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Research Report

The difference in microleakage levels of nanohybrid composite resin using eighth-generation ethanol and isopropanol solvent bonding materials under moist and dry conditions (in vitro study)

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ABSTRACT

Background: *Microleakage during restoration causes secondary caries. The shrinkage of nanohybrid composite resin can occur during the polymerization process, affected by both the selection of bonding materials featuring different solvents, such as ethanol and isopropanol, as well as contrasting conditions such as moist and dry.* ***Purpose:*** *This study aimed to determine and analyze the differences of microleakage level of nanohybrid composite resin using the eighth-generation bonding materials made from ethanol and isopropanol solvents under moist and dry conditions.* ***Methods:*** *This research constituted an experimental laboratory study. The samples were divided into four groups. Group I used a bonding material produced from ethanol under dry conditions. Group II used a bonding material produced from ethanol under moist conditions. Group III used a bonding material produced from isopropanol under dry conditions. Group IV used a bonding material produced from isopropanol under moist conditions. The levels of microleakage were subsequently tested using a stereo microscope.* ***Results:*** *Microleakage examination was performed by means of a stereo microscope to observe the methylene blue color penetration with assessment subsequently being performed on a scale of 0 to 3. The statistical results of a Kruskal-Wallis test showed that no significant differences occurred in any of the treatment groups (sig = 0.141, $p<0.05$).* ***Conclusion:*** *There was no difference in the microleakage levels of nanohybrid composite resin using eighth-generation bonding materials produced from ethanol and isopropanol solvents under moist and dry conditions.*

Keywords: *eighth-generation bonding; moist; dry; ethanol; isopropanol*

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INTRODUCTION

Eighth-generation bonding materials are known to be universal adhesive materials which can be applied not only using total-etch and self-etch techniques, but also by means of a selective-etch technique.[1] Eighth-generation bonding has several advantages including its applicability to moist and dry cavities, since it can be made from solvents such as ethanol (C_2H_5OH) and isopropanol (C_3H_7OH) which can absorb excess water relatively effectively.[2] Isopropanol demonstrates a greater ability to bind water and a higher viscosity than ethanol. The evaporation rate of isopropanol is lower than that of ethanol with the result that it can absorb water more effectively and the smear layer below the liquid can be modified and infiltrated into the dentinal tubules that then bind to collagen fibers.[2]

Under moist conditions, the bonding technique produces strong bonds between dentine and composite resin, while excessively moist dentin conditions can induce the trapped water to interfere with the diffusion and polymerization of monomer resins. During this process, porous layers can be formed with the result that the bond decreases both in vivo and in vitro. Meanwhile, under dry dentine conditions, the application of bonding will result in obstruction of monomer diffusion due to collagen matrix collapse.[3]

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A previous study compared the shear bond strength of the attachment between ethanol and acetone solvents using one step self-etch bonding technique under dry and moist dentine conditions. This previous study demonstrated that bonding material made from ethanol solvent possessed higher shear bond strength under dry conditions than ethanol solvent under moist conditions. Moreover, this previous study also showed that bonding material made from acetone solvent possessed a higher adhesive shear strength under moist conditions than did such materials under dry conditions.[4]

Nanohybrid composite resin contains nano-sized particles, namely; 0.005-0.020 μm in the resin matrix.[5] It also contains additional components of the resin matrix in the form of nanoparticles and nanoclusters[6], the combination of which can reduce the interstitial distance between particles, thereby increasing resistance filler, physical properties, mechanical properties and retention.[7,8]

Microleakage can be caused by shrinkage during the polymerization process and the lack of adhesive material attachments to enamel and dentin. Emergent cracks are still considered restoration-related problems because fluids, ions and bacteria can pass through them, causing other problems such as secondary caries, discoloration of ridge edges, pulp irritation and sensitive teeth. Therefore, the eighth-generation bonding that combines etching, primer and adhesive components is expected to reduce the weakness of previous generation bonding with the result that it can be applied not only to moist and dry cavity conditions, but can also support dentists in their application to achieve the success of restoration by causing more limited microleakage.[8] Hence, this study aimed to determine the difference of microleakage levels of nanohybrid composite resin using the eighth-generation bonding materials made from ethanol and isopropanol as solvents under moist and dry conditions.

