COMPARATIVE EVALUATION OF SURFACE ROUGHNESS AND MICROHARDNESS OF BULK-FILL COMPOSITE RESIN AND TRADITIONAL NANOHYBRID COMPOSITE RESIN AFTER EXPOSURE TO THREE DIFFERENT BEVERAGES

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LIST OF ABBREVIATIONS

Sr. No.	Abbreviations	Full form
1.	Bis-GMA	Bisphenol-A-glycidylmethacrylate
2.	UDMA	Urethane dimethacrylates
3.	TEGDMA	Triethylene Glycol Dimethacrylate
4.	Ra	Surface Roughness
5.	SEM	Scanning Electron Microscope
6.	Um	Micrometer
7.	Rpm	Rotations per minute
8.	GIC	Glass Ionomer Cement
9.	P value	Probability of happening of an event
10.	Mm	Millimeter
11.	LED	Light Emitting Diode
12.	QTH	Quartz Tungsten Halogen
13.	LCU	Light Curing Unit
14.	VHN	Vickers Hardness Number
15.	PAC	Plasma Arc Curing
16.	AFM	Atomic Force Microscope
17.	N	Number of specimen in each group
18.	SD	Standard Deviation
19.	ANOVA	Analysis of Variance
20.	Nm	Nanometer
21.	KHN	Knoops Hardness Number
22.	i.e	That is
23.	SD	Standard Deviation
24.	S	Significant

25.	NS	Non-Significant
26.	HS	Highly Significant
27.	Min.	Minimum
28.	Max.	Maximum
29.	No.	Number
30.	HV	Vickers Hardness Number

INTRODUCTION

"The best plan for success is to begin with the end in mind."

Esthetics is derived from Greek word "aisthetikos" meaning pertaining to sense perception. As **Goldstein** says, "Esthetic dentistry is the art of dentistry in its purest form." In today's world patients are acutely aware of their looks and hence there is an increase in demand for esthetic enhancement. Esthetics being the current need of era, often motivates patients to seek dental treatment. Through the evolution and development of many exciting conservative esthetic dental materials and techniques, dental artistry is a reality today more than ever.[1]

Various treatment modalities for aesthetic rehabilitation includes micro abrasion, direct composite resin restoration, indirect composites, ceramic inlays, onlays, crowns and veneers. Among the different restorative dental materials, composite resin is considered the first choice to be used nowadays. This is due to many factors including superior esthetics, bonding to tooth structure, conservative tooth preparation and good longevity. However resin composite have some inherent disadvantages like colour instability, polymerization shrinkage, microleakage, lower fracture toughness.

Inspite of all precautions and guidelines being scrupulously followed by clinician, discoloration of the composite is a challenge regularly faced in clinical practice . Discoloration of restorative materials can be caused by intrinsic or extrinsic factors.

Intrinsic factors involve discoloration of the resin material itself, such as alteration of the resin matrix and the interface of matrix and fillers. Extrinsic factors for discoloration include staining by adsorption or absorption of colorants because of contamination from exogenous sources. Previous studies have shown that composite resins are susceptible to color instability when exposed to various staining media, especially red wine, coffee, cola and tea.[2]

Novel resin composites have improved filler technology, modifications in organic matrixes and a greater degree of polymerization that improves their mechanical and physical properties. One of the most significant advances in the last few years is resin composites containing nanoparticles.[3]

The advent of visible-light-polymerizing resin and the usage of finer filler particles permit tooth-coloured restoratives be polished to a higher degree. In an effort to eliminate the problems of surface roughness, new tooth-coloured materials have been produced combining the proven composite and the innovative nanotechnology.[4]

Nanomers are discrete nanoagglomerated particles of 20-75 nm in size, and these nanoclusters are loosely bound agglomerates of nano-sized particles. The manufacturer suggests that the combination of nanomer-sized particles and nanocluster formulations reduces the interstitial spacing of the filler particles and provides increased filler loading, which results in better physical properties and hence improved polishibility.[5]

Moraes RR et al. **2019**[6] conducted an in vitro study comparing nanohybrid and microhybrid and they stated that nanohybrid composite resin have better physical properties than microhyrid and any other traditional composite resin.

Recently, Bulk-Fill composites were introduced in an attempt to overcome some of the limitations and concerns associated with the traditional composites. In contrast to conventional composites, which require incremental placement, these materials contain more sensitive photo initiators that allow the depth of cure to reach up to 5 mm while maintaining predictable degree of conversion. This would allow clinician to place a single increment in deep lesions without the need for a layering technique expediting the restorative procedure and decreasing the overall chair time.[7]

Yazici AR et al. **2017** [8] conducted in vivo study comparing bulk fill and nanofill composite observed that bulk fill composite has better clinical performance in terms of marginal discoloration and adaptation than nanofilled composite.

The esthetics and longevity of restorations can be enhanced by proper finishing and polishing of composites.[9]

Madhyastha PS et al. 2017[10] stated that improper finishing/polishing of restorations can result in plaque accumulation, gingival irritation, surface staining, and poor esthetic of restored teeth, thus affecting the clinical performance of materials.

Park JK et al. 2017[11] suggested that consumption of beverages such as coffee, tea and soft drinks causes discoloration of composite restoration.

Coffee, tea and soft drinks are the most commonly consumed beverages in India.

