and the two composite materials was not affected by either of the used adhesive bonding agent.*

Keywords*: Microleakage, Shear punch bond strength, Silorane, Filtek Supreme XT, Nanofilled RMGI, Total bonding, Sandwich technique.*
J Clin Pediatr Dent 35(2): 173–182, 2010

INTRODUCTION

The glass ionomer-based composite sandwich technique is a viable option for tooth restoration. Stratified tooth restoration using glass ionomer-based composite is a scientifically sound concept based on principle of biomimesis, which is defined by Bugliarello as the attempt to imitate features of living systems.[1]

Polymerization shrinkage stress is still considered as the main drawback of resin composite (RC).[2] One of the major problems in class II resin composite restorations is de-bonding in the cervical margins, especially when the gingival wall is located below cemento-enamel junction (CEJ).[3,4] This de-bonding is caused by polymerization shrinkage stress in the resin matrix, which may result in microleakage, recurrent caries and pulpitis.[5] Several alternative clinical techniques have been introduced to reduce the stress problems in class II cavities. Among these is the replacement of the substantial part of the resin composite with a glass-ionomer cement (GIC) base in the so called (composite laminated

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GIC) or sandwich technique.[6] In the closed sandwich technique, the GIC lining is fully enclosed by composite resin.[7,8] Its effectiveness is explained by the initial rubbery behavior and the intrinsic porosity of the cement leading to reduced stress.[9, 10]

In the open sandwich technique, GIC covers most of the exposed dentin and extends to the periphery of the proximal box to form the cervical seal. This technique has been recommended in high-caries-risk patients like children with proximal lesions due to improved marginal seal and continuous fluoride release.[6,8,11]

Clinical evaluation using conventional GICs in the open-sandwich restorations has shown a high failure rate due to partial or total dissolution of the GIC part or fracture of the restorations.[7,8] Modified open-sandwich technique using resin modified glass ionomer cements RMGICs which have high degree of elastic deformation during the early stage of setting can relieve contraction stresses by acting as an elastic buffer.[6,10,12]

The published studies have been conducted with RMGIC materials composed of powder-liquid formats. More recently paste/paste versions of RMGIC liners with nano-fillers have become commercially available. The major innovation of these materials involves the incorporation of nano-technology, which allows highly packed filler composition (~69%) of which approximately two-thirds are nano-fillers. However, not much information is available in the literature regarding their performance. It is also not clear how the addition of nano-fillers will influence the clinical performance of RMGICs.[13]

In an attempt to solve the shrinkage problem of the direct RC restorations, a new category of resin matrix for dental composite was developed based on ring-opening monomers.[14] This hydrophobic composite is derived from the combination of siloxane and oxirane polymers. The major advantage of this innovative restorative material is its reduced shrinkage and its mechanical properties comparable to those of the methacrylate based composite materials.[2,14–16] Although this new composite can form a strong bond with identical material, its capacity to form bonds with dissimilar materials is still open to question.[17]

This *in vitro* study aimed to evaluate the microleakage of low shrink silorane –based composite versus methacrylate based composite using three different restorative techniques, i) total bonding resin composite RC, ii) closed sandwich and iii) open sandwich lined by nano-filled RMGIC for class two cavities in primary molars. Moreover the shear bond strength between the two types of composite and the nano-filled RMGIC was also tested using the shear punch test.

The null hypothesis tested was that when placed in class II preparations in primary molars,the microleakage of the directly placed resin composite restorations (total bonding) and nano-filled RMGIC/composite sandwich restorations will not be significantly different. In addition, the shear bond strength of both the used composite materials to the nano-filled RMGIC will also not be significantly different.

MATERIALS AND METHOD

Microleakage test

The details about the compositions, manipulative techniques and applications of the tested materials are presented in Table (1). A3 color shade was selected for all the materials and LED Blue phase Ivoclar-Vivadent with power output of 500mW/cm^2 and 50-60 Hz frequency was used for all light-curing procedures.

Specimens preparation

Sixty non carious extracted primary molars at the time of shedding were collected after obtaining an informed consent from the parents at pediatric dental clinic, Mansura University. They were cleaned, and stored in aqueous solution of 0.1% thymol for less than 3 months to be used in the study. In each tooth, two standardized class II cavities were prepared in the proximal surfaces (mesial and distal slots) with the following dimensions: axial depth of 1.4mm i.e, the diameter of the square-ended diamond fissure bur (ISO 014) and buccolingual width of 2.7 mm. The gingival margin was placed approximately one mm below the CEJ.[18] The buccal and lingual walls of the preparations were approximately parallel and connected to the gingival floor with rounded line angles. All the preparations were made by one operator using high speed water cooled hand piece. No bevels were made on the enamel. The prepared teeth were randomly divided into two main equal groups (n = 30) according to the type of composite used to restore the teeth. Each group was further subdivided into three equal subgroups (n = 10) according to restorative techniques (total bonding RC, closed and open sandwich) thus resulting into the following six groups:

Group 1: Silorane P90 RC (total bonding) restorative technique.
Group 2: Filtek Supreme XT RC (total bonding) restorative technique.
Group 3: Silorane P90 closed sandwich restorative technique.
Group 4: Silorane P90 open sandwich restorative technique.
Group 5: Filtek Supreme XT closed sandwich restorative technique.
Group 6: Filtek Supreme XT open sandwich restorative technique.

