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Comparative Evaluation of Post Operative Sensitivity after Posterior Composite Restorations Using Two Different Bonding Agents (With and Without Nanofillers) in Two Different Age Groups: An in Vivo Study

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Abstract

Background: Postoperative sensitivity is one of the major problems regarding posterior resin composite restorations that causes patient discomfort and maybe a reason for replacement of the restoration with an additional office time.

Aim: The study aimed at evaluating the post operative sensitivity following restoration done using two different bonding agents (with and without nanofillers) for posterior composite restorations and to evaluate the role of nano fillers in reducing postoperative sensitivity in two different age groups.

Materials And Methods: Eighty-eight patients requiring class II cavity were included in the study and were randomized in to two groups Group 1 G-Premio bond bonding agent (with nanofiller) and group 2 prime and bond bonding agent (without nano filler) these groups were divided in to sub groups according to age, sub group A (15-25yr) and sub group B (35-45yr). After class II cavity preparation patients were contacted for evaluation of postoperative sensitivity at 1 day, 1 week, 1 month, and 3 months on VAS. The mean VAS score was calculated for all individuals in the treatment group. The data was tabulated in Microsoft excel and analysed with SPSS V.24 software. The continuous variables were presented with mean and standard deviation. The categorical variables were presented with frequency and percentage. Independent t test and Repeated measures ANOVA was used for the statistical analysis. The p value ≤0.05 was considered statistically significant.

Results: The group 1, showed a significantly less postoperative sensitivity compared with the group 2, at 1 day, and 1-week evaluation periods. While both groups did not possess any significant difference at 1 month, and 3 months periods.

Conclusion: The problem of postoperative sensitivity following resin composite restorations could be reduced by the addition of nanoparticles into dental adhesives and higher POS was seen in younger patients.

Keywords: Copolymerize, Cavity, Microleakage, Postoperative Sensitivity

Introduction

Composite resins and adhesive technology have developed rapidly. Despite these developments, postoperative sensitivity following composite restorations is still a challenge for practitioners. Clinical studies revealed the presence of such complaints in 0-30% of the study populations [1]. It was reported that postoperative pain could be related to preparation trauma and microleakage of bacteria [2]. Other studies reported that polymerization shrinkage of composite leads to internal stresses, debonding and gap formation between the composite and tooth, leading to deformation of restorations under occlusal stresses which transmits hydraulic pressure to the odontoblastic processes causing pain [3,4]. Several strategies have been presented in the literature trying to solve the problem of postoperative sensitivity, by using different light curing modes [5], different adhesive strategies [6], applying cavity disinfectants and desensitizers before the bonding procedure [7], and implementing different techniques for placement of posterior composite restorations [8].

Post-operative sensitivity solution has been related to dentin adhesives' ability to seal up the gaps and open dentinal tubules that are present at the interface between the dentin adhesive and the dentin rather than the continuous trial to decrease polymerization shrinkage and its effects on cuspal deflections and marginal adaptation as was generally believed [9]. To address this solution, it was necessary to develop novel dental adhesives that could block theses gaps, thus decreasing postoperative sensitivity.

7th generation bonding agents have high bond strength of 20 – 30 MPa to enamel and dentine and thin film thickness ensures complete seating of restoration.7th generation bonding agents are tolerant to moist and dry environment and they are radiopaque so it is easier to differentiate adhesive layer from recurrent caries. 7th generation bonding agents use the smear layer as a bonding substrate the acidic primer demineralizes the smear layer and the top layer of underlying dentine surface. the acidic primer also infiltrates the exposed collagen along with hydrophilic monomer which then copolymerise. They cause little to no marginal discolouration over time.[18]

8th generation bonding agents are compatible with total etch, self-etch, and selective etch techniques providing excellent versatility. It's all in 1 step which limits the number of bottles to one so reducing the clinical time and nano fillers increase the penetration of resins monomer and the hybrid layer thickness, which in turn improves the mechanical properties of bonding system and with a unique combination of three functional monomer (4-MET, MDP MDTP) ensures excellent stability and exceptional bond strength. Adhesive system simultaneously etch, infiltrate, and polymerize to seal the prepared dentin.