The chemicals in beverage formulations can lead to wear and surface degradation of composite restorations, resulting in unaesthetic external pigmentation, such as the stains. Consumption of these beverages affects the esthetic and physical properties such as surface roughness and microhardness of the composites, thereby undermining the quality of restorations.[12]

Badra VV et al in 2005[13] reported that beverages such as coffee, tea and coca- cola increase surface roughness of composite resin and coca cola showed highest increase in surface roughness.[13] The surface roughness can lead to discoloration as this surface has different surface dimensions and different contact rates with coloring agents. Surface roughness can be measured up to nanoscale by qualitative methods such as scanning electron microscopy or quantitative methods such as profilometry.[14] **Poggio C et al. 2018**[15] stated that composite showed lower microhardness values after immersion in acidic solution. The lowest values were registered after immersion in acidic solution for 1 week.

A lower microhardness of a resin composite indicates that the material is more susceptible to scratches and surface defects that can reduce the materials flexural strength and cause premature failure of the restoration.[16] However presently there are no studies comparing the surface roughness and microhardness of Bulk-Fill composite resin with nanohybrid composite resin after exposure to three different beverages i.e. tea, coffee, soft drink at various time intervals.

Thus, this in vitro study was aimed to evaluate and comparing the surface roughness and microhardness of Bulk-Fill composite resin with nanohybrid composite resin after exposure to three different beverages i.e. tea, coffee, soft drink at various time intervals.

The null hypothesis was that there is no significant difference on surface roughness and microhardness of Bulk-Fill composite resin with nanohybrid composite resin after exposure to three different beverages i.e. tea, coffee, soft drink at various time intervals.

AIMS AND OBJECTIVES

Aim

To evaluate and compare the surface roughness and microhardness of Bulk-Fill composite resin and traditional nanohybrid composite resin after exposure to three different beverage i.e. tea, coffee and soft drink at various time intervals (after 3 months, 6 months and 12 months).

Objectives:

1. To evaluate the surface roughness of Bulk-Fill composite resin and nanohybrid composite resin in three different beverages i.e. tea, coffee and soft drink at various time intervals (after 3 months, 6 months and 12 months).

2. To compare the surface roughness of Bulk-Fill composite resin and nanohybrid composite resin in three different beverages i.e. tea, coffee and soft drink at various time intervals (after 3 months, 6 months and 12 months).

3. To evaluate the microhardness of Bulk-Fill composite resin and nanohybrid composite resin in three different beverages i.e. tea, coffee and soft drink at various time intervals (after 3 months, 6 months and 12 months).

4. To compare the microhardness of Bulk-Fill composite resin and nanohybrid composite resins in three different beverages i.e. tea, coffee and soft drink at various time intervals (after 3 months, 6 months and 12 months).

5. To analyze relationship between surface roughness and microhardness of Bulk-Fill composite resin and nanohybrid composite resin in three different beverages i.e. tea, coffee and soft drink at various time intervals (after 3 months, 6 months and 12 months).

REVIEW OF LITERATURE

Aliping-mckenzie et al. 2004[17] Studied the effects of Coca-Cola and fruit juices on the surface hardness of glass–ionomers and compomers. They used (i) A conventional glass–ionomer, namely ChemFlex, (ii) Two resin-modified glass–ionomers namely Vitremer Core Buildup/Restorative and Fuji II LC (capsulated) (iii) Two polyacid-modified composite resins, F2000, and Dyract AP. Six disc-shaped specimens were prepared from each material and stored in sets of six in the following storage media: 0.9% NaCl (control), Coca-Cola, apple juice and orange juice for time intervals of 1 day, 1 week, 1 month, 3 months, 4 months, 6 months and 1 year. Results showed that tooth-coloured dental restorative materialsbehave differently in different storage media. In 0.9% NaCl, all types of GIC (conventional glass–ionomer, resin-modified glass–ionomer and polyacid-modified composite resin) were found to reduce the pH and to retain or slightly increase their surface hardness over time periods up to 1 year. In acidic beverages, however, they increased the pH, while showing sharp reductions in surface hardness. Behavior was different in Coca-Cola, apple juice and orange juice, with the latter two proving more aggressive than the Coca-Cola.

Badra et al. 2005[13] assessed the influence of different types of beverages such as artificial saliva , sugar cane , Coca – Cola , sprite, coffee on the microhardness and surface roughness of microfilled (A110, 3M/ESPE), hybrid (Z250 3M/ESPE) and flowable (Flow, 3M/ESPE) resin composites, over periods of 24 hours, 7 days, 30 days and 60 day. They observed that for all resin composites, microhardness remained stable up to the 30-day record, decreasing significantly at the 60- day evaluation and for all resin composites surface roughness increased at the 7th day measurement, decreasing at the 30-day record and even more at the 60th day of measurements and comparing the beverages coca cola and coffee showed highest change than sugar cane and artificial saliva .

Lu et al. 2005[18] investigated the effect of surface roughness on stain resistance of Filtek Supreme (nanocomposite), Filtek A110 (microfilled composite), Filtek Z250 (microhybrid composite) and Filtek P60 (microhybrid composite). Thirty-six specimens per material were prepared and immersed in a coffee solution for 14 days and they concluded that coffee had a significant influence on discoloration of the dental resin composite materials tested and discoloration increased as surface roughness increased for the composites tested, except with Filtek A110 and the discoloration process was accelerated with time.

Wongkhantee et al. 2006[19] investigated the effect of cola soft drink, drinking yogurt, orange juice, sports drink, tom-yum soup on surface hardness of various substrates such as enamel, dentine, universal composite, microfilled composite, conventional glass ionomer, resin- modified glass ionomer, polyacid-modified resin composite. They observed that microhardness of enamel, dentin, microfilled composite, and resin-modified glass ionomer decreased significantly after immersion in cola soft drink which is suggestive of erosive behavior of acidic food and drinks.