Restorative techniques

Total bonding technique

In this technique, the related self etch adhesive bonding system was applied to the entire cavity surface. Due to the difference in monomer chemistry of Silorane P90 a specific self etch based on two bottles adhesive was used whereas, with Filtek SupremeXT, Adper Easy Bond Self Etch Adhesive (AEBSEA) bonding agent in a blister form was used. The cavities were restored with composite in increments not

Tablr 1. Restorative materials, composition, manufacturers and restorative procedures used.

Material	Composition	Manufacturer	Restorative Procedures
Silorane P90 Adhesive (2 bottles) primer Lot N0 8AY **Adhesive Lot N0 8AY**	**Self etch primer** Phosphorylated methacrylates, vitrebond copolymer, bisphenol A diglycidyl methacrylate (BisGMA). 2 hydroxyethyl methacrylate (HEMA), water, ethanol, silane-treated silica filler, initiators, stabilizers **Adhesive bond** Hydrophobic methacrylates, phosphoryalted methacrylates, triethylene glycol dimethacrylate (TEGDMA), silane-treated silica filler, initiators, stabilizers.	3M,ESPE, ST-Paul,MN,USA.	- Application of Silorane system adhesive self etch primer for 15 sec with black microbrush, followed by gentle air disperse and 10 sec of light curing - Application of Silorane system adhesive bond with green micro-brush followed by gentle air dispersion and 10 sec of light curing.
Silorane P90 (microhybrid low shrink composite) (Syringe) Lot N0 20080927	**Filler** Silanized quartz, yttrium fluoride 76 wt% **Resin matrix** 3,4-Epoxycyclohexylethyl-cyclopolymethylesiloxrane, bi-3,4-epoxycyclohexylethyl-phenylmethylsilane.	3M,ESPE,ST,Paul, MN,USA.	- Placement and shaping of Silorane P90 composite not more than 2mm thick,then 40 sec light curing. - Finishing and polishing (Sof- 1ex™).3M,ESPE
Adper™ Easy Bond Self Etch Adhesive AEBSEA L-pop dispenser blister for single use Lot N0. 301555	2-hydroxyethyl methacrylate (HEMA), Bis-GMA, methacrylated phosphoric esters, 1,6-hexanediol dimethacrylate, methacrylate functionalized polyalkenoic acid (Vitrebond copolymer), finely dispersed bonded silica filler with 7 nm primary particle size, ethanol, water, initiators based on camphor quinone, stabilizers.	3M,ESPE,ST,Paul, MN,USA	Apply the adhesive with the disposable applicator for 20 sec to all surfaces of the cavity. Air thin the liquid for 5 sec until the film no longer moves indicating complete vaporization of the solvent Light cure for 10 sec
Filtek™ supreme XT Nano-hybrid composite (syringe) Lot N0. 8UM	**Filler** Silica nanofiller, zirconia/silica nanocluster, 78.5 wt% **Resin matrix** Bis-GMA, Bis-EMA, urethane dimethacrylate,triethylene glycol dimethacrylate(TEGDMA)	3M,ESPE	- Apply the Filtek supreme composite to the cavity and light cure each increment not more than 2mm thick for 20 sec. - Finishing and polishing using (Sof-lex™).
Ketac nano Primer Lot N0 .3527P	Water(40-50%),HEMA(35-45%),acrylic/itaconic acid copolymer(10-15%),photo-initiators.	3M ESPE St Paul ,MN ,USA	KN primer was applied to the cavity surface for 15 sec then air dried for 10 sec with no rinsing leaving shiny surface. The primer was then light cured for 10 sec.
Ketac Nano (K N100) Light curing RMGIC paste/paste clicker dispense Lot N0.3527	Two pastes 1-Paste A:silane treated glass(40-50%),silane treatedZrO2 silica(20-30%),silane treated silica(5-15%),TEGDMA(5-15%),HEMA(1-10%),Bis-GMA(<5%),TEGDMA(<5%) Paste B:silane treated ceramic (20-30%),silane treated silica (20-30%),water(10-20%),HEMA(1-10%),acrylic/itaconic acid copolymer(20-30%).	3M ,ESPE St Paul, MN, USA	The two pastes were squeezed from the clicker dispenser and mixed together on a paper pad then applied to the cavity surface, light cured for 20 sec.

greater than 2 mm in thickness and light cured according to the manufacturer's instructions (Table 1).