MATERIALS AND METHODS

This study, which constituted an experimental laboratory research involving 36 maxillary permanent premolars, received ethical approval from the Health Research Ethics Commission of the Faculty of Medicine, Universitas Jenderal Soedirman (Number: 272/KEPK/X/2018). A rectangular grade V cavity on the buccal side 1mm above the cervical line of the tooth was created in each sample. The resulting cavities had a mesiodistal length of 3 mm, an occluso-gingival width of 2 mm and a buccolingual direction depth of 2 mm.[9] A self-etch technique was employed to apply the eighth-generation bonding materials to those cavities which were then filled with nanohybrid composite. Thereafter, the samples were divided into four groups, namely: Group I - ethanol-based bonding applied under dry conditions, Group II - ethanol-based bonding applied under moist conditions, Group III - isopropanol-based bonding applied under dry conditions and Group IV - isopropanol-based bonding applied under moist conditions.

In Groups I and III, application of the eighth-generation bonding material under dry conditions was performed after the cavities had been cleaned and dried with a wind spray for ten seconds. Meanwhile, in Groups II and IV, the application of the eighth-generation bonding material under moist conditions was conducted after the cavities had been cleaned with water and rubbed for three seconds using an absorbent pad without contact being made with the bases of the cavities. The eighth-generation bonding material produced from ethanol solvent was applied to Groups I and II for 20 seconds, while the cavities in those groups were scrubbed. Similarly, the eighth-generation bonding material manufactured from isopropanol was also applied to Groups III and IV for 20 seconds, while the cavities in those groups were being scrubbed. After application of the bonding materials, the cavities were dried with a wind spray for ten seconds and a curing light for 20 seconds. Nanohybrid composite resin was then applied to the cavities until they were completely closed.[10]

The samples were soaked in receptacles containing distilled water, placed in an incubator at 37^{o}C for 24 hours and dried a with paper towel. The entire surface of the samples up to 1 mm around the restoration areas was subsequently coated with transparent nail polish before being immersed in a methylene blue solution and incubated for four hours at 37^{o}C. After each group had been treated, all the teeth were washed with water to remove the remaining methylene blue and dried with a paper towel. Finally, the samples were cut vertically to enable the mesial and distal portions to be extracted.[11]

Each pair of tooth halves was examined for signs of microleakage around the edge of the teeth with a stereo microscope (Olympus SZ61). One side of the tooth halves in each sample which had the deepest penetration of methylene blue 0.5% was then selected for scoring. The scores for microleakage assessment comprised: score 0 which indicated no color penetration of the cavity; score 1 which related to penetration of less than or equal to half the cavity wall; score 2 which indicated color penetration of more than half the cavity wall, but not extending to the base of the cavity and score 3 which related to color penetration reaching the base of the cavity.[12] The results of the data obtained were in the form of ordinal data scales. The data was subsequently analyzed using a non-parametric statistical test, the Kruskal Wallis test, to determine differences in microleakage levels between groups.

RESULTS

Microleakage examination was performed by means of a stereo microscope to observe the methylene blue color penetration with assessment subsequently being performed on a scale of 0 to 3. The mean score of microleakage levels in each group can be seen in Figure 1 which shows that the

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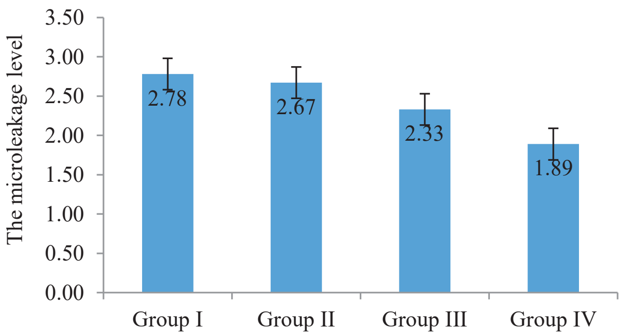

Figure 1. Microleakage levels

Table 1. Microleakage level results of *Kruskal-Wallis* test.