Silva et al. 2008[20] studied the color and surface roughness of nanoparticle (C1) and nanohybrid (C2) composites after immersion in distilled water, acai juice, grape juice and red wine and repolishing . After recording the initial surface roughness and color, the specimens were divided into four groups according to the storage solution. The specimens were reassessed after immersion for 1, 2, 4, 8, and 12 weeks and after repolishing. Both Filtek Z350 XT and Evolu-X resins showed clinically unacceptable color change after immersion in grape juice and red wine, even after repolishing, indicating a need for replacement of the restoration. Filtek Z350 XT specimens showed a difference in the roughness of the red wine group after 12 weeks of immersion, but this difference was reversed after repolishing.

Yanikoglu et al. 2009[21] studied effects of different solutions like tea, coffee, Turkish coffee, mouthwash, coca cola and distilled water on five composite resins namely filled (Estelite), nanofilled (Elite), unfilled (Valux Plus), hybrid (Tetric ceram), and Ormocer-based (Admira) composite resins . Six specimens of each material were immersed in one of the six different solutions for 30 days. At the end of 30 days, Estelite registered its lowest surface hardness in cola. They concluded that material type, storage solution, surface treatment, material surface, and immersion time were significant factors that influenced surface hardness. Decrease of surface hardness was time dependent and rough composite surface affected the surface hardness forncomposite materials when stored in tea, coffee, or cola .

Catelan et al. 2010[22] evaluated the effect of artificial aging on the surface roughness and microhardness of sealed microhybrids and nanofilled composites. In their study, one hundred disc-shaped specimens were made for each composite. After 24 hours, all samples were polished and surface sealant was applied to 50 specimens of each composite. Surface roughness was determined with a profilometer and Knoop microhardness was assessed with a 50-g load for 15 seconds. Ten specimens of each group were aged during 252 hours in a UV-accelerated aging chamber and immersed for 28 days in cola soft drink, orange juice, red wine staining solutions, or distilled water. They reported that artificial aging decreased microhardness values for all materials, with the exceptions of Vit-l-escence and Supreme XT sealed composites and surface roughness values were not altered. Water storage had less effect on microhardness, compared with the other aging processes.

Hamouda et al. 2010[23] evaluated effects of mirinda orange, mango juice, and natural milk on microhardness, surface roughness of conventional glass ionomer, resin-modified glass ionomer, compomer and composite resin after 7days. They reported that the surface hardness was reduced and surface roughness was increased and it was smaller for composite resin (composan LCM) and greater for conventional glass ionomer (Medifil). There was a negative correlation between surface roughness and hardness .

Bansal et al. 2012[12] studied the effect of three beverages whiskey, coca-cola, and nimbooz on color stability and surface roughness of Methacrylate-Based Nanofilled Composite and Silorane-Based Microhybrid Composite at various time intervals of 7days , 14 days , 28 days and 56 days and they reported that the overall maximum surface roughness change took place in the methacrylate-based composite as compared to the silorane-based composite. The maximum change in surface roughness took place in Coca-Cola>Whiskey>Nimbooz and minimum in Distilled. The composites exhibited increased staining and surface roughness change, over time, on selective exposure to alcoholic and nonalcoholic beverages .

Reddy et al. 2013[24] studied effects of three beverages coke ,coffee and tea on surface roughness of nano, microhybrid, and hybrid composites. Each material was randomly divided into four equal subgroups of 10 samples according to the beverages used (cola, coffee, tea, distilled water). The samples were immersed in each beverage for 1, 15 and 30 days . They concluded that coke shown more surface roughness changes than coffee and tea after 30days .

Kumavat et al. 2014[25] analyze the effect of four beverages (Sparkling Wine, Energy Drink, Jamun Juice and Cola drink) on color stability, surface roughness and fracture toughness of UDMA based composite and a Bis-GMA based composite at various time intervals of 7th, 14th and 28th day. Results reveled that after 14th days, the maximum change took place in the Bis-GMA based composite than UDMA based composite and when surface roughness in different beverages was considered, maximum roughness took place in Cola drink > Jamun Juice > Energy drink > Sparkling Wine.

Tanthanuch et al. 2014[26] investigated the effects of five beverages (apple cider, orange juice, Coca-Cola, coffee, and beer) on microhardness and surface characteristic changes of nanohybrid resin composite and giomer. Ninety-three specimens of each resin composite and giomer were prepared. Before immersion, baseline data of Vicker's microhardness was recorded and surface characteristics were examined using scanning electron microscopy (SEM). Five groups of discs (n = 18) were alternately immersed in 25 mL of each beverage for 5 s and in 25 mL of artificial saliva for 5 s for 10 cycles for 28 days. They found that Microhardness values of all groups were decreased from the initial week of immersion until the end of the 28 days period and the greatest change in hardness shown occurred within the first 7 days and Coca-Cola produced the roughest surface as compare to other beverages.

Sadeghi et al. 2016[27] studied effects of distilled water, coffee, and cola on the roughness of nanohybrid and microhybrid resin composites. After 7 days of immersion microhybrid composite showed a greater Ra than nanohybrid in all solutions . Specimens immersed in coffee exhibit significantly greater surface roughness than that of distilled water and cola. They concluded that nano-hybrid composite showed a significantly smoother surface than microhybrid.

