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One-Year Clinical Evaluation of Composite Restorations in Posterior Teeth: Effect of Adhesive Systems

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Clinical Relevance

Class I composite restorations, placed using either a total etch or a self-etch bonding system, showed equally satisfactory clinical performance after one year.

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SUMMARY

This clinical study assessed the performance of posterior composite resins applied with the Adper™ Single Bond Plus (SB) and Adper™ Scotchbond SE (SE) adhesive systems and Filtek™ Supreme Plus composite resin, using modified US Public Health Service criteria. A total of 97 restorations were placed in posterior teeth by two calibrated operators. Application of the materials followed manufacturers' instructions. The restorations were evaluated by two examiners at baseline and after one year. Statistical analyses were conducted using the proportion test at a significance level of 5% ($p<0.05$). All the restorations evaluated (ie, 100%) received an alpha rating for the criteria of marginal discoloration and marginal integrity at baseline. At one year, for marginal discoloration, 64.6% of SB and 61.2% of SE

received an alpha rating. For marginal integrity, 72.9% of SB and 77.6% of SE received an alpha rating. The other restorations received bravo ratings for both criteria. None of the teeth that received the restorative systems presented caries lesions around the restorations. A total of eight teeth presented postoperative sensitivity one week after baseline, five with SB and three with SE; the symptom had disappeared one year later. One year later, composite resin restorations using either adhesive system showed satisfactory clinical performance.

INTRODUCTION

The introduction of resin-based adhesive materials was revolutionary for the restoration of anterior teeth, and their use was extended to posterior teeth; however, initial clinical evaluations of resin-based restorations in posterior teeth showed shortcomings in this restorative procedure compared with restorations performed with dental amalgam, particularly in regard to marginal discoloration, wear resistance, and incidence of secondary caries,[1,2] factors possibly related to the restorative technique employed and the properties of the adhesive systems in relation to dental tissues, especially dentin tissue.

Since then, researchers and manufacturers have developed and analyzed adhesive systems and techniques for good marginal sealing in dental restorations. In view of this concern, various types of adhesive systems have been developed, including the total etching adhesive system[3] and self-etching adhesive systems.[3,4]

Total etching adhesive systems using phosphoric acid etching have shown excellent clinical performance in terms of durability and bond strength to enamel,[5] but these results are not commonly observed with self-etching adhesive systems.[6] However, when a self-etching adhesive is applied to dentin tissue, the smear layer is not washed out.[7] Thus, pulpal pressure is not modified, explaining the low sensitivity found in a longitudinal clinical study by Gordan and Mjor[8] in 2002 in which resin-based restorative material and self-etching primer in posterior restorations did not result in significant short- or long-term postoperative sensitivity.[9,10]

Although several laboratory studies of adhesive systems have been described in the literature, clinical studies are necessary to determine whether problems identified in the laboratory are clinically significant.

Table 1: *Composition of Adhesive Materials Used in This Study*

Material	Composition
Adper™ Single Bond Plus	Bis-GMA; HEMA; copolymer of polyalkenoic acid, ethanol, water, and photoinitiator
Adper™ Scotchbond SE Plus	Bottle A (primer): water, HEMA, surfactant, and dye pink.
	Bottle B (bond): UDMA, TEGDMA, TMPTMA, HEMA, MHP zircon nanofiller, and canphoroquinona
Filtek Supreme Plus	Bis-GMA, BIS-EMA, UDMA, TEGDMA, and inorganic filler

The aim of this clinical study was to evaluate posterior nanofilled composite resin restorations using a two-step total etching or two-step self-etching adhesive system at baseline (one week later) and one year later. The response variables were marginal discoloration, marginal adaptation, caries lesions, and postoperative sensitivity.

MATERIALS AND METHODS

Experimental Design

A total of 97 class I restorations were placed in 15 patients (10 women and 5 men) of the Dental School of Araçatuba—UNESP with good oral hygiene and ages ranging between 13 and 21 years. Each patient had at least one restoration done with one of the adhesive systems employed in this study.