Group	Mean rank	Sig.
I	22.28	
II	22.50	0.141
III	16.67	
IV	13.56	

respective mean microleakage scores in the various groups was as follows: Group I - 2.78 ± 0.441, Group II - 2.67 ± 0.707, Group III - 2.33 ± 0.707 and Group IV - 1.89 ± 1.054. The microleakage test-produced data of all groups were then statistically analyzed with a Kruskal-Wallis test to determine the effects of the overall bonding solvents on microleakage levels under different conditions (see Table 1).

According to the Kruskal-Wallis statistical test results, the p-value of the microleakage level between groups was 0.141. This indicates that there was no significant difference in the levels of microleakage between groups ($p<0.05$).

DISCUSSION

The results of this study showed that there was no significant difference between the application of the eighth-generation bonding material made from ethanol solvent under moist and dry conditions. The low level of viscosity characteristic of ethanol enables it to facilitate penetration of bonding material into dentinal tubules. Ethanol also has a vapor pressure of 5.95 kPa with the result that the high evaporation rate will cause the solvent to vaporize more rapidly. As a result, the eighth-generation bonding materials, which still require longer to penetrate the dentinal tubules, can evaporate faster.[13]

The results also indicated that the dry and moist conditions of cavities does not affect the bonding materials when the self-etch technique is employed. Moreover, because it is not applied to the etching separately, it neither removes the smear layer nor open ups collagen fibers. Under moist conditions, the water molecules remain present in the dentine. If ethanol-based bonding material is applied under moist conditions, these cannot vaporize entirely because of the high level of ethanol evaporation resulting in disruption of the remaining water molecules and penetration of the bonding material. Meanwhile, under dry conditions, no water molecules are present in the dentine with the result that the bonding material can penetrate the dentinal tubules. High levels of ethanol evaporation can accelerate bonding material evaporation before completely penetrating the dentinal tubules resulting in a low hybrid layer.[14]

Acid in the eighth-generation bonding derived from ethanol and isopropanol solvents will produce areas of demineralization. However, because of the presence of acid in the eighth-generation bonding material with a pH higher than 2.5, the resulting demineralization is shallow. The dissolved smear layer will then emerge around the collagen fibers that form a low hybrid layer because of the area of low demineralization.[11] The low hybrid layer will result in a weak bond between the tooth structure and the composite leading to microleakage. The enamel bonding mechanism will subsequently experience chemical interactions between the 10-MDP functional monomers which produce low microtags with the result that the self-etch bonding technique does not address all problems associated with enamel attachment.[15] This finding is consistent with that of research conducted by Usha *et al.* (2017),[15] and Choi *et al.* (2017),[16]. For example, Usha *et al.* (2017),[15] showed that high evaporation rates in ethanol trigger more rapid evaporation of bonding materials, while the results of a study conducted by Choi *et al.* (2017),[16] showed that the application of bonding material under dry dentin conditions will produce a low hybrid layer.

In addition, the results of this study also found that there was no significant difference between the application of the eighth-generation bonding material made from isopropanol solvent under moist conditions and the application of such material under dry conditions. The viscosity level of isopropanol was high with the result that the bonding material will immediately dissolve the smear layer and open the dentinal tubules. High viscosity makes it difficult for bonding material to pass into dentinal tubules and expose collagen fibers.[17] Isopropanol also has a vapor pressure of 1.99 kPa. Low vapor pressure will cause the solvent to evaporate over a longer period with the result that the bonding material still has time to penetrate the dentinal tubules to produce deeper dentine demineralization.[18]

If the bonding material made from isopropanol is applied under moist conditions, the the water molecules will be evaporated by isopropanol. The high viscosity of the bonding material made from isopropanol solvent renders the penetration of the bonding material shallow. Similarly, under dry conditions, isopropanol does not cause water molecules to evaporate. However, the high viscosity of the bonding material made from isopropanol solvent triggers the formation of the low hybrid layer.[14] Finally, it can be concluded that the application of bonding materials made from ethanol and isopropanol solvents under moist and dry

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conditions still induces microleakage due to differences in evaporation and viscosity levels resulting in low hybrid layers. Hence, it can be stated that there is no difference in the microleakage levels of nanohybrid composite resin between the eighth-bonding materials made from ethanol and isopropanol under both moist and dry conditions.

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