Gezawi et al. 2016[28] conducted study on potential of Bulk versus incrementally applied and indirect composites by using three beverages cola, orange juice and anise for immersion period of 40 days .They concluded that the beverages of different pH values have a deteriorating effect on the color stability and microhardness of various formulation of resin composites. Immersion in beverages for 40 days produced variable deteriorations in color in bulk-fill as well as incremental and indirect composites and the effect of repolishing and further immersion is material dependent. Immersion in beverages produced progressive but variable patterns of deteriorations in the top and bottom microhardness of bulk-fill, incremental, and indirect resin composites. Filtek P90 Silorane-based microhybrid composite is more resistant to surface degradation than bulk- fill composites .

Borah et al. 2017[29] evaluated effect of two dietary drinks Coca Cola and Tropicana orange juice on the surface hardness of two aesthetic nanocomposite materials. Surface hardness tests were performed before immersion and at time intervals of 1 hour,1 day and 1 week intervals. They stated that decrease in hardness of the restorative material was the result of the pH and the chemical composition of the beverage used. Coca Cola contained phosphoric acid whereas Tropicana orange juice has citric acid and malic acid. Each acid behaves in a different manner in softening the restorative material and hence decreasing its hardness.

Tanthanauch et al. 2018[30] conducted study on surface changes of various bulk-fill resin-based composites after exposure to different food simulating liquid and beverages namely spicy and sour soup, spicy soup, pineapple juice, passionfruit juice, and deionized water for immersion period of 28days. They concluded that acidic food-simulating liquids and beverages significantly increased the surface roughness of bulk-fill Resin Based Composites after evaluation at the end of the 28-day immersion period.

Poggio et al. 2018[15] studied effect of immersion in acidic drink on the Vickers microhardness (VK) of different esthetic restorative materials one nanohybrid

Ormocer‑based composite, one nanoceramic composite, one nanofilled composite, and one microfilled hybrid composites .Thirty specimens of each esthetic restorative material were divided into three subgroups (n = 10): specimens of group 1 were used as control, specimens of group 2 were immersed in 50 ml of acidic drink for 1 day, specimens of group 3 were immersed in 50 ml of acidic drink for 7 days. They reported that each composite showed lower microhardness values after immersion in acidic solution and the lowest values were registered after immersion in acidic solution for 1 week .

Fatima et al. 2018[31] evaluated the effect of apple and orange juices on the surface hardness of resin-modified glass ionomer cement and composite resin. In their study 45 discs of both restorative material were prepared and divided into groups of 15, which were immersed for 7 days in deionized water, apple juice, and orange juice. They concluded that exposure to juices significantly reduced the hardness of both materials. Resin composite (Filtek Z350) materials are more resistant to acidic degradation than resin-modified glass ionomer cements (Vitremer) and the acidic agents tested (apple and orange juices) have an equal effect on the surface hardness of restorative materials.

Gupta et al. 2018[32] evaluate effects of various beverages on microhardness of esthetic restorative materials. In their study 160 disc -like specimens were prepared with 40 specimens of nanocomposite resin, nano- ionomer, compomer, and conventional composite resin. These specimens were immersed in four beverages namely aerated drink Coca-Cola, orange juice (Minute Maid), lemon juice (Rasna), fermented milk (Yakult) . Results showed that comparing the effects of common drinks on the surface hardness of different restorative materials and tooth enamel, the change in surface microhard-ness was found to be higher when specimens were immersed in Coca-Cola as compared with Pulpy Orange, Rasna, and Yakult.

Tavangar et al. 2018[33] evaluated the degree of surface roughness of resin composites (RC) after immersion in three beverages ; soft drink, distilled water and coffee for 1 week. They have reported that the polishing techniques, storage solutions, as well as material compositions were found to be important in the surface roughness(Ra) of all composite resins. After 7 days of immersion, the Ra of almost all materials significantly decreased.

Karadaş et al. 2018[34] Studied the effects of coffee, tea, grape juice , orange juice and strawberry fruit punch on surface roughness four bulk- fill resin composites (SonicFill, Filtek Bulk Fill Flowable, X-tra fil, Filtek Bulk Fill Posterior) and three nanocomposites (G-aenial Universal Flo, Herculite XRV Ultra, Filtek Ultimate). They stated that surface roughness after aging increased significantly for SonicFill, Filtek Bulk Fill Flowable, X-tra fil, Filtek Bulk Fill Posterior. Xtra Fil showed highest surface roughness.

Ozkanoglu et al. 2019[35] investigated the effects of distilled water , tea , coffee, cola on the color stability and microhardness of two direct composite resins (Filtek Z250, Filtek Z550); one indirect composite resin (Solidex); and one high viscosity glass ionomer cement (Equia Forte Fil) . After one week samples were tested for microhardness and they reported that the highest values of hardness were observed in the Z550 group. The highest levels of hardness change were detected in the coffee and cola groups and nanohybrid composite resins are resistant to external coloration and hardness change.

Correia et al. 2019[36] investigated the effect of acidic drinks on the different properties of conventional and bulk-fill composite resins. In their study the samples were divided into 5 groups: control, artificial saliva, acai juice, red wine, and Coca-Cola and were maintained for 30 days they reported that all surface topography parameters increased significantly after the acidic drinks and were greatest for Coca-Cola and the microhardness decreased significantly for all composite resins tested.

Chowdhury et al. 2020[1] evaluated the surface roughness of a nanohybrid composite resin after exposure to tea, coffee, Coca-cola, and artificial saliva on the 7th, 14th, and 28th day. They have stated that nanohybrid composite resin (Beautifil II) was susceptible to surface roughness when exposed to beverages like tea, coffee, Coca cola. Surface roughness was highest in Coca cola followed by coffee and tea. Surface roughness was time dependent as with increase in time, surface roughness and change also increases.

