Original Research Article

Comparing microleakage in Silorane based composite and nanofilled composite using different layering techniques in class I restorations: An in vitro study

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International Archives of Integrated Medicine, Vol. 4, Issue 7, July, 2017.

Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 07-06-2017 **Accepted on:** 18-06-2017
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Shafia Sarfi, Neerja Sharma, Ekta Garg, Dildeep Bali. Comparing microleakage in Silorane based composite and nanofilled composite using different layering techniques in class I restorations: An in vitro study. IAIM, 2017; 4(7): 23-32.

Abstract

Background: It won't be wrong to admit that composite resins are currently the back bone of aesthetic and conservative dentistry. However a major drawback of composite resins is that their setting reaction involves formation of polymer chains leading to polymerization shrinkage.

Aim: To compare microleakage in silorane composite using oblique, vertical and horizontal layering techniques to microleakage of nanofilled composite using oblique, vertical and horizontal layering techniques.

Materials and methods: 120 extracted maxillary premolar teeth were assigned to 2 groups based on the material used Group A nanocomposite and Group B-silorane and each group was divided further into 3 subgroups depending on incremental technique used for restoration into horizontal, oblique and vertical (sub groups A1, A2, A3, B1, B2 and B3). A Class 1 cavity measuring 3mm×3mm×2mm was prepared in all the teeth. In group A teeth Clearfil ™SE Bond (Kurary Medical inc. Okayama, Japan) was applied. Group A teeth were filled with Filtek™ Z350 XT (nanocomposite) (3M ESPE, St Paul, USA) using horizontal (A1), oblique (A2) and vertical (A3) incremental layering technique and each increment was cured for 30 seconds. In Group B teeth P90 system adhesive was applied and teeth were filled with Filtek^{TM} P90 silorane (3M ESPE, St. Paul, USA) using horizontal (B1), oblique (B2) and vertical (B3) incremental layering technique. Specimens were thermocycled for 1000 cycles (5/55ºC, 30 seconds) and immersed in 2% methylene blue dye for 24 hours. Following immersion teeth were sectioned and observed under a stereomicroscope. Results were analysed using Kruskal-Wallis test followed by Mann Whitney U test.

Results: Siloranes showed significantaly less microleakage than nanofilled composites. The difference between the horizontal group, oblique group and the vertical group was found to be statistically non-significant (P value >0.05) but mean microleakage was more in vertical group compared to oblique and horizontal group.

Conclusion: Within the limitations of this study, we found that Siloranes exhibit significantly less microleakage as compared to nanofilled composites irrespective of the layering technique used.

Key words

Microleakage, Nanofilled composites, Oblique layering technique, Vertical layering technique.

Introduction

It won't be wrong to admit that composite resins are currently the back bone of aesthetic and conservative dentistry. However a major drawback of composite resins is that their setting reaction involves formation of polymer chains leading to polymerization shrinkage.

When composite resin is bonded on all surfaces, shrinkage is compensated by strain (flow) of the composite, tooth, or adhesive/bonding agent [1]. If this stress is greater than the cohesive strength of the composite, damage occurs within the composite [2]. If the stress exceeds the tensile strength of enamel, the enamel fractures [3, 4]. Polymerization shrinkage occurring during composite curing induces stresses at the tooth-restoration interface resulting in gap formation leading to microleakage, secondary caries, debonding, post-operative sensitivity and eventually failure.

Polymerization shrinkage in composites is governed by various factors of which some are under the manufacturers control while others are under the clinicians' control. Factors under manufacturers control include, type and amount of the resin matrix, type and amount of the filler and photo activator system used.

Clinicians have been trying to minimize the polymerization shrinkage and hence microleakage by various techniques such as using incremental placement, placing thicker adhesive layers under composites, using fibre inserts, various light curing methods like ramp curing, pulse curing and curing towards the bonded surfaces, lowering the cavity configuration factor C – factor, type of bonding system and use of low shrinkage composites.

C-factor (cavity configuration factor) is the ratio of bonded to unbonded surfaces of the cavity [5]. It is highest for class I and V cavities, greatest stress occurs in these cavities as composite is bonded to five walls of the prepared cavity (C = 5) and its lowest for class IV cavities as material has enough unbonded surfaces to flow, providing stress relief. Shallow and large designs reduce the C-factor; therefore, it is important to have a lower cavity configuration [6].