The selected teeth were restored because they presented primary or secondary caries lesions or restorations with amalgam or composite resin that needed replacing either because of recurrent caries lesions or fractures or even for esthetic reasons; all teeth were in occlusion. The clinical procedures were performed by two calibrated operators. The study was approved by the Ethics Committee of the Institution (process no. 2008-01502). The procedures were explained to the subjects, who gave their written consent to participate.

A nanofilled composite resin, Filtek Supreme Plus (FS;3M ESPE Dental Products, St Paul, MN, USA), in association with a two-step total etching adhesive system, Adper Single Bond Plus (SB), and a two-step self-etching adhesive system, Adper Scotchbond SE Plus (SE; 3M/ESPE; Table 1), were used in this

study. The factors were adhesive systems on two levels (two-step total etching and two-step self-etching), and the response variables were marginal discoloration, marginal adaptation, caries lesions, and postoperative sensitivity. Randomization was used to perform restorations, and there was always present in each patient at least one restoration of each adhesive used.

Operative Procedures

All restoration procedures were performed after anesthesia and dental prophylaxis with pumice and water. The cavity was opened or the existing restoration removed using a cylindrical diamond bur number 1092 (KGSorensen, Industria e Comercio Ltda, São Paulo, Brazil) mounted in a high-speed water-cooled hand piece. In the cave-surface enamel, beveling was not conducted. When carious lesions were found, they were removed with hand instruments and low-speed spherical drills in sizes compatible with the sizes of the lesions. A rubber dam was used. Only deep cavities received a thin layer of resin-modified glass ionomer Fuji II LC (GC Corp, Tokyo, Japan) as a liner, following the manufacturer's instructions.

All cavities were restored with a nanofilled resin composite, Filtek Supreme Plus (3M ESPE). For 48 cavities, a total etching adhesive system (SB) was used, and for 49 cavities, a two-step self-etching adhesive system (SE) was used. The cavities were restored in a randomized way. Table 1 shows the distribution of restorations among selected patients in the maxillary and mandibular arches. The materials were applied according to the manufacturers' instructions as follows.

Adper Single Bond Plus—The entire cavity was etched with 35% Scotch Etchant (3M ESPE) for 15 seconds in dentin tissue and 60 seconds in the enamel, rinsed with water spray, and air-dried. After drying, the enamel surface was completely dry, and the dentin had a moistened appearance . The adhesive system was applied with a microbrush and light cured for 20 seconds with a halogen light source, an Ultralux (Dabi Atlante, Ribeirão Preto, Brazil) with a power of 450 mW/cm^2.

Adper Scotchbond SE Plus—The cavity preparation was rinsed with water spray and air-dried. The self-etch adhesive system (SE) was composed of liquids designated A and B. Liquid A was initially applied to the cavity with a microbrush, immediately followed by liquid B, which was applied to the cavity for 20 seconds under moderate pressure. The adhesive was air-dried for 10 seconds. After that, a second layer of liquid B was applied, and light polymerization was performed for 10 seconds using an Ultralux (Dabi Atlante) halogen light appliance with a power of 450 mW/cm^2.

Filtek Supreme Plus—Following an incremental technique, the composite materials were applied using the oblique layering technique, with each layer not exceeding 2 mm. Each increment was light polymerized separately for 40 seconds using an Ultralux light-curing unit with a power of 450 mW/cm^2 Ultralux (Dabi Atlante).

The occlusal adjustment was performed with carbon paper (Accufilm: MDF for Parkell). The restorations were finished with diamond point number 1190 (KGSorensen, Indústria e Comércio Ltda), followed by the application of Enhance finishing points (Dentsply, Indústria e Comércio Ltda, Rio de Janeiro, Brazil).