Closed sandwich technique

The nano-filled RMGIC (KN100) primer was applied, air dried, and light cured, then the two pastes were mixed and inserted into the proximal cavity away from the cervical cemento-dentinal junction. KN100 covered the axial wall of the proximal box 1 mm short of the occlusal dentino-enamel junction, then light cured according to the manufacturer's instructions. The restorations were completed by the application of the self etch adhesive bonding system of the matching composite to all the cavities including KN100,then RC was applied and light cured as *per* the manufacturer's instructions. The same material and technique were placed both in the mesial and distal cavities of each tooth.

Open sandwich technique

The restorative technique was similar to the closed sandwich technique. The only difference being that RMGIC (KN100) was extended cervically to the periphery of the proximal cavity leaving a layer of 2mm in depth to act as cervical seal.

All restorations were finished with sof-lex discs (3M, St. Paul, MN, USA). The exposed KN100 was covered with petroleum jelly then, stored in distilled water at 37°C for 7 days to allow for complete acid-base reaction in the RMGIC. The restored teeth were thermo- cycled for 500 cycles between 5°C and 55°C with a dwell time of 10 seconds. The resorbed areas and the root apices of the restored teeth were sealed with sticky wax. Two coats of nail varnish were applied on each tooth one mm short of the cavity margins of each proximal box to be exposed to dye. The teeth were then immersed in 2% buffered methylene blue dye solution for

24 hr at 37°C. After removal from the dye, teeth were rinsed with water, cleaned and sectioned longitudinally through the restorations in a mesio-distal direction with a double-sided diamond disc and assigned a code number for blind evaluation. Each section was viewed under a stereomicroscope (Olympus, Tokyo, Japan) at 20X magnification. Microleakage was assessed by the extent of dye penetration at the gingival margin according to the following scores:[18]

0 = No leakage.
1 = Leakage up to halfway along the gingival floor of the proximal box.
2 = Leakage on the full length of the proximal box.
3 = Leakage involving the axial wall.
4 = Extensive leakage toward the pulp.

Each evaluator scored the microleakage of the two halves of the restorations. Thus each restoration was scored 4 times by the 2 examiners. Each restoration was given the highest score (worst score) obtained from any of the two surfaces examined. The intra and inter examiner reliability was assessed using Kappa statistics. The comparison of frequencies and percentages of microleakage scores among the groups was statistically analyzed using Kruskal Wallis test followed by Mann Whitney U test for pair wise comparison between groups at $P \leq 0.05$. Bar chart was used for graphical presentation.

Shear punch test

The shear bond strength between the two types of composite and the nano-filled RMGIC (KN 100) was examined using a punch tool and a specially designed brass mold.

The mold was designed having an inner split brass mold with an outer washer space of 10 mm diameter and one mm thickness and an inner central part punch hole 3.5 mm diameter. A stainless steel punch rod with a flat end 3.2 mm diameter was used to create the shear force by sliding through the punch hole 3.5 mm diameter[19] as illustrated in Figures 1 and 2.

The nano- filled RMGIC (KN 100) base and catalyst were mixed according to the manufacturer's instruction and packed in the central part of the mold 3.5 mm diameter and covered with a glass microscope slide to produce a smooth surface and to facilitate smooth curing. It was then light cured for 20 seconds. After the cement had set, the composite resin was applied in the outer washer space. A Polyester strip was used to cover the composite material under hand pressure to ensure proper placement. Excess material was extruded laterally over the top of the washer ensuring that the upper surface of the specimen remained flat and flushed with the surface of the washer. Each section of the specimen was cured for 20 seconds using overlapping exposures to ensure that the whole specimen was properly cured. Any excess material around the periphery of the washer was removed with a scalpel. Disc specimen was carefully removed from the mold and both sides were polished with 1000 grit silicon carbide paper under continuous water irrigation resulting in a specimen with both sides flat and parallel to each other 10 mm in diameter and about one mm standard thickness. Thirty specimens were prepared and divided into five equal groups, six specimens each according to different surface treatment applied to each group as the following:

Group A: Silorane P90 bonded to nano-filled RMGIC (KN100) without application of its adhesive bonding agent.
Group B: Silorane P90 bonded to nano-filled RMGIC (KN 100) with application of its dedicated adhesive bonding agent.
Group C: Filtek Supreme XT bonded to nano-filled RMGIC (KN 100) without application of adhesive bonding agent.
Group D: Filtek Supreme XT bonded to nano-filled RMGIC (KN 100) with application of AEBSEA.
Group E: Silorane P 90 bonded to nano-filled RMGIC (KN100) with the application of AEBSEA (experimental group).