With regular research work and improvements in the manufacturing we now have composite resins with high wear resistance and strength. Newer generations of composite resin with different filler particle sizes and volume are being introduced to suit the requirements of an ideal restorative material.

At the beginning of new century nano technology was introduced, nanocomposites consist of nanomers (5-nm to 75-nm particles) and nanocluster agglomerate fillers (0.6 µm to 1.4 µm), nanofilled composites are composed of zirconia/silica nanoparticles from 5 nm to 20 nm in size [7, 8]. Fused together at contacts, the porous structure is filled with silane and demonstrates mechanical and physical properties similar to those of hybrid composites [7, 8].

Siloranes, the new class of ring opening compound is a monomer obtained from the reaction of oxirane and siloxane molecules. Silorane claims to have <1% volumetric shrinkage as the ring opening compound polymerize by opening, flattening and extending towards each other. Ilie N, Hickel R [9] conducted a macro-, micro- and nano-mechanical investigation on silorane and methacrylate-based composites and concluded that the mechanical properties of silorane were comparable to clinically successful methacrylate-based composite materials, encouraging the clinical use of the new composite material.

The purpose of our study was: To compare microleakage in Siloranes with Nanofilled composites using different (oblique, horizontal and vertical) layering techniques, to see the effect of material and technique on microleakage of composite resins.

Materials and methods

One hundred twenty caries/cracks free human maxillary premolars extracted for periodontal/orthodontic reasons were collected, cleaned with a slurry of pumice and stored in normal saline at room temperature to be used within a period of six months [10, 11, 12].

Tooth preparation

A class 1 cavity measuring 3mm×3mm×2mm was prepared in all the teeth using No. 245 carbide bur [13] (SS White, U.S.A) in high speed hand piece (NSK, Japan) with water cooling. The bur was changed after every 5 cavity preparations. The depth of the cavity was measured from the centre of central fissure using UNC 15 probe (University of North Carolina U.S.A, Hu-Freidy Mfg. Co. Inc., Chicago, IL, USA). The breadth and width of the cavity were standardized using a divider and scale. The prepared 120 teeth were randomly divided into 2 groups of sixty teeth each based on the restorative material as Group A-nanocomposite and Group B-silorane. Each group was divided further into 3 subgroups (**Figure - 1**) depending on incremental technique used for restoration into:

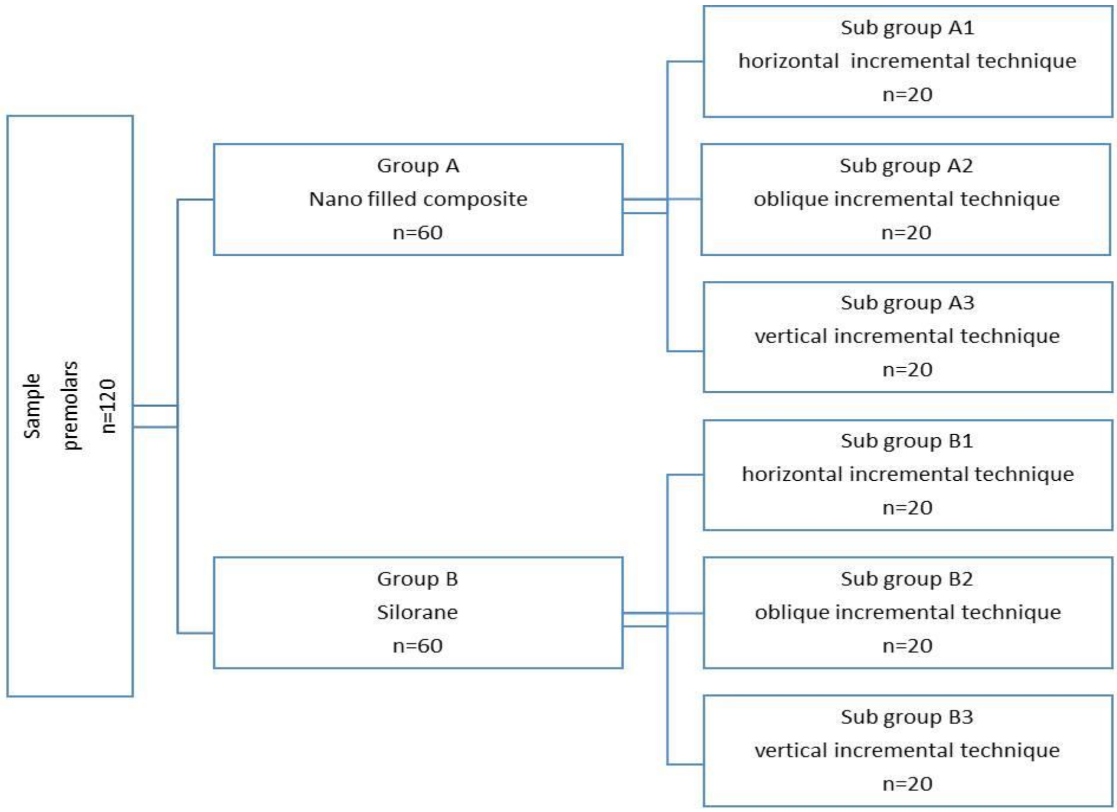
Group A 1: nanocomposite using horizontal incremental technique,
Group A 2: nanocomposite using oblique incremental technique,
Group A 3: nanocomposite using vertical incremental technique,
Group B 1: silorane composite using horizontal incremental technique,
Group B 2: silorane composite using oblique incremental technique,
Group B 3: silorane composite using vertical incremental technique.