Clinical and Statistical Analysis

Clinical analysis of the restorations was performed at baseline (one week after the procedure) and after one year in a duly illuminated operative field. Two duly calibrated independent clinicians not involved in the original placement evaluated the restorations after their placement at baseline and after one year, using an exploratory probe number 5 and a buccal mirror. In the case of disagreement over assessments, the examiners had to reach a consensus, considering the factors of marginal adaptation, marginal discoloration, the presence of marginal caries lesions, and postoperative sensitivity, using modified USPHS criteria[11] (Table 2).

The results were analyzed using the kappa test to evaluate the degree of reproducibility between the two examiners. Statistical analysis was conducted using the proportion test at a significance level of 5% ($p<0.05$).

RESULTS

The kappa test reported 80% concordance between the two examiners. All the restorations evaluated received an alpha rating for the criteria of marginal discoloration and marginal integrity at baseline. The results of clinical evaluations one year after the baseline exam are shown in Figures 1 and 2 for marginal discoloration and marginal integrity, respectively. After one year, for marginal discoloration, 64.6% of SB received an alpha rating, compared with 61.2% for SE adhesive systems. For marginal integrity, 72.9% of SB and 77.6% of SE adhesive

Table 2: *Modified US Public Health Service[14] Criteria*

Category	Code	Criteria
Marginal discoloration	ALPHA/A	Absence of marginal color alteration of restoration
	BRAVO/B	Alteration of marginal color of restoration, in a small extension
	CHARLIE/C	Alteration of marginal color of restoration, in a large extension
	DELTA/D	Alteration of marginal color of restoration, in the full extension
Caries lesions[a]	ALPHA/A	Absence of caries lesion at the restoration margin
	BRAVO/B	Presence of caries lesion at the restoration margin
Postoperative sensitivity one week after restoration (baseline)	ALPHA/A	Absence of sensitivity
	BRAVO/B	Presence of sensitivity
Postoperative sensitivity one year after restoration	ALPHA/A	Absence of sensitivity
	BRAVO/B	Presence of sensitivity
Marginal adaptation	ALPHA/A	Absence of gap at restoration margin; the explorer does not catch at the tooth/restoration interface
	BRAVO/B	Presence of gap at the restoration margin, with retention of the explorer at the tooth/restoration interface, but without dentinal exposure
	CHARLIE/C	Presence of gap at the restoration margin, with retention of the explorer at the tooth/restoration interface, but with dentinal exposure
	DELTA/D	Presence of gap at the restoration margin, with retention of the explorer at the tooth/restoration interface, with dentinal exposure and the restoration fractured and/or showing mobility

[a] *A region of the restoration margin was considered carious if the explorer caught or resisted removal, after moderate pressure, and if one of the following factors was observed: presence of softened dental tissue or marginal white stain lesion with evidence of demineralization.*

systems received an alpha rating. The remaining restorations were cataloged with a bravo rating for both criteria.

The proportion test revealed no statistically significant differences between SB and SE adhesive systems for marginal discoloration ($p=0.732$) or marginal integrity ($p=0.597$) after one year.

Postoperative sensitivity was observed in eight restored teeth (five SB and three SE) one week later. None of the restorations were cataloged with charlie or delta rating criteria or lost during the evaluation period of one year, and no sensitivity was found in the one-year follow-up. No verified secondary caries were found around the restorations one year later.

DISCUSSION

Adhesive systems are constantly being improved; however, their development has been so rapid that long-term clinical data on specific products are rarely available because of the regular introduction of "improved" versions,[9] justifying the need for laboratory research and longitudinal clinical studies.