To simulate the clinical situation, in the bonded groups B, D and E, the corresponding adhesive bonding agent was

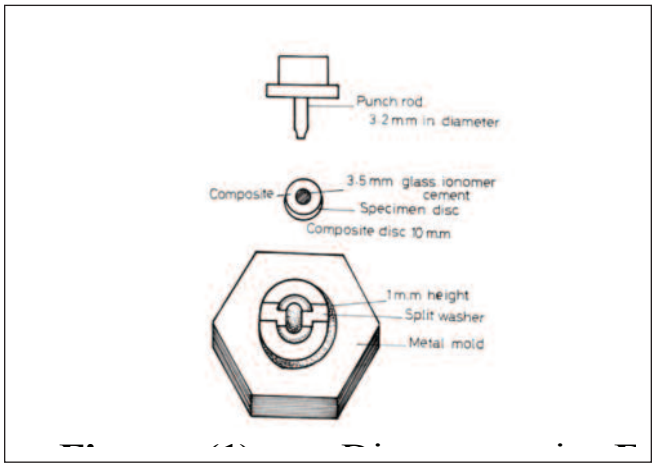

Figure 1. Diagrammatic illustration of shear punch mold and set up.

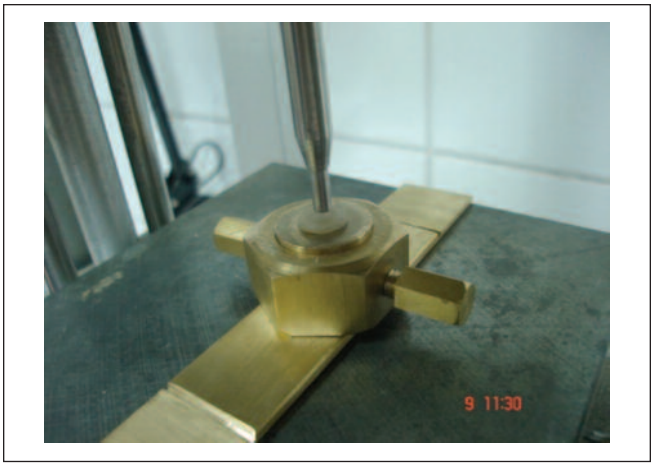

Figure 2. The specimen under shear punch testing.

Table 2. Comparison of microleakage scores in% among the six study groups.

Micro-leakage scores	Group 1[ac] Silorane total bonding N (%)	Group 2[a] Filtek total bonding N (%)	Group 3[bc] Silorane closed sandwich technique N (%)	Group 4[abc] Silorane open sandwich technique N (%)	Group 5[bc] Filtek closed sandwich technique N (%)	Group 6[b] Filtek open sandwich technique N (%)
Score 0	9 (90)	10 (100)	6 (60)	8 (80)	6 (60)	4 (40)
Score 1	1 (10)	0	2 (20)	0	2 (20)	2 (20)
Score 2	0	0	0	0	1 (10)	0
Score 3	0	0	2 (20)	1 (10)	1 (10)	3 (30)
Score 4	0	0	0	1 (10)	0	1 (10)
Median	Score 0	Score 0	Score 0	Score 0	Score 0	Score 1
Kruskal Wallis test P value	12.01 0.04*					

*** Kruskall Wallis test analysis shows statistical significant difference among the six studied groups, P<0.05.**
Different superscript letters denotes statistically significant differences, using Mann-Whitney U-test for pair wise comparison between groups.

applied first to outer surface of the RMGIC (KN 100) discs according to manufacturer's instructions before applying the composite.

The exposed nano-filled RMGIC was protected with petroleum jelly before storing of the specimens in 100% relative humidity at 37^{O}C for 24 hours before testing. The specimens were restrained by tightening the screw clamps to the top of the mold before loading. The shear punch-jig was adjusted in lower plate of the universal testing machine (Commten Industries, FL, USA). Care was taken to centralize the punch rod (3.2mm in diameter) on the center of the nano-filled RMGIC (KN 100) surface. The shear punch-test was performed at a crosshead speed of 1 mm /min. The peak force in Newton (N) at the point of extrusion of the RMGIC (KN 100) disc from the composite sides was recorded and taken as point of bond failure. The mode of failure (adhesive, cohesive or combined) was evaluated visually for each specimen. To express the shear punch bond strength in MPa, the load value recorded in Newton was divided by the area of the bonded interface. It was calculated as the following:[20]

Shear strength in MPa = Force (N)/ Area of the bonded interface (A)

A= 2π r h, where π is the constant 3.14, r is the radius of the KN 100 disc and h is the thickness of the disc.

The actual thickness of the specimen was measured just before testing using a micrometer. The mean shear punch bond strengths of bonded and un-bonded specimens were compared by statistical analysis of variance (ANOVA) followed by Tukey post hoc test to determine specific pair wise group differences. Statistical analysis was done using SPSS version 13 at $p \leq 0.05$.