Restoration techniques

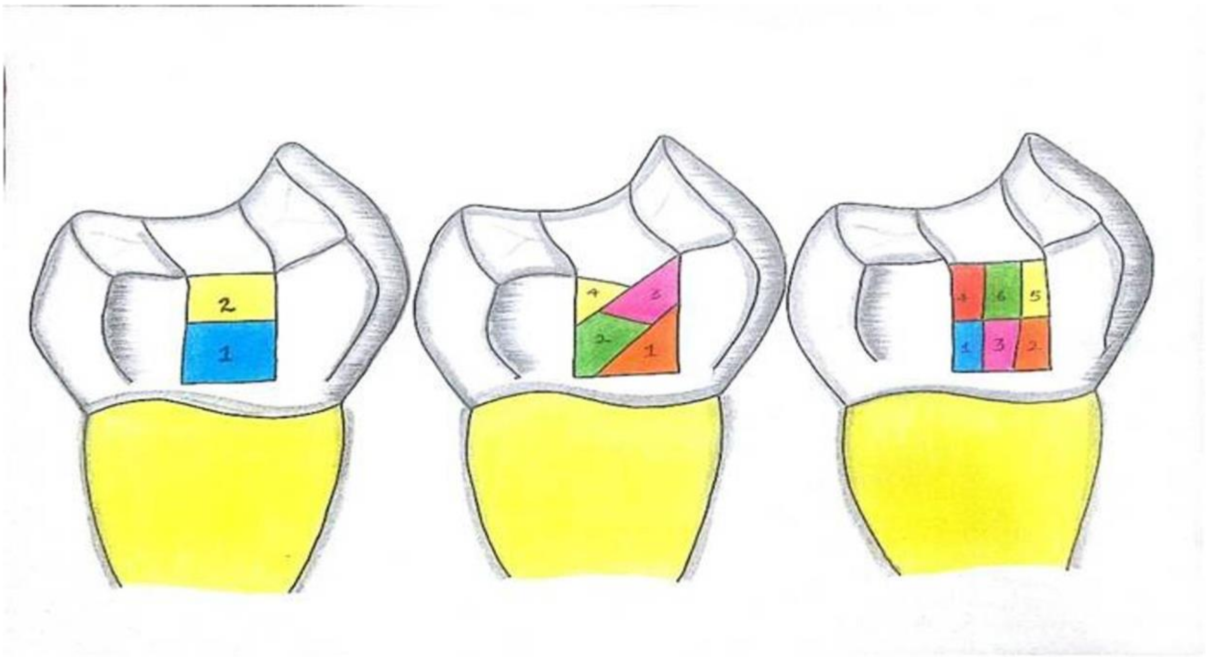
Group A (Nanofilled composite group): Clearfil™ SE Bond - Primer (Kurary Medical inc., Okayama, Japan) was applied for 20 seconds using a microbrush, gently dried with mild air flow, then Clearfil™ SE Bond - bond (Kurary Medical inc. Okayama, Japan) was applied with a separate microbrush and spread evenly using gentle stream of air. The bonding agent was cured for 10 seconds with LED light (Ivoclar Vivadent). Subgroups A1, A 2 and A 3 teeth were filled with nanocomposite Filtek™ Z350 XT (3M ESPE, St Paul, USA) using horizontal, oblique and vertical incremental technique respectively (**Figure - 2**), each increment was kept 1mm thick and cured for 30 seconds with LED light.