The proposed study was aimed at evaluating the incidence and severity of post restoration sensitivity using 7th and 8th generation dentin bonding agents in two

different age groups, it is proposed that [1] due to presence of filler particles better penetration and thicker hybrid layer 8th generation bonding agents will be associated with lesser post operative sensitivity.[2] Post operative sensitivity in older age group patients may not be affected by the presence of filler particles in bonding agents to the extent it affected the younger patients due to increased mineral content, narrow dentinal tubules and presence of reparative dentin.

Material and Methods

Inclusion Criteria

- Selected patients had to have a moderate to deep proximal carious lesion in posterior teeth as diagnosed by clinical examination and an intra oral periapical radiograph.
- Selected teeth had to have an occlusal contact with natural or crowned antagonist tooth so that it could be tested for post operative pain during food mastication.
- Patients had to have healthy gingival tissues, without gingival recession or alveolar bone loss.

Exclusion Criteria

- Patients with signs and symptoms of pulpal and periapical disease.
- Patients with defective restorations that need replacement
- Patients taking any medications and analgesics

Randomization

- Baseline data of patients was calculated and was included in the study as per inclusion criteria. Stratified randomization technique based on age group was used to randomize the patient in each of the two arms.
- Blinding of participants and statistician was done whereas blinding was not be possible for clinician.
- Candidates with proximal caries of posterior teeth were randomly allocated to two different groups

Group 1 Adhesive with nanofillers

A) Age group 15 – 25year

B) Age group 45 – 55year

Group 2 Adhesive free of nanofillers

A) Age group 15 – 25year

B) Age group 45 – 55year

Treatment procedure

- Administration of local anesthesia i.e., 1.8ml of 2% xylocaine with adrenaline 1:80000 was done.
- The field of operation was isolated with the application of Rubber dam and Conventional Class II cavity preparation was done using a high-speed handpiece with constant air and water coolant.
- In group 1 after cavity preparation G -Premio Bond bonding agent (contains nano filler) was applied according to the manufacturer's instructions in subgroup A and B: a generous amount of the bonding agent was applied to the enamel and dentin surfaces using a disposable applicator brush. Scrubbing of the surfaces was done with a brushing motion for 20 seconds and was cured with light cure unit, cavity was restored with composite restoration.
- In group 2 after cavity preparation Prime & Bond Universal bonding agent (free of nano fillers) was applied according to the manufacturer's instructions in subgroup A and B: applying generous amount of the bonding agent to the enamel and dentin surfaces using a disposable applicator brush. Scrubbing of the surfaces was done with a brushing motion for 20 seconds and then was cured with light cure unit after drying, cavity was then restored with composite restoration.

Figure 1:

(a) Is showing preoperative intraoral photo of class II cavity under rubber dam isolation,

(b) Post operative photo,

(c) Photo showing materials used in this study,

(d) Showing pre and post operative IOPA radiograph

Data collection

- Post operative sensitivity was evaluated using VISUAL ANALOGUE SCALE
- It was 100 mm horizontal line with a descriptor at its far-left end indicating no pain, and at its far-right end indicating the worse pain.
- Illustration of facial expressions with color code was added in Visual Analog Scale.

Post Operative Sensitivity was tested against normal daily life stimuli, patients were requested to report their pain levels against cold, hot, stimuli during drinking or eating, and pressure stimuli during their masticatory routine.

- Post operative sensitivity was evaluated on follow up on 1st day, 1 week, 1 month, and 3 months

Data Analysis

- Data was tabulated in Microsoft excel and was statistically analyzed using SPSS software.
- The descriptive variables were presented as mean and standard deviation.
- Statistical analysis of difference was performed using independent t test. The two-sided p value < 0.05 was considered as statistically significant

Result

The present study was carried out with an aim to evaluate the post operative sensitivity between two different bonding agents for posterior composite restorations and to evaluate the role of nano fillers in reducing postoperative sensitivity in two different age groups. The experimental protocols were implemented exactly as planned, and no modifications were performed. A total of 88 patients were recruited and assessed for eligibility. These patients were divided into two groups. Group 1(G-Premio bond) with nanofiller bonding agent and group 2 (prime & bond) without nanofiller and these groups were further divided into two sub groups according to their age. Sub group A with patient age between 15 -25 year and sub group B with patients age between 45 – 55year. Then these patients were subjected to the randomisation procedure and allocated to one of the treatment options to be 22 patients in each group from the both age groups. All patients returned to a 3 months recall.