In this study, we evaluated the clinical performance of posterior composite resin restorations made with a two-step total etching adhesive system

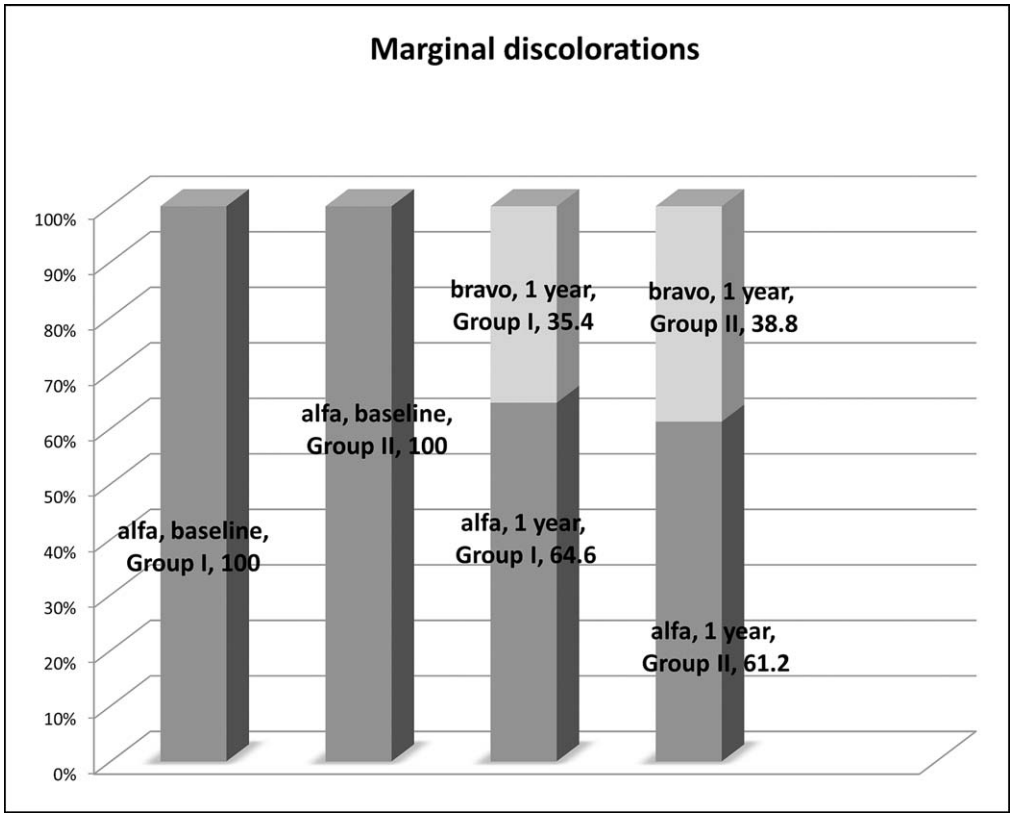

Figure 1. *Scores for marginal discoloration of the clinical evaluation of posterior composite restorations carried out with Filtek™ Supreme Plus and the SB and SE adhesive systems*

(SB) or a two-step self-etching adhesive system (SE) over a period of 12 months. It was observed that no restorations were lost, and there were no significant differences between restorations applied with either adhesive system in the variables of secondary caries incidence, postoperative sensitivity, marginal discoloration, or marginal adaptation. Similar clinical observations have been made in other clinical studies.[9–13]

It has been scientifically established that etching on the enamel surface followed by the application of an adhesive system is able to penetrate the dental surface,[6,14] but this has not been observed with self-etching adhesive systems.[6,14] However, our results showed similar marginal discoloration and integrity among the restorations applied with SE or SB, probably as a result of adequate incremental technique, avoiding simultaneous bonding of the composite to the opposite walls, reducing cavity configuration factors,[15] low polymerization contraction by nanofilled composite resin, and adequate light on the polymerization unit.[16–18] It is worthwhile to consider that, after polymerization, the direct class I resin composite restorations present a three-dimensional cavity configuration that favors the retention of restorative material, unlike those of direct class IV and V resin composite restoration cavities such that their retention is maintained almost exclusively by the action of the adhesive system used.[19–22]

Furthermore, we must consider that adequate solvent evaporation, the application according to the manufacturer's recommendations, and the use of a rubber dam during the restorative procedure improved the performance of the adhesive.[23–25]

After one year, the majority of restorations applied with either adhesive system, SB or SE, and the nanofilled composite resin presented with an alpha rating, with 64.6% and 61.2% marginal discoloration and 72.9% and 77.6% marginal integrity for SB and SE adhesive systems, respectively. The other restorations were given bravo ratings. When marginal discoloration was observed in some restorations, it was slight.