Group B (Silorane group): P90 system adhesive self-etch primer (3M Deutschland GmbH, Neuss-Germany) was applied with a microbrush for 15 seconds followed by drying with mild air flow and curing for 10 seconds with LED light. Then P90 system adhesive- bond (3M Deutschland GmbH, Neuss-Germany) was applied with a separate microbrush and spread evenly using gentle stream of air, this was followed by curing for 10 seconds. Teeth were divided into subgroups B 1, B2 and B3 and filled with Filtek^{TM} P90 silorane (3M ESPE, St. Paul, USA) with 1mm thick increments in horizontal, oblique and vertical incremental technique respectively (**Figure - 2**) and each increment was cured for 40 seconds.

<u>Figure -1</u>: Summary of Experimental Design.



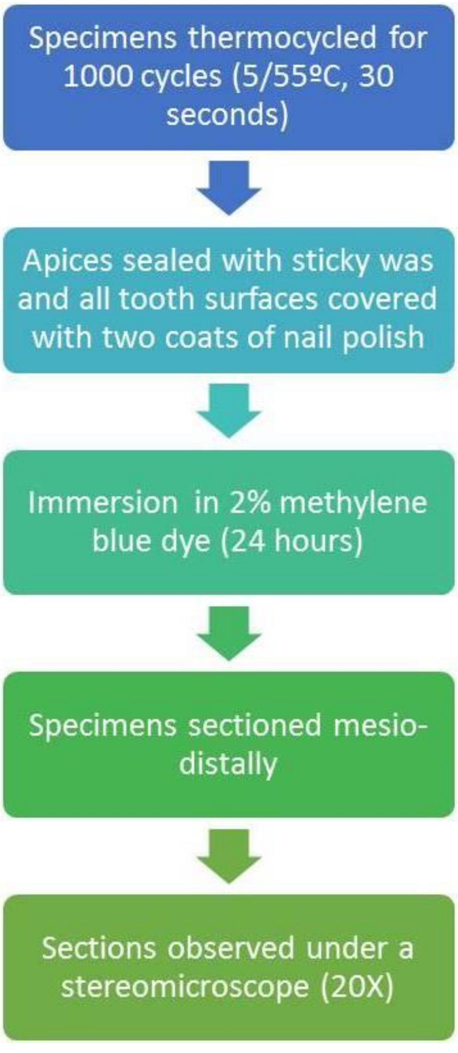
<u>Figure - 2</u>: Different layering techniques used for restoration (Horizontal, Oblique and Vertical).



Microleakage evaluation

All specimens were thermocycled for 1000 cycles (5/55ºC, 30 seconds) in Eppendorf Master cycler gradient (Eppendorf AG, Hamburg, Germany). After thermocycling, apices of the teeth were sealed with a layer of sticky wax, and all tooth surfaces were covered with two coats of nail polish, with the exception of 1 mm area around the tooth-restoration interface. All samples were immersed in 2% methylene blue dye for 24 hours. Following immersion teeth were washed with distilled water then dried and sectioned mesio-distally using diamond disc at slow speed and observed under a stereomicroscope (**Figure - 3**).

Figure - 3: Flow chart showing steps in microleakage evaluation.



The cut sections were observed under 20X magnification and the area of maximum dye penetration was considered [14]. Two examiners scored extent of dye penetration using an ordinal scale (0-4) (**Table - 1** and **Figure - 4, 5, 6, 7**) by consensus. Examiners were blind to material and/or technique used. Results were analysed using Kruskal-Wallis test followed by Mann Whitney U test.

Figure - 4: Microleakage Score 1

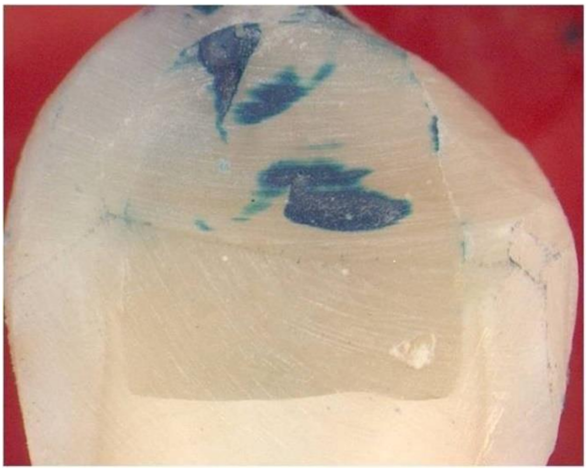


Figure - 5: Microleakage Score 2.

