Original Article

Comparative evaluation of microhardness of three restorative materials after immersion in chlorhexidine mouthwash: An *in vitro* study

Shilpa S. Shah, Nishtha K. Patel, Kruti P. Yagnik, Aarshati Vyas, Prerak Doshi, Pooja R. Keshrani

Department of Conservative Dentistry and Endodontics, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India

Abstract

Aim: To evaluate and compare the microhardness of Filtek Z250XT, Beautifil II, and Neo Spectra ST HV after immersion in chlorhexidine mouthwash.

Materials and Methods: Thirty disc specimens (10 for each group) made of three different restorative materials, Group 1 – Filtek (3M ESPE), Group 2 – Beautifil II (Shofu), and Group 3 – Neo Spectra ST HV (Dentsply). To simulate 1 year of daily mouthwash use, 10 specimens from each group were immersed in chlorhexidine, kept in an incubator at 37°C for 12 h, and later subjected to microhardness measurement using Vicker's hardness test. Finally, analysis of variance and post hoc tests were used to analyze the results statistically.

Results: A significant reduction in microhardness was observed after immersion in chlorhexidine in Groups 1 and 3 compared to Group 2.

Conclusions: Filtek Z250XT exhibits the highest microhardness compared to the other two materials. However, Beautifil II is more resistant to chlorhexidine mouthwash and does not show a significant reduction compared to the other two restorative materials.

Keywords: Analysis of variance; Beautifil II; chlorhexidine; Filtek Z250XT; microhardness; Neo Spectra ST HV

INTRODUCTION

Dental plaque plays a vital role in developing dental caries and periodontal diseases.[1] Since it is challenging to achieve levels of plaque control and caries activity only with mechanical methods such as brushing and flossing, dentists recommend using chlorhexidine mouthwash to control plaque and caries in patients due to antimicrobial activity.[2,3] Mouth rinse solutions include various components, such as detergents, emulsifiers, organic acids, dyes, and alcohol (mainly ethanol). Alcohol is a carrier agent for other active ingredients, helps break down plaque, and acts as an antiseptic.[4-6]

Research and development in restorative dentistry have yielded significant advancements. The quest for an ideal restorative material that can substitute natural teeth and a growing demand for products with good mechanical and caries-protective properties has led to numerous new restorative materials.[5] Resin composites have revolutionized operative dentistry by providing long-term

Address for correspondence:
Dr. Kruti P. Yagnik,
Department of Conservative Dentistry and Endodontics,
College of Dental Sciences and Research Centre, Opp. Pleasure Club, Near Navneet Printing Press, Bopal, Ghuma – Manipur, Ahmedabad - 382 115, Gujarat, India.
E-mail: krutiyagnik97@gmail.com

Date of submission : 15.02.2024
Review completed : 26.03.2024
Date of acceptance : 01.04.2024
Published : 10.05.2024

Access this article online	
Quick Response Code:	Website: https://journals.lww.com/jcde
	DOI: 10.4103/JCDE.JCDE_87_24

How to cite this article: Shah SS, Patel NK, Yagnik KP, Vyas A, Doshi P, Keshrani PR. Comparative evaluation of microhardness of three restorative materials after immersion in chlorhexidine mouthwash: An *in vitro* study. J Conserv Dent Endod 2024;27:520-3.

durability and excellent esthetics in the oral cavity. Today, it is the most preferred direct restorative material that has achieved a high degree of excellence for building anterior and posterior restoration due to its superior esthetic features and improved physical and mechanical properties with predictable results, unlike the previous restorative materials.[7]