Whereas during a rigorous adhesive restorative procedure in posterior teeth a nonpurposeful excess of composite resin material can be left beyond the

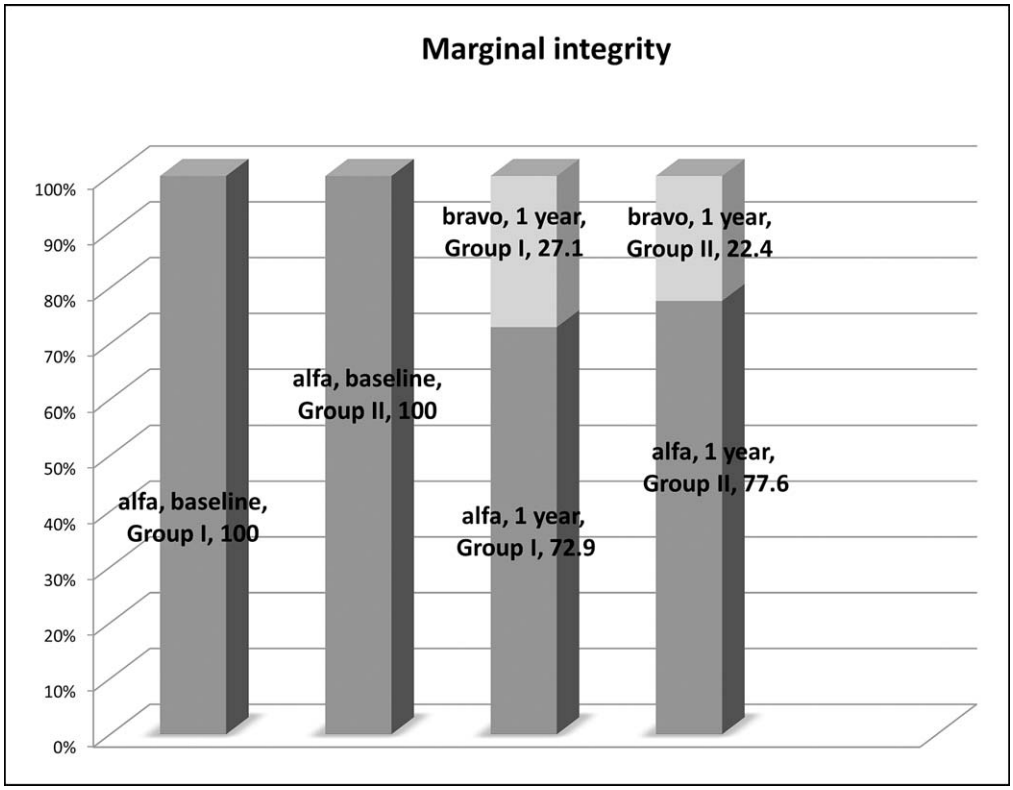

Figure 2. *Scores for marginal integrity of the clinical evaluation of posterior composite restorations carried out with Filtek™ Supreme Plus and the SB and SE adhesive systems*

cavity margin, considered "overfilling,"[26] this undesired effect, even when slight, can contribute to small marginal fractures, leading to bravo scores for marginal integrity. It is worth noting, however, that cataloged restorations with bravo scores are still considered clinically acceptable because of the rigorous criteria used, precluding the need for replacement of these restorations.[27]

Postoperative sensitivity must be considered an important factor in the success of restorations; in this study, 10.4% of SB restorations and 6.1% of SE restorations showed slight postoperative sensitivity one week after the restorations (baseline exam), but no sensitivity was found in the one-year follow-up. Possibly, this postoperative sensitivity verified only during the baseline exam is related to the dimensions of the cavity preparations, the enamel marginal sealing, and the occlusal adjustments accomplished after treatment.[25] However, the sensitivity was not present after one year.