RESULTS

Microleakage test

The Kappa statistics (0.967) for the mesial surface and (0.846) for the distal surface indicate strong agreement between the examiners. Comparison of the observed frequency of microleakage scores among the different studied

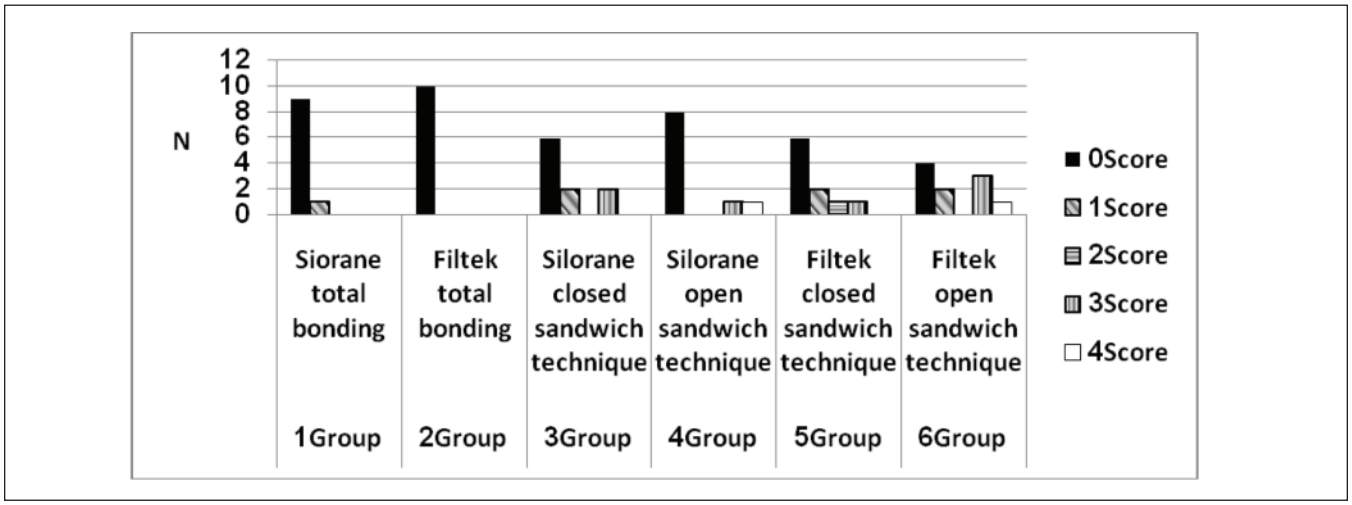

Figure 3. Showing a graphical representation of different leakage scores in the six study groups.v

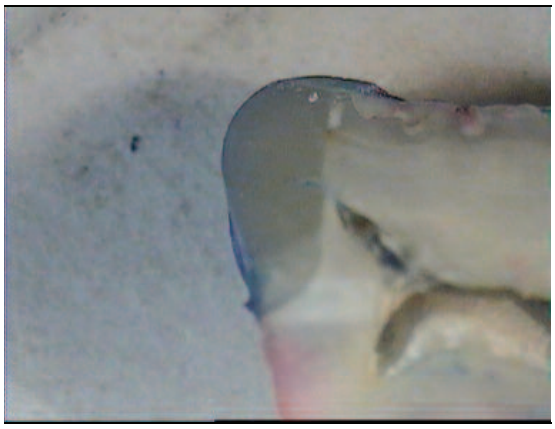

Figure 4. Silorane open sandwich score zero

Figure 5. Filtek Supreme closed sandwich score 3

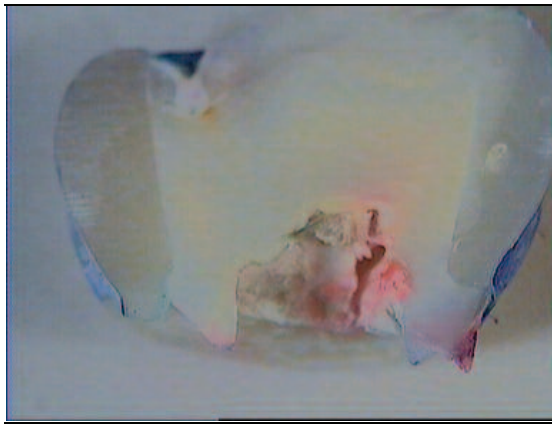

Figure 6. Silorane total bonding score zero

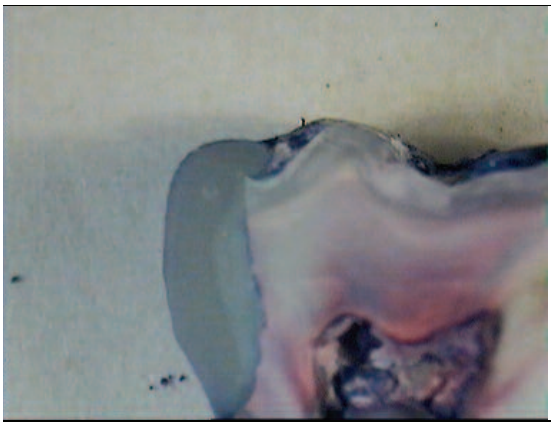

Figure 7. Silorane closed sandwich score 3

Figures 4-7. Showing different microleakage scores for different materials and restorative techniques.

restorative materials and techniques are presented in Table 2, graphically in Figure 3 and photographically in Figures 4–7. None of the groups showed complete prevention of dye penetration except for total bonding Filtek SupremeXT restorative group which showed 100% zero leakage score.