None of the subjects needed an analgesic drug to reduce postoperative sensitivity (POS). Regardless of the group, most of the postoperative sensitivity complaints occurred within the 1 day and 1st week evaluation periods.

Table 1: Comparison of post-operative sensitivity between Group 1A and 1B

Time	Group 1A		Group 1B		P value
	Mean	SD	Mean	SD	
Preoperative	3.14	2.27	2.45	0.96	0.173
Day 1	0.73	2.35	0.00	0.00	0.032
1 week	0.73	2.35	0.00	0.00	0.029
1 month	0.00	0.00	0.00	0.00	-
3 months	0.00	0.00	0.00	0.00	-

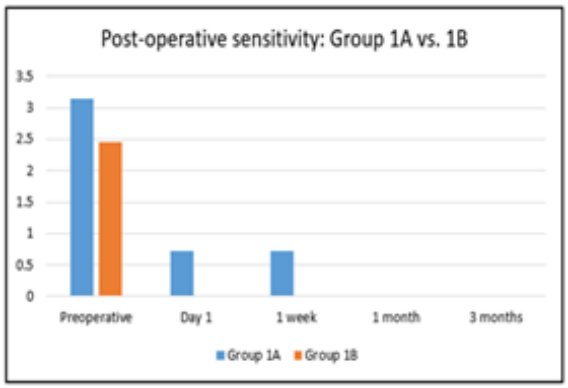


Table 2: Comparison of post-operative sensitivity between Group 2A and 2B

Time	Group 2A		Group 2B		P value
	Mean	SD	Mean	SD	
Preoperative	5.23	2.98	2.32	1.62	<0.001
Day 1	2.00	2.60	0.32	1.49	<0.001
1 week	2.82	3.32	0.36	1.71	<0.001
1 month	0.00	0.00	0.00	0.00	-
3 months	0.00	0.00	0.00	0.00	-

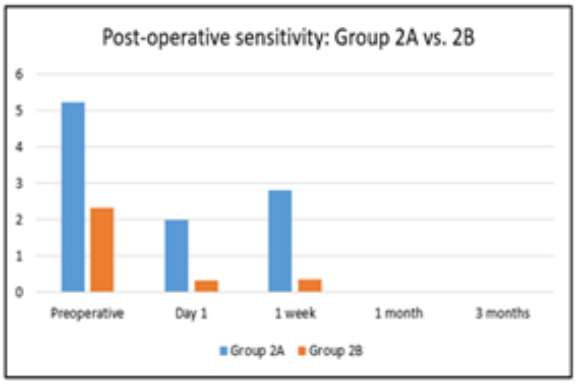


Table 3: Comparison of post-operative sensitivity between Group 1A and 2A

Time	Group 1A		Group 2A		P value
	Mean	SD	Mean	SD	
Preoperative	3.14	2.27	5.23	2.98	0.122
Day 1	0.73	2.35	2.00	2.60	<0.001
1 week	0.73	2.35	2.82	3.32	<0.001
1 month	0.00	0.00	0.00	0.00	-
3 months	0.00	0.00	0.00	0.00	-

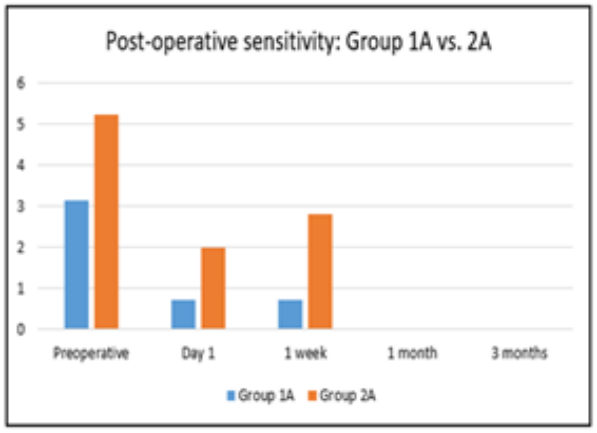
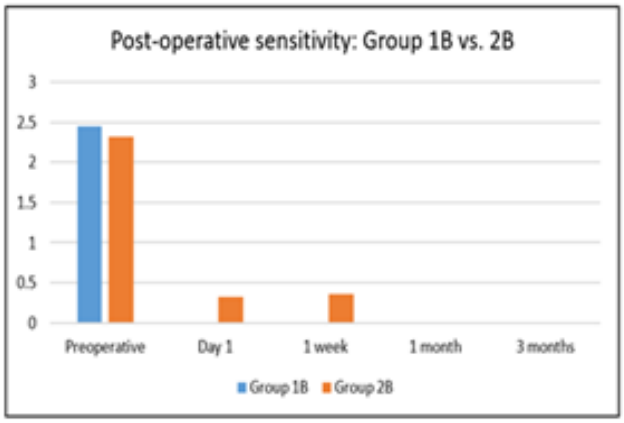