Marginal imperfections and secondary caries lesions in posterior composite restorations are some of the factors that predict their need for replacement.[28] However, this study found no restorations with secondary caries lesions one year later for either adhesive system employed. Observations consistent with those of Bekes[27] in 2007 and Akimoto[29] in 2007 reinforced the finding that marginal imperfections, such as those found in this study and receiving a bravo rating, do not necessarily lead to secondary caries lesions.[11]

It is important to emphasize that this study evaluated only direct class I resin composite restorations, where all the margins were in enamel, without dentinal exposure at the tooth/restoration interface; dentin substrate is more challenging for any composite bonding system, so our results are not applicable to restorations with borders in the dentin or root. Assessment in future years will be necessary to gain useful information regarding material performance.

Early clinical results are promising, but long-term assessment is required for more precise conclusions. Thus, we must consider that the success of bonded restorations is determined mainly by the excellence of the technique employed, with appropriate application of the adhesive system and adherence to the steps for insertion, polymerization, finishing, and polishing of these restorations.[30] Likewise, we cannot overlook the fact that the collaboration of

the patients will certainly significantly influence the longevity of their restorations.[11]

CONCLUSION

This clinical evaluation of composite resin restorations in posterior teeth performed with a nanofilled composite resin and a one-bottle total etching adhesive system or self-etching adhesive system presented good clinical performance after one year.

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CONFLICT OF INTEREST

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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REFERENCES

1. Osborne JW, Gale EN, & Ferguson GW (1973) One-year and two-year clinical evaluation of composite resin x amalgam. *Journal of Prosthetic Dentistry* **30(5)** 795-800.
2. Phillips RW, Avery DR, Mehra R, Swartz ML, & McCune RJ (1973) Observations on a composite resin for class II restorations: Three-year report *Journal of Prosthetic Dentistry* **30(6)** 891-897.
3. Tay FR, & Pashley DH (2003) Have dentin adhesives become too hydrophilic? *Journal of the Canadian Dental Association* **69(11)** 726-731.
4. Perdigao J (2007) New developments in dental adhesion *Dental Clinics of North America* **51(2)** 333-357, viii.
5. Ramires-Romito AC, Reis A, Loguercio AD, Hipólito VD, de Goes MF, Singer JM, Grande RH. (2007) Microtensile bond strength of sealant and adhesive systems applied to occlusal primary enamel. *American Journal of Dentistry* **20(2)** 114-120.
6. Sundfeld RH, de Oliveira CH, da Silva AM, Briso AL, & Sundfeld ML (2005) Resin tag length of one-step and self-etching adhesives bonded to unground enamel *Bulletin of Tokyo Dental College* **46(3)** 43-49.
7. Tay FR, & Pashley DH (2001) Aggressiveness of contemporary self-etching systems. I: Depth of penetration beyond dentin smear layers *Dental Materials* **17(4)** 296-308.
8. Gordan VV, & Mjor IA (2002) Short- and long-term clinical evaluation of post-operative sensitivity of a new resin-based restorative material and self-etching primer *Operative Dentistry* **27(6)** 543-548.
9. Celik C, Arhun N, & Yamanel K (2010) Clinical evaluation of resin-based composites in posterior restorations: 12-month results. *European Journal of Dentistry* **4(1)** 57-65.
10. Swift EJ Jr, Ritter AV, Heymann HO, Sturdevant JR, & Wilder AD Jr (2008) 36-month clinical evaluation of two adhesives and microhybrid resin composites in class I restorations. *American Journal of Dentistry* **21(3)** 148-152.
11. Rezwani-Kaminski T, Kamann W, & Gaengler P (2002) Secondary caries susceptibility of teeth with long-term performing composite restorations *Journal of Oral Rehabilitation* **29(12)** 1131-1138.
12. Cvar JF, & Ryge G (2005) Reprint of criteria for the clinical evaluation of dental restorative materials. 1971 *Clinical Oral Investigations* **9(4)** 215-232.
13. Gaengler P, Hoyer I, & Montag R (2001) Clinical evaluation of posterior composite restorations: The 10-year report *Journal of Adhesive Dentistry* **3(2)** 185-194.
14. De Alexandre RS, Sundfeld RH, Giannini M, & Lovadino JR (2008) The influence of temperature of three adhesive systems on bonding to ground enamel *Operative Dentistry* **33(3)** 259-268.
15. Carvalho RM, Pereira JC, Yoshiyama M, & Pashley DH (1996) A review of polymerization contraction: The influence of stress development versus stress relief *Operative Dentistry* **21(1)** 17-24.
16. Correr AB, Sinhoreti MA, Correr Sobrinho L, Tango RN, Schneider LF, & Consani S (2005) Effect of the increase of energy density on Knoop hardness of dental composites light-cured by conventional QTH, LED and xenon plasma arc *Brazilian Dental Journal* **16(3)** 218-224.
17. Ferracane JL (2006) Hygroscopic and hydrolytic effects in dental polymer networks *Dental Materials* **22(3)** 211-222.
18. Ferracane JL, Ferracane LL, & Musanje L (2003) Effect of light activation method on flexural properties of dental composites *American Journal of Dentistry* **16(5)** 318-322.
19. Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, & Van Meerbeek B (2005) Clinical effectiveness of contemporary adhesives: A systematic review of current clinical trials *Dental Materials* **21(9)** 864-881.
20. Van Meerbeek B, Braem M, Lambrechts P, & Vanherle G (1993) Two-year clinical evaluation of two dentine-adhesive systems in cervical lesions *Journal of Dentistry* **21(4)** 195-202.
21. Van Meerbeek B, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, & Peumans M (2005) A randomized controlled study evaluating the effectiveness of a two-step self-etch adhesive with and without selective phosphoric-acid etching of enamel *Dental Materials* **21(4)** 375-383.
22. Van Meerbeek B, Perdigao J, Lambrechts P, & Vanherle G (1998) The clinical performance of adhesives *Journal of Dentistry* **26(1)** 1-20.
23. Tay FR, Pashley DH, Garcia-Godoy F, & Yiu CK (2004) Single-step, self-etch adhesives behave as permeable membranes after polymerization. Part II. Silver tracer penetration evidence *American Journal of Dentistry* **17(5)** 315-22.
24. Tay FR, Pashley DH, Suh B, Carvalho R, & Miller M (2004) Single-step, self-etch adhesives behave as permeable membranes after polymerization. Part I. Bond