Resin composites are materials based on polymers and, as a result, they are vulnerable to degradation in the oral environment. According to studies conducted by Ilie and Hickel, Hamouda, the surface of restorative materials placed on teeth can be affected by various types of food, drinks, and oral hygiene maintenance products through chemical action.[8,9] The restorative material must be strong enough to withstand the chewing forces when replacing missing tooth structures. Microhardness tests can assess the durability of resin composites. The microhardness of tested materials is composition-dependent and can be affected by aging, water sorption, and surface reaction.[10] Microhardness measurements are conducted using indentation tests (with Vickers indenters), which can reasonably determine the resistance to localized plastic deformation. This aspect is essential in dentistry, as any chemical softening from mouthwash would affect the restorative material's clinical durability.[4] Gürgan *et al*. stated that alcohol-containing and alcohol-free mouthwashes may influence the hardness of the restorative materials. Microhardness is related to the material's strength, rigidity, and durability, which has implications for the longevity of restorations.[11]

It is clinically significant to understand how chlorhexidine mouthwashes affect the microhardness of restorations as it provides insights into the potential challenges dentists and patients may face when exposed to chlorhexidine mouthwash and helps make informed decisions about choosing restorative materials for specific patients. Understanding how all these materials interact with chlorhexidine mouthwash can help assess its performance and validate its claims. This research will contribute to advances in dental materials and facilitate the development of more durable and esthetically pleasing dental restoration options. Overall, conducting this study will help fill gaps in restorative knowledge and provide critical information for better clinical decision-making, improved patient outcomes, and advancements in dental materials.

Since there have not been studies comparing these materials and also because of their enhanced properties, this study aimed to measure the microhardness of three different esthetic restorative materials, i.e., Filtek Z250XT (3M ESPE), Beautifil II (Shofu), and Neo Spectra ST HV (Dentsply) after immersion in chlorhexidine mouthwash. The null hypothesis was formulated: chlorhexidine mouthwash does not impact the resin composite's microhardness.

MATERIALS AND METHODS

The sample size of the current study was calculated using G*Power (Heinrich Heine University Dusseldorf, Germany) with a power of 90% and an assumed significance level of 0.05 implemented in the estimation.[10,11] In this *in vitro* study, three different esthetic restorative materials, i.e., Filtek Z250XT (3M ESPE), Beautifil II (Shofu), and Neospectra ST HV (Dentsply), were selected and immersed in chlorhexidine mouthwash. The manufacturer's details and composition of the chosen resin composites are described in Table 1.

Composite specimen preparation

Three different restorative materials were used and grouped ($n = 10$) to prepare specimens. Group 1: Filtek Z250XT (3M ESPE), Group 2: Beautifil II (Shofu), and Group 3: Neospectra ST HV (Dentsply).

To prepare 30 specimens ($n = 10$), they were placed in plastic rings with 2 mm depth and 5 mm internal diameter. The rings were then interplaced between two glass slides and pressed to ensure a smooth surface with no gaps. Finally, the specimens were light-cured for 40 s by applying the light polymerization unit against the glass slide. The immersion protocol was followed based on the assessment by Gürgan *et al*. ($n = 10$); specimens from each group were immersed in chlorhexidine mouthwash and incubated at 37°C for 12 h, equivalent to 1 year of mouthwash use at 2 min/day. After this, the specimens were washed under abundant water. Baseline values of the surface microhardness of each specimen were taken for each group.[11]

Microhardness testing

The specimens were tested for microhardness using a Vicker's hardness tester (microhardness tester, Reichert, Austria) with a 100-g force and a dwell time of 20 s. Three indentations were made on the top surface, ensuring a distance of 1 mm minimum between each other. The average of the three readings was taken as the hardness value for each sample in each group ($n = 10$).

Statistical analysis

The results were subjected to statistical analysis using analysis of variance at a 95% confidence level. A *post hoc* test was also conducted to determine if there were significant differences in the mean microhardness among the three groups. In addition, an unpaired t-test was performed to identify which pairs exhibited significant differences in the mean microhardness. All the statistical tests used in the present study consider a $P < 0.05$ to be significant ($P < 0.05$).