Table 4: Comparison of post-operative sensitivity between Group 1B and 2B

Time	Group 1B		Group 2B		P value
	Mean	SD	Mean	SD	
Preoperative	2.45	0.96	2.32	1.62	0.735
Day 1	0.00	0.00	0.32	1.49	<0.001
1 week	0.00	0.00	0.36	1.71	<0.001
1 month	0.00	0.00	0.00	0.00	-
3 months	0.00	0.00	0.00	0.00	-



To sum up when group 1(with nanofiller) A (15-25yr) was compared with 1 (with nanofiller) B (45-55yr) higher POS was found in group 1(with nanofiller) A(15-25yr).

When group 2(without nanofiller) A (15-25yr) was compared with 2(without nanofiller) B (45-55yr) higher POS was found in 2(without nanofiller) A (15-25yr).

When group 1(with nanofiller) A (15-25yr) was compared with 2(without nanofiller) A (15-25yr) higher POS was found in 2(without nanofiller) A (15-25yr).

When group 1(with nanofiller) B(45-55yr) was compared with 2(without nanofiller) B (45-55yr) higher POS was found in 2(without nanofiller) B (45-55yr).

Discussion

Placing successful posterior composite restorations is challenging and technique sensitive, so any mistake during placement of such restorations will lead to postoperative problems. It is well reported that Post Operative Sensitivity is one of the main problems associated with this type of restoration.

Adhesive restorations bond directly to the tooth structure and reinforce weakened tooth structure.[35] Development of newer dentin bonding agents aims to improve the bonding quality and reduce the time consumption in application.[36] Most common bonding agents used today belong to the sixth-, seventh-, or the most recent eighth-generation.[32]

The blending of nanotechnology with adhesive dentistry led to the development of eighth-generation bonding agents.[30] They are dual-cured (except older formulation), self-etching, nano - reinforced agents and produce comparable bond strengths to both dentin and enamel.[34]

Class II cavities were chosen for this study because of the incidence of post-operative sensitivity in class II cavities is higher than that of other cavity preparations [19], as the increased amount of destruction of dental structure that is found in class II cavities seems to be the determinant factor in the occurrence of post operative sensitivity, this was explained by a series of cuspal contraction and expansion that occurs during the bonding procedure.[13]

Illustration of facial expressions with colour codes was added below the 10- centimetre line Visual Analog Scale, in an attempt to make it better understood by patients.

The three months evaluation period that was assigned for the current study might have provided a more reasonable scenario for testing the effectiveness of the investigated materials, giving them more time to block the incompletely sealed dentinal tubules present in the hybridised layer, thus decreasing post operative sensitivity on longer periods.

In this present study higher POS was seen in sub group 1A (15 -25yr) and sub group 2A (15 -25yr). Less POS was seen in subgroup 1B (45-55yr) and sub group 2B(45-55yr) this is because by increasing age, the thickness of dentine and its sclerosis increases which may lead to decreased nerve stimulation through dentinal tubules. our result was in accordance with the study by Neelam Naz et al in which they reported significant higher hypersensitivity in the age group

below 20 years of age, as compared to age groups 20-30 and above 30 years old.

Higher POS in sub group1A (15-25yr) and 2A (15-25yr) can be attributed to large diameter of dentinal tubules in younger population and higher amount of reparative dentine formation in mature teeth.

Ryou H, Romberg E et al [48] "Importance of age on the dynamic mechanical behaviour of intertubular and peritubular dentin" found that Dentine from young teeth exhibits markedly open tubule lumens, whereas the majority of the tubules from old teeth are completely filled with minerals, with tubular diameter in coronal dentine varying from 4·9 μm in young individuals (between 16 and 30 years old) to 2·9 μm in older individuals (between 51 and 75 years old). Thaler A et al[49] in "Influence of tooth age and root section on root dentine dye penetration" found that tubular occlusion in dentine of older individuals leads to a reduction in fluid movement within the tubules, which explains the decrease in prevalence of DH.