Bahbishi et al. 2020[37] studied the effects of tea ,coffee, berry juice and distilled water on surface microhardness and color stability of five different bulk fill composites namely Filtek Z350, Filtek Bulk-Fill, Tetric N-Ceram Bulk-Fill, Sonic Fill 2, and SDR after 10days, 30 days, 60 days , 90days they reported that all bulk fill composites have lower surface microhardness compared to universal composite resin and there were no major differences between Bulk-Fill tested brands regarding color change.

Meenakshi CM et al. 2020[38] evaluated the effect of artificial saliva, orange juice, and Coca-Cola on surface roughness and color stability of Filtek Bulk-Fill posterior restorative composite in comparison with Filtek P60 posterior restorative composite. The surface roughness and color change of both composites increased significantly in acidic beverages and more in Coca cola. Surface roughness bulk-fill composite in artificial saliva is lowest and microhybrid in Coca-Cola highest among all the groups. There was a significant surface degradation in all the acidic beverages and microhybrid composite exhibited more roughening than bulk-fill composite.

Liliany et al. 2020[39] studied effect of soft drink on surface roughness of preheated and non -preheated nanohybrid composite after 15days. In their study they fabricated cylindrical samples of nanohybrid composite resin Filtek ™Z 250 XT(10 mm in diameter and 2 mm in height) were prepared and divided into two groups : preheated and non – preheated and they reported that soft drinks significantly increased the surface roughness of preheated nanohybrid composite resins after 15 days of immersion.

Vaidya et al. 2020[40] evaluated the surface roughness of three flowable esthetic restorative materials after exposure to sports/energy drinks and alcoholic beverages. Total of 210 specimens of dimension (2cm diameter and 2 mm thickness) with giomer, compomer, and composite (70 samples with each esthetic material) were made with the help of plastic rings. The prepared samples were tested in six experimental sports/energy drinks (beer, whiskey, vodka, Gatorade, Red Bull, and Sting) and distilled water was considered as the control group. Profilometric analyses of all samples were recorded before immersing into the experimental and control solutions. Then, the samples were stored in the experimental and control group solutions for 5min for 30 days And they reported that Flowable composite showed the minimum surface roughness, whereas the flowable compomer showed the maximum surface roughness and When the erosive potential of the test solutions was evaluated, surface roughness values were more for sports/energy drinks when compared to that of alcoholic beverages.

Al qarani et al. 2021[41] assess the effect of daily consumable drinks on microhybrid and nanohybrid direct composite resin Each sample was immersed in test media such as Arabic coffee, black tea, orange-juice and distilled water as control group at room temperature for 15 days and they stated that highest values of microhardness were noted in the Arabic coffee followed by black tea and orange juice, whereas the lowest values were noted in the control and microhardness reduced in both the materials microhybrid and nanofilled composite following immersion in all the tested beverages.

Camilotti et al. 2021[42] conducted a study on impact of dietary acids on the surface roughness and morphology of three composite resins (4 Seasons, Z250, after immersion into the solutions G1: distilled water; G2, Coca-cola, and G3: orange juice for period of 180 days and they stated that 4 Seasons and Z250 had statistically similar roughness values for all the solutions and evaluation periods. With the exception of 180-day immersion in Coca-cola, 4 Seasons showed significantly higher values than Z250.

MATERIALS AND METHODS

ARMAMENTARIUM

INSTRUMENTS AND EQUIPMENTS

- Glass slabs
- Mylar Matrix Strips (Samit Matrix Strips, India)
- Teflon Mold
- Light Emitting Diode (LED) Curing Unit (blue phase, Ivoclar vivadent)
- Shofu finishing and polishing kit
- Beakers
- Digital Vernier Calliper (Absolute Digimatic, Mitutoyo, Japan)
- Composite Manipulation Instruments (API)
- Tweezers (GDC)
- Micromotor

- Contra angle handpiece (NSK, Japan)
- Incubator (DBK BOD, Model - DTC 96, Innovative Bacteriological Incubator)
- Roughness tester (Mitutoyo-Japan, Model: SJ 210)
- Micro Vickers Hardness testing Machine (ASTM E 384)
- pH meter (Konvio Neer)

MATERIALS:

- Tetric N-Ceram Bulk Fill (Ivoclar Vivadent)
- Tetric N-Ceram (Ivoclar Vivadent)
- Oral beverages – Tea powder (Red label), Coffee powder (Nescafe), Soft drink(Coca-Cola)

Artificial saliva (Wet mouth – ICPA Health products Ltd.)

METHOD

PROCEDURE EMPLOYED IN THE STUDY:

- A total of 120 composite discs of dimensions 10 mm X 2 mm were made from a custom made teflon mould , 60 discs of Tetric N-Ceram Bulk Fill (Ivoclar Vivadent) 60 discs of Tetric N-Ceram (Ivoclar Vivadent) .

1. Composite disc preparation:

A Teflon mold of 10mm diameter and 2mm thickness were used for sample preparation. A glass slab was used on which mylar strip was placed over which teflon mold was placed. The resin composites were inserted into mold cavity in a single increment and covered with mylar strip .To another glass slab was place over the resin/mold assembly to remove excess material and provide smooth and highly flat surface. After 30 seconds, the second glass slab was removed and resin composite light cured for 40 seconds each from both upper and lower side using LED light curing unit.