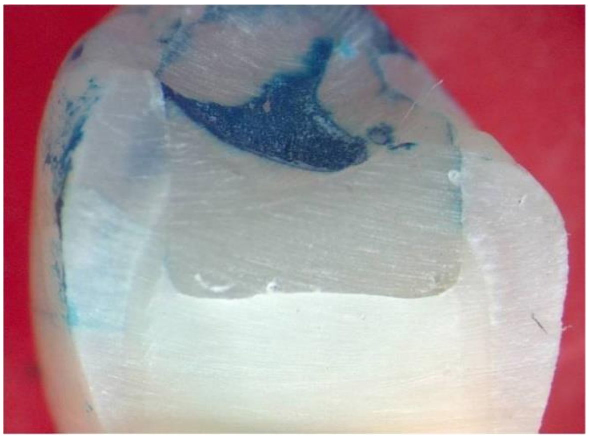


Figure - 6: Microleakage Score 3.

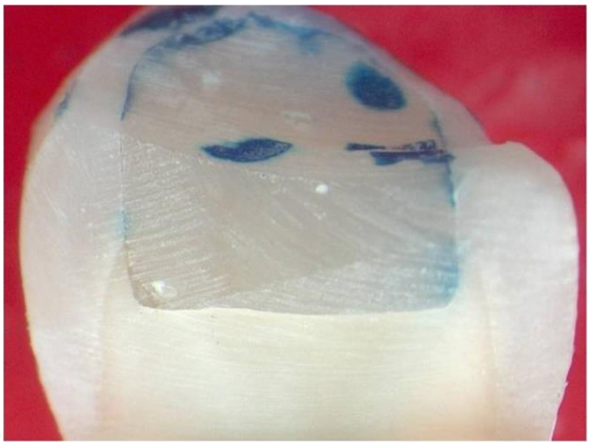
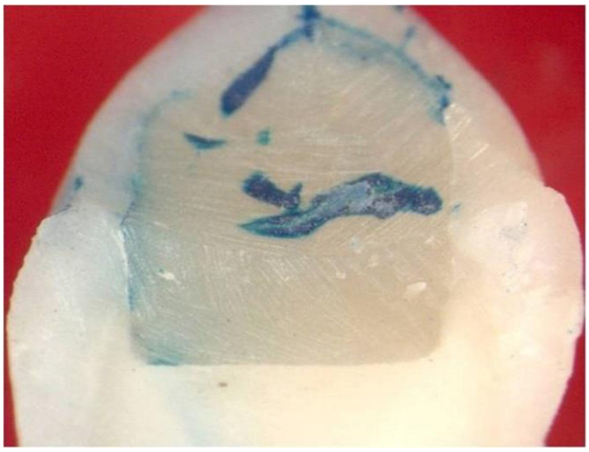


Figure - 7: Microleakage Score 4.



Results

Within the limitations of the study the results (**Table - 2, 3, 4**) showed that there is a statistically significant difference between the microleakage of six groups. The nanofilled composite group in all three layering techniques horizontal (1.8±1.10), oblique (1.70±1.42) and vertical (2.10±1.25) had significantly more mean microleakage (**Graph - 1**) in comparison to the silorane group (0.45±0.59, 0.40±0.68 and 0.55±0.69).There was a statistically significant difference between the microleakage of nanofilled composites in all layering technique and silorane group (**Table - 3**) (P value <0.05). However, the intragroup microleakage comparison was found to be statistically non-significant (P value >0.05) for both nanofilled composite and silorane.

Table - 1: Scoring criteria.

SCORE	DESCRIPTION
0	NO EVIDENCE OF DYE PENETRATION AT TOOTH RESTORATION INTERFACE
1	DYE PENETRATION ALONG THE CAVITY WALL UPTO 1/3RD OF CAVITY DEPTH
2	DYE PENETRATION GREATER THAN 1/3RD, BUT LESS THAN 2/3RD OF CAVITY DEPTH.
3	DYE PENETRATION GREATER THAN 2/3RD OF CAVITY DEPTH BUT NOT ALONG THE DENTINAL TUBULES
4	DYE PENETRATION TO THE CAVITY DEPTH AND ALONG THE DENTINAL TUBULES.