Bharti Sachdeva et al[53] revealed that eighth generation adhesive shows better bond strength than seventh generation. This may be due to the component MDP (Methacryloyloxydecyl dihydrogen phosphate) which has potential to bond chemically with hydroxyapatite crystal. This result was in accordance to the study carried out by Yosheda et al (2004)[54] who concluded that monomer 10-methacryloxydecyl dihydrogen phosphate (10-MDP) readily adhered to hydroxyapatite. This bond appeared very stable, as confirmed by the low dissolution rate of its calcium salt in water.

Both seventh and eighth generation dentin bonding agents contain functional monomers, cross-linking monomers, solvent, inhibitors, and activators, but in different proportions. Cross-linking monomers provide most of the mechanical strength[56], eighth generation bonding agent contain micro sized cross linking functional monomers therefore, there is a potential for higher bond strength than seventh generation.

SH. Kasraei et al[51] in their study on Effect of Nanofiller Addition to an Experimental Dentin Adhesive on Microtensile Bond Strength to Human Dentin concluded that Filler content may be one of the important factors influencing the bond strength of dental adhesives. Adding silanized silica nanofillers to dentin adhesive agent increases microtensile bond strength but it is important to determine the optimum filler level to optimize the dentin bond strength.

Conclusion

In this study clinical follow-up was conducted on 88 class II composite restorations over a 3-month period for POS. In this study least POS was observed in group 1(with nanofiller) B (45-55yr) in which 8th generation bonding agent was used.

Less POS can be due to the incorporation of nanosized cross-linking silica fillers in 8th generation bonding agent. On comparison between different age groups less POS was observed in 35-45 yr age group compared to 15-25yr.This can be attributed to large diameter of dentinal tubules in younger population and higher amount of reparative dentine formation in mature teeth.

Within the limitations of this study, it can be stated that, 8th Generation Bonding Agent show better performance than 7th Generation Bonding Agent in relation to POS.

Though further clinical studies need to be carried out using larger sample size. The 8th Generation Bonding Agent seem promising for adhesion and reduce the problem of postoperative sensitivity following posterior resin composite restorations.

References

1. Al-Nahlawi T, Altaki Z, Abbood D. Post-operative sensitivity of class I, II amalgam and composite resin restorations: Clinical evaluation in an undergraduate program. Int Dent Med J Adv Res 2015;1:1-4.
2. Bjørklund G. The history of dental amalgam. Tidsskr Nor Laegeforen 1989;109:3582-5.
3. Uçar Y, Brantley WA. Biocompatibility of dental amalgams. Int J Dent 2011;2011:981595.Wassell RW, Walls AW, McCabe JF. Direct composite inlays versus conventional composite restorations: three-year clinical results. Br. Dent. J. 1995; 179(9):343-9. https://doi.org/10.1038/sj.bdj.4808919 PMid:74956304.
4. Sutalo J. Composite materials in aesthetic dentistry. Lijec Vjesn 1991;113:187-90.
5. Sabbagh J, Fahd JC, McConnell RJ. Post-operative sensitivity and posterior composite resin restorations: A review. Dent Update 2018;45: 207-213.
6. Akpata ES, Sadiq W. Post-operative sensitivity in glass-ionomer versus adhesive resin-lined posterior composites. Am J Dent 2001;14:34-8.
7. Brännström M. Infection beneath composite resin restorations: Can it be avoided? Oper Dent 1987;12:158-63.
8. Eick JD, Welch FH. Polymerization shrinkage of posterior composite resins and its possible influence on postoperative sensitivity. Quintessence Int 1986;17:103-11.
9. Jordan RE, Suzuki M, Boksman L. Posterior composite restorations -where do we stand? Ont Dent 1985;62:13-4, 17-8, 20.
10. Berkowitz GS, Horowitz AJ, Curro FA, Craig RG, Ship JA, Vena D, et al. Postoperative hypersensitivity in class I resin-based composite restorations in general practice: Interim results. Compend Contin Educ Dent 2009;30:356-8, 360, 362-3.
11. Alomari Q, Omar R, Akpata E. Effect of LED curing modes on postoperative sensitivity after class II resin composite restorations. J Adhes Dent 2007;9:477-81.
12. Coelho-de-Souza FH, Klein-Júnior CA, Camargo JC, Beskow T, Balestrin MD, Demarco FF. Double-blind randomized clinical trial of posterior composite restorations with or without bevel: 6-month follow-up. J Contemp Dent Pract 2010;11:001-8.
13. Hajizadeh H, Ghavamnasiri M, Majidinia S. Randomized clinical evaluation of the effect of chlorhexidine on postoperative sensitivity of posterior composite resin restorations. Quintessence Int 2013;44:793-8.
14. Costa T, Rezende M, Sakamoto A, Bittencourt B, Dalzochio P, Loguercio A, et al. Influence of Adhesive Type and Placement Technique on Postoperative Sensitivity in Posterior Composite Restorations. Oper. Dent. 2017; 42(2):143-54. https://doi.org/10.2341/16-010-C PMid:27892839
15. Vejai Vekaash CJ, Venkatesh KV, Kumar Reddy TV, Devaraj K. A novel method to reduce postoperative sensitivity after composite restoration: A triple-blinded in vivo study. J NTR Univ Health Sci 2018;7:19-22.
16. Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. Dent Mater 2011;27:17-28.