Finishing and polishing of composite discs

All specimens were stored in Artificial saliva at 100% humidity for 24 hours at 37 ^{0}C in an incubator. The 60 samples of each of the two composite resins were finished and polished with Shofu finishing and polishing kit as specified by the manufacturer. The coarse, medium, fine and super fine sequentially used for 20 sec each as specified by the manufacturer and the number of strokes were standardized for each specimen

Distribution of Samples

Three beverages Tea,coffee and soft drink were three test solutions and artificial saliva was used as control group.

Both resin material samples randomly divided into four subgroups 15 samples for each subgroups (artificial saliva ,tea ,coffee , soft drink) and each subgroup was divided into 5 samples each for different time intervals (3 months ,6 months 12 months).

Before immersion into beverages baseline values of surface roughness and microhardness for both composite resins was taken .

Distribution of samples into various groups and sub-groups for Tetric N-Ceram Bulk Fill:

COMPOSITE RESIN	TEST SOLUTIONS	TIME INTERVAL
I] <u>Tetric N-Ceram Bulk-Fill</u> (n = 60)	**IA] ARTIFICIAL SALIVA** (Control) (n = 15)	I Aa) 3 MONTHS (n = 5)
		I Ab) 6 MONTHS (n = 5)
		I Ac) 12 MONTHS (n = 5)
	IB] TEA (n = 15)	I Ba) 3 MONTHS (n = 5)
		I Bb) 6 MONTHS (n = 5)
		I Bc) 12 MONTHS (n = 5)
	IC] COFFEE (n = 15)	I Ca) 3 MONTHS (n = 5)
		I Cb) 6 MONTHS (n = 5)
		I Cc) 12 MONTHS (n = 5)
	ID] SOFT DRINK (n=15)	I Da) 3 MONTHS (n = 5)
		I Db) 6 MONTHS (n = 5)
		I Dc) 12 MONTHS (n = 5)

Distribution of samples into various groups and sub-groups for Tetric N-Ceram :

COMPOSITE RESIN	TEST SOLUTIONS	TIME INTERVAL
II] <u>Tetric N-Ceram</u> (n = 60)	**II A] ARTIFICIAL SALIVA** (Control) (n = 15)	II Aa) 3 MONTHS (n = 5)
		II Ab) 6 MONTHS (n = 5)
		II Ac) 12 MONTHS (n = 5)
	II B] TEA (n = 15)	II Ba) 3 MONTHS (n = 5)
		II Bb) 6 MONTHS (n = 5)
		II Cc) 12 MONTHS (n = 5)
	II C] COFFEE (n = 15)	II Ca) 3 MONTHS (n = 5)
		II Cb) 6 MONTHS (n = 5)
		II Cc) 12 MONTHS (n = 5)
	II D] SOFT DRINK (n=15)	II Da) 3 MONTHS (n = 5)
		II Db) 6 MONTHS (n = 5)
		II Dc) 12 MONTHS (n = 5)

Immersion of composite discs in oral beverages:

To prepare test solutions, 30 grams of Coffee powder and 30 grams of Tea were added, each into 1 litre of boiling distilled water. After 10 minutes of stirring, the solution was filtered through a filter paper. 250 ml of milk and 50 grams sugar were added to both the solutions. Soft drink and artificial saliva are commercially available as coca cola and wet mouth artificial saliva .

Time of immersion was calculated according to **Von Fraunhofer et al 2004**[43]. To simulate the period of 3 months, 6 months and 12months exposure of restorative material to the beverages in oral condition, time of immersion for samples is calculated as 4min in 24hr for 7 days, 15 days and 30 days.

Composite discs will be kept for 4min in 24hr in respective beverages. Everyday new freshly prepared test solutions was used.

Same cycle of immersion was continued for 7 days, 15 days and 30 days. During the whole period of study all the samples was stored in incubator of 37^{o}c temperature.

TESTING OF THE SAMPLES

SURFACE ROUGHNESS TEST

The surface roughness of each sample was performed with the Surface Roughness Tester (Mitutoyo-Japan, Model: SJ 210) with a standard cut off value of 0.8 mm, a transverse length of 8 mm, and a stylus speed of 0.1 mm/s. The “Ra” of a specimen was defined as the arithmetic average height of roughness component irregularities from the mean line measured within the sampling length.

Three profilometric tracings were made near the center of the specimen and a numeric average was determined for each specimen.

MICROHARDNESS EVALUATION

Microhardness of each sample was tested on Vickers's Hardness Tester using 100 grams of load and a dwell time for 15 seconds. For each sample three indentations were made on the surface of each sample.

Each indentation was measured by a microscope attached to the Vickers's Hardness

Tester and a mean value was determined for each sample. The results were then converted to Vickers's microhardness value. The hardness values were calculated using the formula;