Table - 2: Showing microleakage in nanofilled composite using horizontal, oblique and vertical layering techniques.

Microleakage	Mean	SD	Comparison	P-value@
Group A1	1.8	1.10	A1 vs A2	0.615
Group A2	1.7	1.41	A1 vsA3	0.523
Group A3	2.1	1.25	A2 vs A3	0.329

@P-value by Kruskal-Wallis test followed by Mann Whitney U test

Table - 3: Showing microleakage in silorane composite using horizontal, oblique and vertical layering techniques.

Microleakage	Mean	SD	Comparison	P-value@
Group B1	0.45	0.59	B1 vs B2	0.688
Group B2	0.40	0.68	B1 vsB3	0.721
Group B3	0.55	0.69	B2 vs B3	0.465

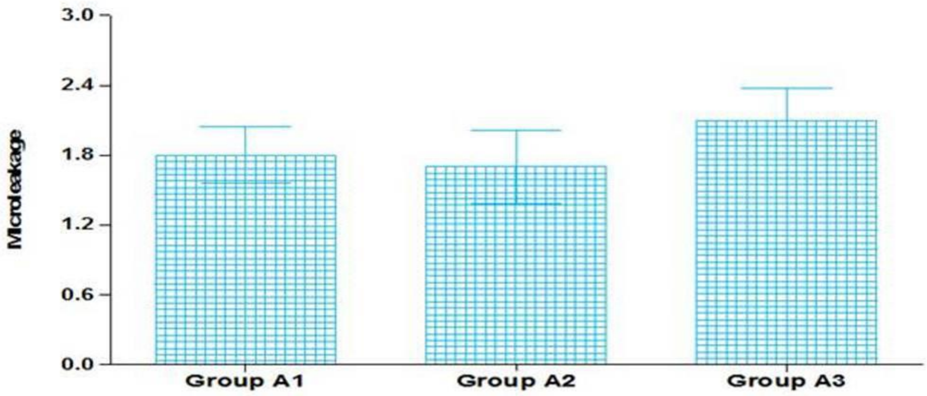
@P-value by Kruskal-Wallis test followed by Mann Whitney U test

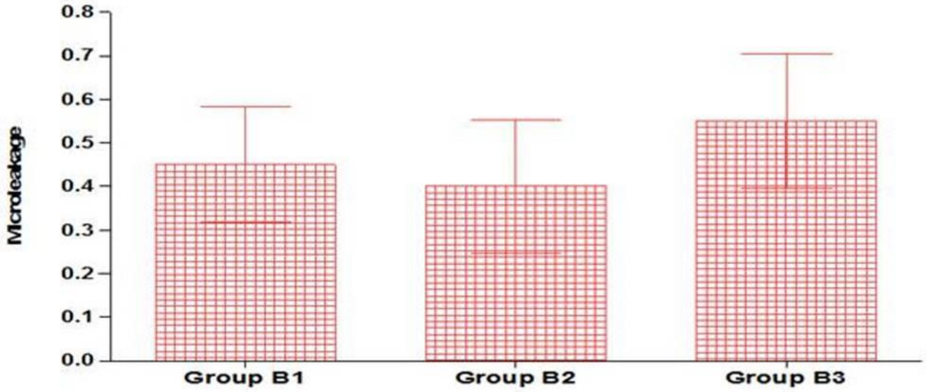
Table - 4: Intergroup comparison of microleakage between nanofilled composite vs silorane composite using horizontal, oblique and vertical layering techniques.

P-value@	A1	A2	A3
B1	0.0001*	0.0035*	<0.0001*
B2	0.0001*	0.0018*	<0.0001*
B3	0.0004*	0.0085*	0.0002*

Statistically Significant Difference (P-value<0.05); @P-value by Kruskal-Wallis test followed by Mann Whitney U test

Graph - 1: Showing mean microleakage in various groups.





Discussion

The development of restorative resins represents a milestone in the field of aesthetic dentistry. Despite the excellent aesthetics, composite resin strength, wear resistance, polymerization shrinkage and hence longevity posed a major problem in accepting them as an alternative to amalgam. With regular research work and improvements in the manufacturing we now have composite resins with high wear resistance and strength.