17. Sarrett DC, Brooks CN, Rose JT. Clinical performance evaluation of a packable posterior composite in bulk-cured restorations. J. Am. Dent. Assoc. 2006; 137(1):71-80. https://doi.org/ 10. 14219/jada.archive.2006.0024 PMid:16457002
18. Farah JW, Powers JM, eds. Bonding agents. Dental Advisor. 2008;25(5):1-9. [www.dentaladvisor.com/ publications/the-dental-advisor/index.shtml]
19. Navyasri K, Alla RK, Vineeth G, Suresh Sajjan MC. An overview of dentin bonding agents. Int J Dent Mater 2019;1(2): 60-67.DOI: http://dx.doi.org/ 10. 37983/IJDM.2019.1204
20. ORBANS ORAL HISTOLOGY AND EMBRYOLOGY chapter one - An overview of oral tissue
21. Navyasri K, Alla RK, Vineeth G, Suresh Sajjan MC. An overview of dentin bonding agents. Int J Dent Mater 2019;1(2): 60-67. DOI: http://dx.doi.org/ 10.37983/IJDM.2019.1204
22. Wassell RW, Walls AW, McCabe JF. Direct composite inlays versus conventional composite restorations: three-year clinical results. Br. Dent. J. 1995; 179(9):343-9. https://doi.org/ 10.1038/ sj. bdj. 4808919 PMid:74956304.
23. C.Montoya[a], S.Arango-Santander[b], A.Pelaez Vargas[b], D.Arola[c], E.AOssa[a] https://doi.org/10.1016/ j.archoralbio.2015.10.002
24. Zhong J, Greenspan DC. Processing and properties of sol-gel bioactive glasses. J. Biomed. Mater. Res. 2000; 53(6):694-701. https://doi.org/10.1002/1097-4636(2000)53:63.0.CO;2-6
25. Abdalla AI, El Zohairy AA, Abdel Mohsen MM, Feilzer AJ. Bond efficacy and interface morphology of self-etching adhesives to ground enamel J Adhes Dent. 2010;12:19–25
26. Melo MAS, Cheng L, Zhang K, Weir MD, Rodrigues LKA, Xu HHK. Novel dental adhesives containing nanoparticles of silver and amorphous calcium phosphate. Dent. Mater. 2013; 29(2):199-210. https:// doi.org/10.1016/j.dental.2012.10.005 PMid:23138046 PMCid:PMC3552134
27. Liang K, Weir MD, Reynolds MA, Zhou X, Li J, Xu HHK. Poly (amido amine) and nano-calcium phosphate bonding agent to remineralize tooth dentin in cyclic artificial saliva / lactic acid. Mater. Sci. Eng. C 2017; 72:7-17. https://doi.org/ 10.1016/ j.msec.2016.11.020 PMid:28024641
28. Chermont AB, Carneiro KK, Lobato MF, Machado SMM, Silva e Souza Junior MHS. Clinical evaluation of postoperative sensitivity using self-etching adhesives containing glutaraldehyde. Braz. Oral Res. 2010; 24(3):349-54. https://doi.org/ 10.1590/S1806- 83242010000300015 PMid: 20877974
29. Ahmed Zakaria Aboelenein[1*], Mona Ismail Riad[2], Mohammed Fouad Haridy[2, 3] Effect of a Self-Etch Adhesive Containing Nanobioglass on Postoperative Sensitivity of Posterior Composite Restorations - A Randomized Trial 2019 Jul 25;7(14):2313–2320. doi: 10.3889/oamjms.2019.585
30. Taneja S, Kumari M, Bansal S. Effect of saliva and blood contamination on the shear bond strength of fifth-, seventh-, and eighth-generation bonding agents: an in vitro study. J Conserv Dent 2017; 20(3):157–160. DOI: 10.4103/0972-0707. 218310
31. Chauhan U, Dewan R, Goyal NG. Comparative evaluation of bond strength of fifth, sixth, seventh, and eighth generations of dentin bonding agents: an in vitro study. J Oper Dent Endod 2020;5(2):69–73. DOI: 10.5005/jp-journals-10047-0103