Comparison between the present two composite restorative materials using the same restorative technique showed no statistical significant difference in microleakage scores without or with nano-filled RMGIC (KN100) liner in closed and open sandwich techniques.

The results showed superior marginal seal with the total bonding restorative technique for both Silorane P90 (90%) and Filtek SupremeXT (100%).The closed sandwich technique for both composite resins showed comparable marginal seal 60% each, which was inferior to the total bonding RC restorative technique. On the other hand, open sandwich technique showed better marginal quality with Silorane P90 (80%) than Filtek SupremeXT (40%) without statistical significant difference. Moreover, Filtek SupremeXT open sandwich restorative technique recorded significantly greater marginal leakage than total bonding Filtek SupremeXT and Silorane P90 restorative techniques.

The nano-filled RMGI (KN100)/composite interface in the present study showed no leakage and was not affected by the various treatments and the adhesive systems used.

Shear punch bond strength

The means and standard deviations of shear punch bond strength between the nano-filled RMGIC(KN100) and both of Silorane P90 and Filtek SupremeXT composites using different bonding techniques are presented in Table 3 and graphically in Figure 8.

The specific pair wise groups' differences showed no statistical significant difference between the two types of composite resin without or with its adhesive bonding system when bonded to nano-filled RMGIC (KN 100).

Using Silorane P90 with its recommended adhesive bonding system recorded the highest mean shear punch bond strength value 28.99±4.17MPa, while using it with AEBSEA recorded the lowest mean shear punch bond strength value 20.39±0.16MPa with statistically significant difference. On the other hand, the use of AEBSEA with Filtek SupremeXT, showed significantly higher mean shear punch bond strength value 26.41±3.81MPa than its use with Silo-