strength and morphologic evidence *American Journal of Dentistry* **17(4)** 271-278.

25. Tay FR, Pashley DH, Yiu C, Cheong C, Hashimoto M, Itou K, Yoshiyama M, King NM. (2004) Nanoleakage types and potential implications: Evidence from unfilled and filled adhesives with the same resin composition *American Journal of Dentistry* **17(3)** 182-190.
26. Briso AL, Mestrener SR, Delicio G, Sundfeld RH, Bedran-Russo AK, de Alexandre RS, Ambrosano GM. (2007) Clinical assessment of postoperative sensitivity in posterior composite restorations *Operative Dentistry* **32(5)** 421-426.
27. Bekes K, Boeckler L, Gernhardt CR, & Schaller HG (2007) Clinical performance of a self-etching and a total-etch adhesive system—2 year results. *Journal of Oral Rehabilitation* **34(11)** 855-861.
28. Gaengler P, Hoyer I, Montag R, & Gaebler P (2004) Micromorphological evaluation of posterior composite restorations—A 10-year report. *Journal of Oral Rehabilitation* **31(10)** 991-1000.
29. Akimoto N, Takamizu M, & Momoi Y (2007) 10-year clinical evaluation of a self-etching adhesive system. *Operative Dentistry* **32(1)** 3-10.
30. Leinfelder KF, Radz GM, & Nash RW (1998) A report on a new condensable composite resin. *Compendium of Continuing Education in Dentistry* **19(3)** 230-232.