32. Somani R, Jaidka S, Arora S. Comparative evaluation of microleakage of newer generation dentin bonding agents: an in vitro study. Indian J Dent Res 2016;27(1):86–90. DOI: 10.4103/0970-9290.179837
33. Freedman G, Leinfelder K. Seventh-generation adhesive systems. Dent Today. 2002;21(11):106–111.
34. Ganesh AS. Comparative evaluation of shear bond strength between fifth, sixth, seventh and eighth generation bonding agents: an in vitro study. Indian J Dent Res 2020;31(5):752–757. DOI: 10.4103/ijdr.IJDR_635_19
35. Deepa VL, Damaraju B, Priyadharsini BI, et al. Comparative evaluation of microshear bond strength of 5(th), 6(th) and 7(th) generation bonding agents to coronal dentin versus dentin at floor of pulp chamber: an in vitro Study. J Int Oral Health 2014;6(5):72–76.
36. Kamble SS, Kandasamy B, Thillaigovindan R. In vitro comparative evaluation of tensile bond strength of 6th, 7th and 8th generation dentin bonding agents. J Int Oral Health 2015;7(5):41–43.
37. Varma M, Sedani S, Nikhade P. Comparative evaluation of 5th- and 7th-generation bonding agents: an in vitro study. J Datta Meghe Inst Med Sci Univ 2019;14(9):166–170. DOI: 10.4103/jdmimsu.jdmimsu_46_19
38. Kamath D, Arun CR. Comparative evaluation of microleakage of class ii composite restoration by using 6th 7th and 8th generation dentin bonding agents. An in vitro study. Int J Appl Dent Sci 2019;5(1):147–150.
39. Ababakr H, Bakr D Kh, Saleem SS, et al. Evaluating shear bond strength efficacy of seventh and eighth generation bonding agents. An in vitro study. EDJ 2022;4(2):135–143. DOI: 10.15218/edj.2021.18
40. Joseph P, Yadav C, Satheesh K, et al. Comparative evaluation of the bonding efficacy of sixth, seventh and eight generation bonding agents: an in vitro study. Int Res J Pharm 2013;4(9):143–147.
41. Poggio C, Beltrami R, Colombo M, Chiesa M, Scribante A. Influence of dentin pretreatment on bond strength of universal adhesives. Acta Biomater Odontol Scand. 2017 Mar;3(1):30–5. doi: 10.1080/23337931.2017.1305273.
42. Cevik P, Yildirim AZ, Artvin Z, Özcan M. Microtensile bond strength and failure type analysis of self-etch adhesive systems on superficial and deep dentin after long-term water storage. Braz Dent Sci. 2020;23(4):12p–12p. [Google Scholar]
43. Fabião A de M, Fronza BM, André CB, Cavalli V, Giannini M. Microtensile dentin bond strength and interface morphology of different self-etching adhesives and universal adhesives applied in self-etching mode. J Adhes Sci Trchnol. 2021 Apr 3;35(7):723–32. [Google Scholar]
44. Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. Dent Mater. 2011 Jan;27(1):17–28. doi: 10.1016/j.dental.2010.10.023. [DOI] [PubMed] [Google Scholar]
45. Pashley DH, Tay FR, Breschi L, Tjäderhane L, Carvalho RM, Carrilho M, et al. State of the art etch-and-rinse adhesives. Dent Mater. 2011 Jan;27(1):1–16. doi: 10.1016/ j.dental. 2010. 10.016. [DOI] [PMC free article] [PubMed] [Google Scholar]
46. Yaseen SM, Subba Reddy VV. Comparative evaluation of shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin