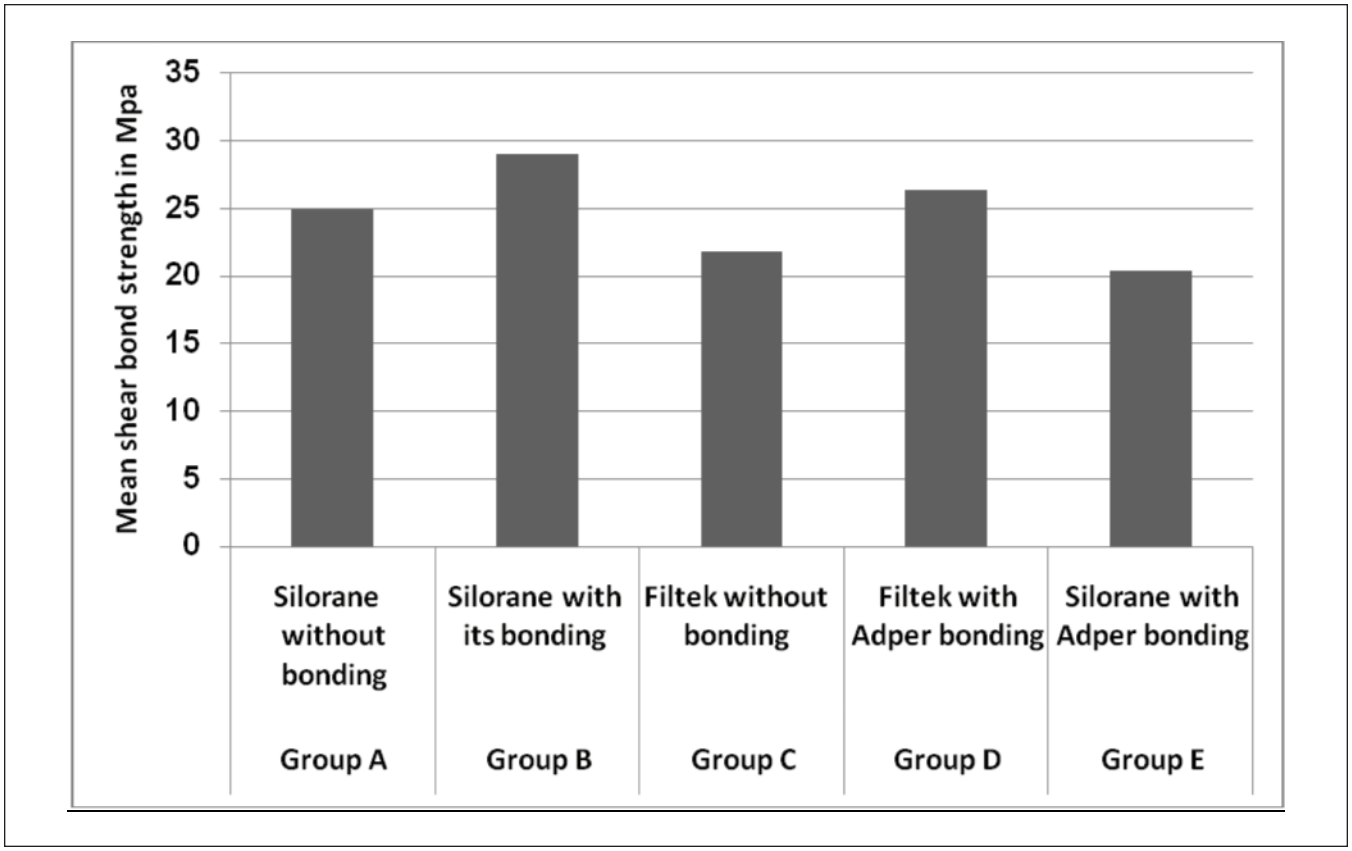

Figure 8. Graphical representation of the mean shear punch bond strength of the five study groups.

rane P90. All the specimens showed visually apparent cohesive mode of failures except for the experimental group where AEBSEA was used with Silorane P90 which recorded adhesive failure.

DISCUSSION

The search for a restorative material with optimal sealing properties has led to a large number of dental materials, bonding systems and restorative techniques. Sealing ability of adhesive restorative materials can be assessed by different tests including microleakage and nano-leakage tests.[21] Although nanoleakage test have been applied in recent papers to compare the dentin bonding performance of materials,[22] its results should be interpreted with care.[23] high regional variability in the hybrid layer makes it very difficult to obtain representative information with regard to the resistance of adhesives against nano-leakage.[21] In addition, nanoleakage is less extensive than microleakage and has probably no immediate clinical relevance.[24] For these reasons microleakage test rather than nanoleakage was used in the present study, being the most popular test method employed to obtain a preliminary idea about the adhesive quality of a new material or combination of materials.[24]

Although composite resins are the most commonly used tooth coloured restorative materials, they still have problems related to polymerization shrinkage. Upon curing, the single resin molecules move towards each other and are linked by chemical bonds (i.e. the conversion of C=C bond to C-C bonds) to form a polymer network. The magnitude of the shrinkage depends on the resin matrix formulation and the amount of the filler used in the RC.[25] This will induce a stress which may result in de-bonding from the cavity walls leading to microleakage.[9] Materials which remain dimensionally stable upon polymerization coupled with advanced bonding to hard tooth structure will markedly enhance the stability of the restoration as proved by the present study results.

The use of Silorane P90 and Filtek Supreme XT as direct RC (total bonding) restorations for class II cavities in primary molars provided the best marginal seal at the cervical margins of the restorations. These results contradict most of the previously described studies with different composite resins and adhesive systems mainly when total bonding RC restorations were compared to those obtained under open sandwich techniques.[4, 10, 26] This can be attributed to the use of the present two innovative composite materials with their adhesive systems. Silorane P90 is a microhybrid low polymerization shrinkage material currently introduced in the markets and it doesn't contain methacrylate. The novel resin is considered to have combined the two key advantages of the individual components: low polymerization shrinkage due to the ring opening oxirane monomer and increased hydrophobicity due to the presence of the siloxane species so, it results in reduced water uptake and related phenomena.[16] At the same time, Silorane P90 adhesive is composed of a hydrophilic one step self-etch primer and a hydrophobic viscous bond coating resin. The manufacturer produced this

adhesive in order to obtain an appropriate bond to hard tooth structure especially because of differences in Silorane curing mechanisms compared to methacrylate yielding superior adaptation.

The superior sealing ability of the cervical margins by the direct nano-hybrid Filtek Supreme XT RC restorations recorded in the present study can be explained by the use of nano-technology with increased nano-filler loading to approximately 60% by volume and the use of bonding agent AEBSEA. Since the polymerization shrinkage is caused by resin, the lower the proportion of resin in a composite, the lower the shrinkage will be. AEBSEA is the latest brand of self-etching systems produced by 3M ESPE. Self-etching systems are generally considered to be less technique sensitive compared to systems that utilize separate acid conditioning and rinsing steps. They seem to eliminate factors such as over etching, over drying and over wetting.[27] This simple technique is an advantage where the operative time is directly associated with the child's behavior. AEBSEA includes phosphoric esters, which under aqueous condition will etch the surface of dentin and enamel to allow for the micro-mechanical bonding of a restorative material. Moreover, the phosphoric esters and the vitrebond copolymer in AEBSEA form a chemical bond to hydroxyl apatite by forming a complex of calcium ions.[28, 29]