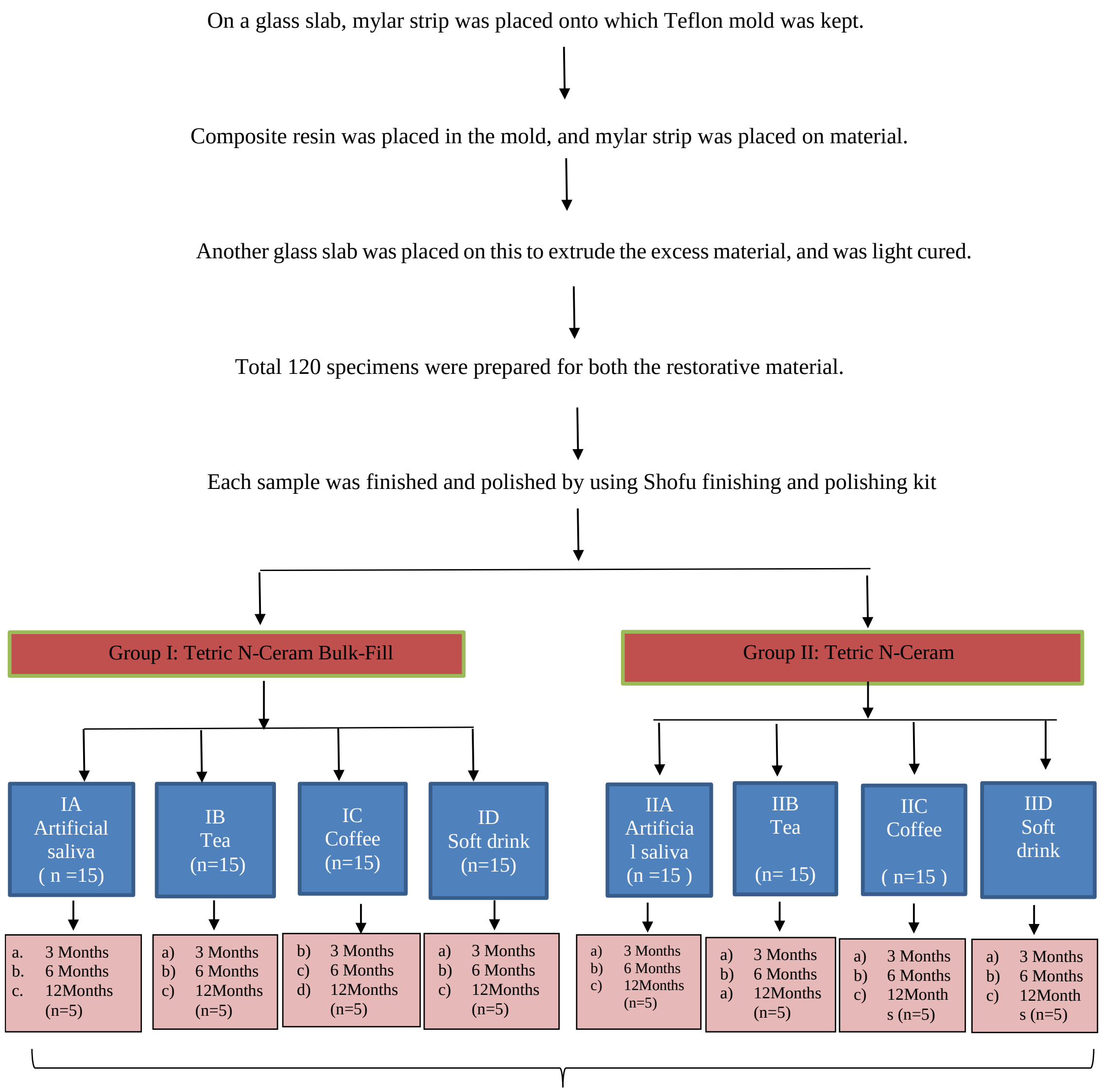
HV = 1.854 x (f/d2)

Where, HV = hardness number

f = load

d = arithmetic mean

ALGORITHM OF METHOD

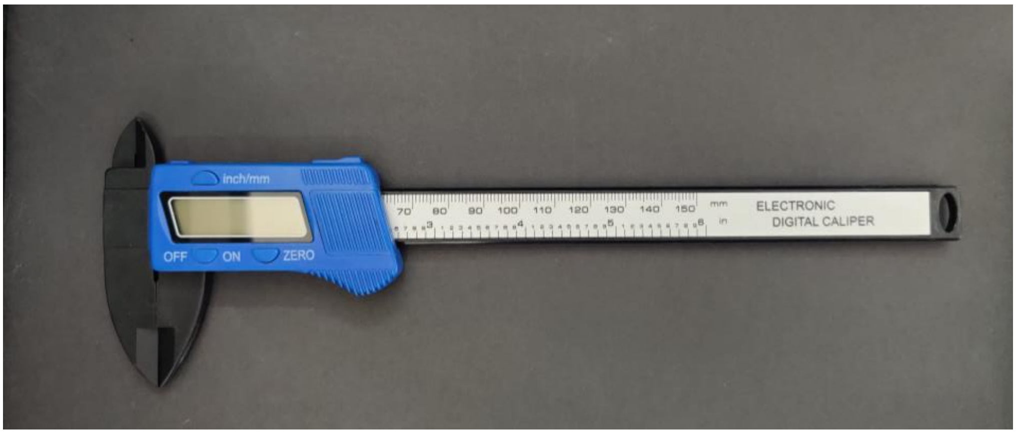


Samples were tested using Profilometer and Vickers microhardness tester. Values were recorded in micronmeter (um) and Vickers hardness number (VHN). The obtained data was collected and documented for statistical analysis