of primary and permanent teeth: an in vitro study. J Indian Soc Pedod Prev Dent. 2009 Mar;27(1):33–8. doi: 10.4103/0970-4388.50814. [DOI] [PubMed] [Google Scholar]

47. Armstrong SR, Keller JC, Boyer DB. The influence of water storage and C-factor on the dentin-resin composite microtensile bond strength and debond pathway utilizing a filled and unfilled adhesive resin. Dent Mater. 2001 May;17(3):268–76. doi: 10.1016/s0109-5641(00)00081-6.
48. Ryou H, Romberg E, Pashley DH, Tay FR, Arola D. Importance of age on the dynamic mechanical behavior of intertubular and peritubular dentin. J Mech Behav Biomed Mater. 2015; 42: 229–242.
49. haler A, Ebert J, Petschelt A, Pelka M. Influence of tooth age and root section on root dentine dye penetration. Int Endod J. 2008; 41: 1115–1122.
50. Tagami J, Nakajima M, Shono T, Takatsu T, Hosoda H. Effect of aging on dentin bonding. Amer J Dent 1993: 6(3): 145-7.
51. SH. Kasraei 1, 2, M. Atai 3, Z. Khamverdi 1 , S. Khalegh Nejad Effect of Nanofiller Addition to an Experimental Dentin Adhesive on Microtensile Bond Strength to Human Dentin
52. T.S.Carvalho et al Age-related morphological, histological and functional changes in teeth https://doi.org/10.1111/joor.12474
53. Bharti Sachdeva1, Parminder Dua2, Ritu Mangla3, Harpreet Kaur4, Swati Rana5, Apra Butail6 Bonding efficacy of 5th,6th,7th & 8th generation bonding agents on primary teeth IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 17, Issue 3 Ver.13 March. (2018),
54. Yoshida Y, Nagakane K, Fukuda R, Nakayama Y, Okazaki M, Shintani H et al. Comparative study on adhesive performance of functional monomers. J Dent Res 2004;83(6):454-458
55. Fukegawa D, Hayakawa S, Yoshida Y, Suzuki K, Osaka A, Meerbeek VB. Chemical interaction of phosphoric acid ester with hydroxyapatite. J Dent Res 2006;85:941-944.
56. Nair M, Paul J, Kumar S, Chakravarthy Y, Krishna V, Prasad S. Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An In-Vitro study. J Conserv Dent 2014;17(1):27–30.
57. Ganesh, A Sri Comparative Evaluation of Shear Bond Strength between Fifth, Sixth, Seventh, And Eighth Generation Bonding Agents An In Vitro Study Indian Journal of Dental Research 31(5):p 752-757, Sep–Oct 2020. | DOI: 10.4103/ijdr.IJDR_635_19
58. Van Landuyt KL, Snauwaert J, De Munck J, Peumans M, Yoshida Y, Poitevin A, et al Systematic review of the chemical composition of contemporary dental adhesives Biomaterials. 2007;28:3757–85
59. Joseph P, Yadav C, Satheesh K, Rahna R. Comparative evaluation of the bonding efficacy of sixth, seventh and eight generation bonding agents: An in vitro study Int Res J Pharm. 2013;4:143–7
60. Milia E, Cumbo E, Cardoso RJ, Gallina G. Current dental adhesives systems-A narrative review Curr Pharm Des. 2012;18:5542–52
61. Savadi-Oskoee S, Kimyai S, Savadi-Oskoee A, et al. Effects of different etching strategies on the microtensile repair bond strength of beautifil II giomer material. J Clin Exp Dent 2018;10(8):732–738. DOI: 10.4317/jced.54436

62. Sano H, Chowdhury AFMA, Saikaew P, et al. The microtensile bond strength test: Its historical background and application to bond testing. Jpn Dent Sci Rev 2020;56(1):24–31. DOI: 10. 1016/ j.jdsr.2019.10.001