As the developed stress is proportional to the volume of the resin composite cured, restricting the volume in so called sandwich or laminate restorations has therefore seemed to improve the interfacial adaptation.[3,6,8] In addition, employing an intermediate layer with low elasticity modulus like RMGIC can relieve some of the composite contraction stress and reduce the occurrence of microleakage by acting as an elastic buffer.[5,6,10,25] This is commonly referred to an elastic wall concept.[5,10,25] In the present investigation, the application of the most recent nano-filled RMGIC (KN100) as a liner in closed sandwich restorative technique didn't result in superior marginal quality compared to total bonding RC restorative technique. This confirms the results of Dietrich, *et al*[3] who concluded that if modern dentine bonding systems are used with direct RC restorative techniques, RMGIC base doesn't have beneficial effect with respect to marginal adaptation. On the other hand, the results of Thonemann, *et al* [30] showed no gap formation in total bonding restorative technique with certain adhesive bonding systems compared to selective bonding where cavities were lined with RMGIC base material in closed sandwich technique.

In previous studies[18,31,32] successful results obtained with significantly smaller gap size found in the open sandwich technique with RMGIC base in class II primary molars restorations had led the authors to suggest this technique for use in pediatric dental practice. This was not in agreement with the present study results where Silorane P90 and Filtek Supreme XT open sandwich restorative techniques didn't show better marginal sealing than the total bonding RC restorative technique. Therefore, elastic wall concept couldn't be confirmed in the present study running with the results of other researchers who came to the same conclusion.[25, 33] The idea that the contraction forces which occur within a polymerizing composite resin are sufficiently strong to disrupt the bond between RMGIC and dentin may account for the lower marginal seal (40%) of Filtek SupremeXT open sandwich technique. On the other hand, the low shrink silorane property may lead to low shrinkage stress resulting into better marginal adaptation (80%) with Silorane P90 open sandwich technique

The insignificant difference identified in microleakage scores between Silorane P90 and Filtek SupremeXT composite materials without or with nano-filled RMGI (KN 100) liner in closed and open sandwich techniques can lead to the acceptance of the first part of the null-hypothesis.

With the shear punch test the fracture occurs parallel to the bonding interface which makes it a true shear test simulating the clinical conditions more closely.[34] Higher mean shear punch bond strength value was recorded in the present study when both the resin composite materials were bonded to nano-ionomer using their adhesive bonding systems. This result agreed with the finding of Yap et al[35] who explained this strong bond by the surface roughness as a result of etching of the GIC and the use of an intermediate resin.

On the other hand, the mean shear punch bond strength between the present nano-ionomer and both of composite materials seemed to be not affected by the application of its recommended self etch adhesive bonding system. Thus, the second part of the null-hypothesis was also accepted. This finding confirmed the results of other studies[36,37] which demonstrated that etching the hybrid ionomers had no statistical significant effect on bond strength when compared with non etched group.

Literature data showed that bonding between GIC and RC occurs because of HEMA in both materials.[38] It is also possible that the bond strength could be influenced by the presence or absence of any chemical bonding mechanism that could occur between the two materials when a laminate technique is used.[37] This can explain the significantly higher mean shear punch bond strength for Silorane P90 with its recommended adhesive bonding system compared to Silorane P90 with AEBSEA experimental group. The adhesive mode of bonding failure in this group confirms the manufacturer's recommendations to use Silorane P90 with its dedicated adhesive bonding system. Bond strength between nano RMGIC and Silorane P90 without the use of bonding agent could not be explained because of difference in Silorane P90 resin composition. This aspect needs more investigations to be clarified.

Several mechanisms that could be involved in the chemical adhesion of KN100 and the present composite materials used for sandwich (laminate) restorations were suggested:[39]

- Increased availability of unsaturated double bonds in the air-inhibited layer of the RMGIC.
- Un-polymerized HEMA on KN100 could increase the surface wetting capability of the bonding agent as well as the bond strength when polymerized.
- Unsaturated methacrylate pendants which are available

on polyacid chain with polymerized KN 100 may also form ionic bonds with the resin bonding agents.

CONCLUSIONS

Under the conditions of this *in vitro* study, the total bonding technique of the present two contemporary composite materials, with their adhesive bonding systems, showed superior marginal seal over the other used techniques to seal the cervical margins of the class II cavities prepared in primary molars below the CEJ. The shear punch bond strength between the nano-ionomer KN100 and the two composite materials was not affected by either of the used adhesive bonding agent. However, the forces exerted clinically on restorations or teeth are complex in nature so, the data obtained by laboratory tests must be supported by the results of the clinical investigations.

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