Dental composites harden by polymerization of the monomer units. As the polymer is formed, the resin matrix changes from a paste or pregel state to a viscous solid [15] depending upon the type of composite resin matrix, the contraction of composite resins ranges from about 1.5% to 5%. The deformation of setting resins produces stresses according to Hooke's Law which states that stress applied to a material is proportional to the strain on that material. Stress development in composite resins is a dynamic process as strain and elastic modulus increase with time. Polymerization shrinkage is governed by various factors of which some are under the manufacturers control while others are under the clinicians control. Factors under manufacturers control include, type and amount of the resin matrix, type and amount of the filler and photo activator system used. Clinicians have been trying to minimize the microleakage by various techniques such as using incremental placement, placing thicker adhesive layers under composites, using fibre inserts, various light curing methods like ramp curing, pulse curing and curing towards the bonded surfaces ,lowering the cavity configuration factor C – factor and use of low shrinkage composites.

Effect of technique

Lekha Santhosh, et al. [10] (2008) and H.L Usha [16] (2011) in their study found that there was no influence of different composite placement techniques on microleakage. This is in disagreement to the observation made by W. Stephan Eakle and Rodney K. Ito [17] (1990) who found that the diagonal insertion technique had the most leak-free margins when the proximal box ended on enamel and Y. H. Bagis (2009) [18] who found that the nanohybrid composites showed better results with vertical layering technique compared to oblique layering for enamel margin. The incremental filling technique has been shown to yield significantly lower cuspal deflection than the bulk filling technique [19]. Park J, et al. (2008) [20] studied stresses developed by various filling techniques and found that the bulk filling technique yielded significantly more cuspal deflection than the incremental filling techniques, while there was no significant difference between the horizontal and oblique increment methods.

In this study, we found that there was no statistically significant difference between the microleakage of horizontal, oblique and the vertical group (P value >0.05) but mean microleakage was more in vertical group compared to oblique and horizontal groups for both nanofilled composite and siloranes.

Effect of material

According to the studies conducted by Min-Huey Chena, et al. (2006) [21] and Mui S. Soh, et al. (2007) [22] the polymerization shrinkage of the nanocomposites is less than that of the conventional resin composite restorative materials. Beun S, et al. [23] found that the nanofilled resin composites show higher elastic moduli than those of universal and microfilled composites [23]. Seema Deshmukh and B Nandal [24] evaluated the shear bond strength of nanocomposites on carious and sound deciduous dentin and found that nanocomposites had significantly higher bond strength than conventional composites.

Studies conducted by William M. Palin (2005) [25], Y.H Bagis, et al. (2009) [18], Roula Al-Boni and Ola M Raja (2010) [26], Motaz A. Ghulman (2011) [27], Mithra N.Hegde (2012) [28] and Asha joseph (2013) [29] have shown that there is significantly less microleakage in silorane composite resins compared to methacrylate based composite resins. This is in agreement with our study where we found that silorane based composite resin showed significantly less microleakage as compared to nanofilled composites in all three layering techniques. But Fahad Umer, Farah Naz, Farhan Raza Khan's (2011) [30] study showed different result, they found that the total-etch conventional composite group performed statistically and significantly better ($P < 0.001$) at the occlusal margin and was marginally and statistically significant ($P = 0.05$) at the gingival margin compared to the self-etch conventional and Silorane groups. This is in agreement with the findings of Schmidt, et al. (2011) [31].

The results of the present study that siloranes demonstrated statistically lower leakage and hence polymerisation shrinkage than nanofilled composites are in agreement with studies of

William M. Palin (2005) [25], Y.H Bagis, et al. (2009) [18], Roula Al-Boni and Ola M Raja (2010) [26], Motaz A. Ghulman (2011) [27], Mithra N.Hegde (2012) [28] and Asha Joseph (2013) [29]. However, the intra-group difference between the horizontal, oblique group and the vertical group was found to be statistically non-significant (P value >0.05) but mean microleakage was more in vertical group compared to oblique and horizontal group. This is in agreement with Lekha Santhosh, et al. (2008) [10] and H.L Usha's (2011) [16] observation who found that there was no influence of different composite placement techniques on microleakage.

Conclusion

Within the limitations of this study, we found that Siloranes exhibit significantly less microleakage as compared to nanofilled composites irrespective of the layering technique used.

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