RESULTS

After immersion in chlorhexidine mouthwash, a significant

Table 1: Materials, trademark, manufacturer, and composition of the substances used[12]

Materials	Trademark	Manufacturer	Composition
Chlorhexidine mouthwash	Augdine mouthwash	Nextgen Health Care (India)	0.2%w/v chlorhexidine gluconate
Microhybrid composite resin	Filtek Z250XT	3M/ESPE (St. Paul, MN, USA)	Matrix: Bis-GMA, Bis-EMA, UDMA, TEGDMA based composite Filler: Zirconia, silica (0.01–3.5 μm), 78 wt%, 60 vol%
Giomer	Beautifil II	Shofu, Kyoto, Japan	Base resin: Bis-GMA (7.5 wt%)/TEGDMA (5 wt%) resin Filler: Multifunctional glass filler and S-PRG filler based on fluroboroaluminosilicate glass Filler loading: 83.3 wt% (68.6 vol%) Particle size range: 0.01–4.0 μm Mean particle size: 0.8 μm DL-camphorquinone
Nanohybrid composite resin	Neo Spectra ST HV	Dentsply, Konstans, Germany	Methacrylate-modified polysiloxane (organically modified ceramic) dimethacrylate resins, ethyl-4 (dimethylamino) benzoate, and bis (4-methyl-phenyl) iodonium hexafluorophosphate. Filler load: 78%–80% by weight: Spherical, prepolymerized SphereTEC fillers (d3,50≈15 μm), nonagglomerated barium glass and ytterbium fluoride

S-PRG: Surface prereacted glass ionomer, Bis-GMA: Bisphenol A-glycidyl methacrylate, Bis-EMA: Bisphenol A ethoxylated dimethacrylate, UDMA: Urethane dimethacrylate, TEGDMA: Triethylene glycol dimethacrylate, DM: Dimethacrylate

Table 2: Mean values of microhardness before and after immersion in chlorhexidine mouthwash

Materials groups	Group 1 (Filtek Z250XT)	Group 2 (Beautifil II)	Group 3 (Neo Spectra ST HV)
Before immersion (baseline)	80.178	46.148	45.154
After immersion (12 h)	65.657	41.949	35.176

reduction in microhardness was observed in Group 1 and Group 3 compared to Group 2. Among the three restorative materials tested, Beautfil II (Shofu) showed more excellent resistance to chlorhexidine mouthwash. The test statistics value obtained for Group 1 was significant ($P < 0.05$). The results are noted in Table 2 and represented in Figure 1.

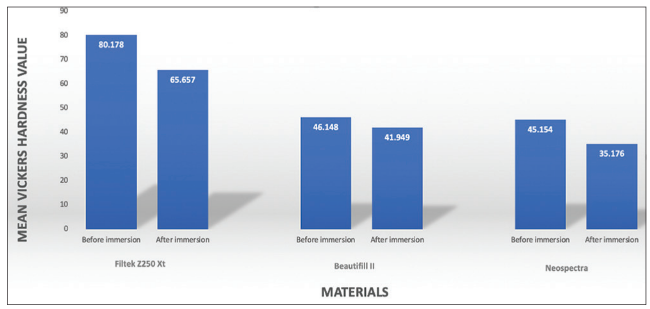

Figure 1: Mean values of microhardness before and after immersion in chlorhexidine mouthwash

DISCUSSION

Over the past few years, there has been a significant rise in the clinical utilization of resin-based restorative materials, primarily because of their improved properties, ease of handling, and excellent esthetic and bonding properties. To be clinically effective, restorative materials must withstand environmental influences. Different chemical compounds influence the characteristics of the restorative material, causing surface degradation of resin composites, which in turn can lead to alterations in microhardness and also affect its long-term clinical performance.[13]

Since it has become increasingly challenging to achieve satisfactory levels of plaque control and decrease caries activity using routine oral hygiene methods, chlorhexidine mouthwash has gained popularity among patients and clinicians as it offers an attractive option for preventing dental problems.[14] The current *in vitro* study evaluates the impact of chlorhexidine mouthwash on the microhardness of three different resin composites, i.e., Filtek Z250XT (3M ESPE), Beautifil II (Shofu), and Neo Spectra ST HV (Dentsply).

Microhardness is used to predict wear resistance and susceptibility to abrasion.[15]

A decrease in microhardness can cause early restoration failure. The microhardness of the resin composite materials that were tested was found to be significantly lower than baseline values. This could be due to the acidic pH of mouth rinses, which may have caused the resin composites to erode through acid etching and leaching the principle matrix, forming cations.[16] This is per the observations by Dieb *et al*., who stated that mouth rinses with low pH are detrimental to the hardness of resin composites.[17]

The study found that Filtek Z250XT (3M ESPE) has the highest microhardness compared to other materials. It comprises the tiniest particles (20 nm silica + 0.1–10 µm zirconia/silica) compared to all the other tested materials. However, according to Venz and Dickens, the effect of mouth rinses on the hardness of restorative materials depends on their chemical composition. The hydrophilicity of matrix monomers follows the order of

TEGDMA > Bis-GMA > UDMA. There is a formation of alcohol and carboxylic acid by-products by the hydrolysis of ester groups, which can further accelerate the degradation process by irreversible leaching of components, which might be responsible for the decrease in the microhardness of Filtek Z250 × T.[18-20]

Beautifil II incorporates S-PRG (surface prereacted glass ionomer) technology, where only the surface of the glass filler is attacked by polyacrylic acid, and the glass core remains stable as it creates an acid-resistant film and the higher acid resistance of the polymer matrix leads to no significant reduction in microhardness even after postimmersion in chlorhexidine. Furthermore, the smaller size filler particles of 0.01–4.0 μm were added, which may lead to the resistance to wear.[21,22]

The Neo Spectra ST HV product contains spherical, prepolymerized fillers made of nonagglomerated barium glass and ytterbium fluoride.[12] Yap *et al*. stated that zirconia glass fillers were susceptible to damage from exposure to aqueous environments. This is congruent with the current research; microhardness was reduced after immersion in chlorhexidine mouthwash. The differences in microhardness are due to variations in filler types and sizes.[23,24]

In a clinical environment, a material's decrease in microhardness may contribute to its degradation.[25,26] As a result, such conditions can negatively impact the polymeric network in the short- or long-term, altering its physical and chemical structure. Within the study's limitations, further *in vivo* investigations may be required to evaluate the effect of chlorhexidine mouthwash on the microhardness of esthetic restorative materials containing different types, sizes, and filler contents.

CONCLUSION

Filtek Z250XT (3M ESPE) showed greater microhardness than other materials. However, Beautifil II, being more resistant to chlorhexidine mouthwash, shows little reduction compared to the other two esthetic materials.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Sajjan P, Laxminarayan N, Kar PP, Sajjanar M. Chlorhexidine as an antimicrobial agent in dentistry – A review. Oral Health Dent Manag 2016;15:93-100.
2. Al-Samadani KH. Color stability of restorative materials in response to Arabic coffee, Turkish coffee and Nescafe. J Contemp Dent Pract 2013;14:681-90.
3. Alessa NA. Effect of mouthwashes on the microhardness of aesthetic composite restorative materials. An Sist Sanit Navar 2023;46:e1049.
4. George R, Kavyashree G. Effect of four mouth rinses on microhardness of esthetic restorative material: An *in vitro* study. J Int Oral Health 2017;9:55-9.
5. Dionysopoulos D, Gerasimidou O. Wear of contemporary dental composite resin restorations: A literature review. Restor Dent Endod 2021;46:e18.
6. Fernandez RA, El Araby M, Siblini M, Al-Shehri A. The effect of different types of oral mouth rinses on the hardness of silorane-based and nano-hybrid composites. Saudi J Oral Sci 2014;1:105-9.
7. Drummond JL. Degradation, fatigue, and failure of resin dental composite materials. J Dent Res 2008;87:710-9.
8. Ilie N, Hickel R. Resin composite restorative materials. Aust Dent J 2011;56 Suppl 1:59-66.
9. Hamouda IM. Effects of various beverages on hardness, roughness, and solubility of esthetic restorative materials. J Esthet Restor Dent 2011;23:315-22.
10. Vasundhara S, Rucha N. Effect of alcohol-containing and alcohol-free mouth rinses on microhardness of three esthetic restorative materials. CODS J Dent 2014;6:5-8.
11. Gürgan S, Onen A, Köprülü H. *In vitro* effects of alcohol-containing and alcohol-free mouthrinses on microhardness of some restorative materials. J Oral Rehabil 1997;24:244-6.
12. Gurgan S, Koc Vural U, Miletic I. Comparison of mechanical and optical properties of a newly marketed universal composite resin with contemporary universal composite resins: An *in vitro* study. Microsc Res Tech 2022;85:1171-9.
13. Vejendla I, Sandeep AH, Pradeep S, Choudhari S. *In vitro* evaluation of the effects of different beverages on the surface microhardness of a single-shade universal composite. Cureus 2023;15:e43669.
14. Poppolo Deus F, Ouanounou A. Chlorhexidine in dentistry: Pharmacology, uses, and adverse effects. Int Dent J 2022;72:269-77.
15. Kandaswamy D. Micro hardness and depth of cure of a newly introduced posterior composite. J Conserv Dentistry 1999;2:16-20.
16. Fathima JN, Hashir MM, Padmanabhan K. Spectrophotometric evaluation of color stability of composite resin after exposure to cold drinks: An *in vitro* study. J Conserv Dent Endod 2024;27:195-9.
17. Diab M, Zaazou MH, Mubarak EH, Olaa MI. Effect of five commercial mouth rinses on the microhardness and color stability of two resin composite restorative materials. Aust J Basic Appl Sci 2007;1:667-74.
18. Venz S, Dickens B. NIR-spectroscopic investigation of water sorption characteristics of dental resins and composites. J Biomed Mater Res 1991;25:1231-48.
19. Dalmia S, Aher G, Gulve M, Samuel R, Kolhe S. Comparative evaluation of the effect of chlorhexidine-based mouthwash and herbal mouthwash on the microhardness of two different composite resins and an *in vitro* study. Int J Adv Res 2018;6:306-11.
20. Goyal DA, George DJ, Mathew DS, Singh DR, Ramesh DP. Effect of four commercial mouth rinses on the microhardness and solubility of a supra nanocomposite and a microhybrid composite: An *in vitro* study. Scholars J Dent Sci 2016;3:272-7.
21. Abdel-Karim UM, El-Eraky M, Etman W. Three-year clinical evaluation of two nano-hybrid giomer restorative composites. Tanta Dent J 2014;11:213-22.
22. Hajira NSWN, Meena N. GIOMER- the intelligent particle (new generation glass ionomer cement). Int J Dent Oral Heal 2016;2:1-5.
23. Yap AU, Tan SH, Wee SS, Lee CW, Lim EL, Zeng KY. Chemical degradation of composite restoratives. J Oral Rehabil 2001;28:1015-21.
24. Dionysopoulos D, Papadopoulos C, Koliniotou-Koumpia E. Effect of temperature, curing time, and filler composition on surface microhardness of composite resins. J Conserv Dent 2015;18:114-8.
25. Chowdhury D, Mukherjee S, Maity I, Mazumdar P. Surface roughness and microhardness evaluation of composite resin restorations subjected to three different polishing systems immediately and after 24 h: An *in vitro* study. J Conserv Dent Endod 2023;26:639-45.
26. Abzal MS, Rathakrishnan M, Prakash V, Vivekanandhan P, Subbiya A, Sukumaran VG. Evaluation of surface roughness of three different composite resins with three different polishing systems. J Conserv Dent 2016;19:171-4.