PLATE -I

ARMAMENTARIUM

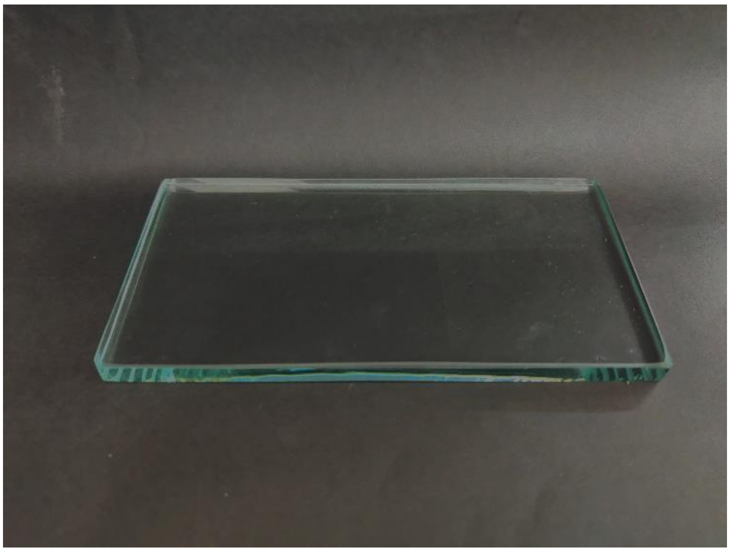
Composite Instruments (API)



Digital Vernier Caliper (Workzone tools)

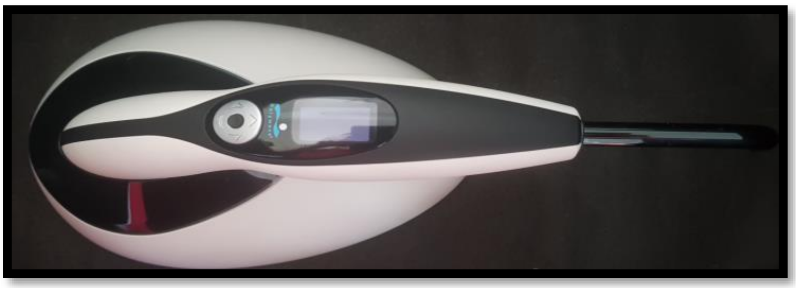
PLATE -II

ARMAMENTARIUM



Glass slab (GDC)

Mylar strip



Light Emitting Diode (LED) Curing Unit

PLATE -III

ARMAMENTARIUM

Shofu Fininshing And Polishing Kit

Beaker

PLATE -IV

ARMAMENTARIUM

Micromotor

Contra angle handpiece

PLATE -V

MATERIALS

Tetric N-Ceram Bulk Fill (Ivoclar Vivadent)

Tetric N-Ceram (Ivoclar Vivadent)

PLATE -VI

MATERIALS

Artificial Saliva (Wet Mouth, ICPA Health products Ltd)

Oral Beverages – Tea Powder (Red label), Coffee Powder (Nescafe), Soft drink(Coca-Cola)

PLATE -VII

ARMAMENTARIUM

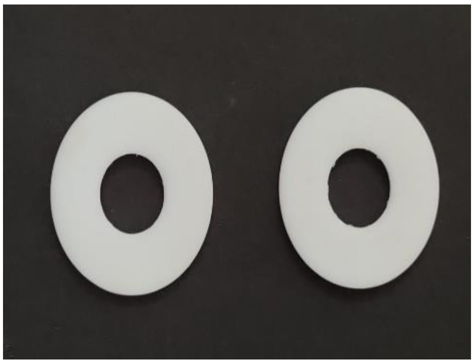
Incubator (DBK BOD, Model - DTC 96, Innovative Bacteriological Incubator)

Roughness tester (Mitutoyo-Japan, Model: SJ 210)

- Micro Vickers Hardness testing Machine (ASTM E 384)

PLATE -VIII

Methodology

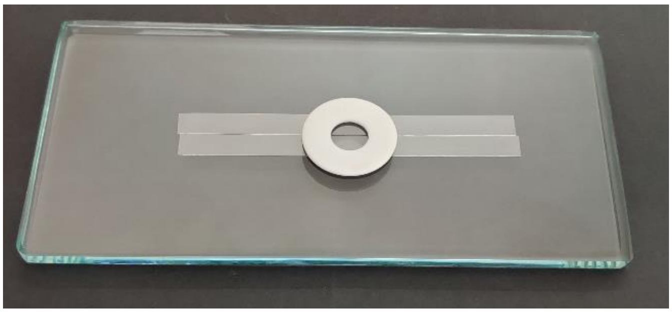


Telfon Mold

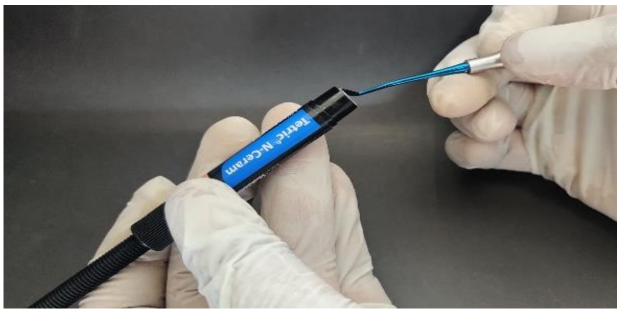
Teflon Mold 2mm Thickness

Teflon Mold ID 10mm

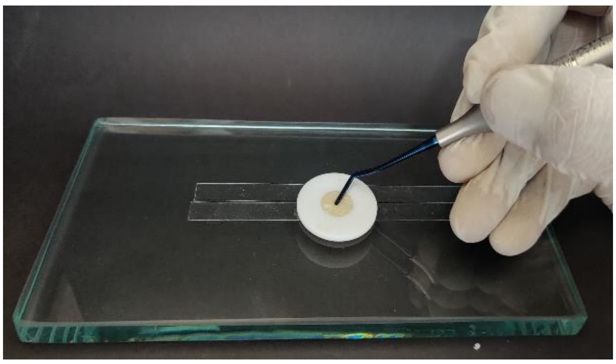
Preparation of Composite Discs



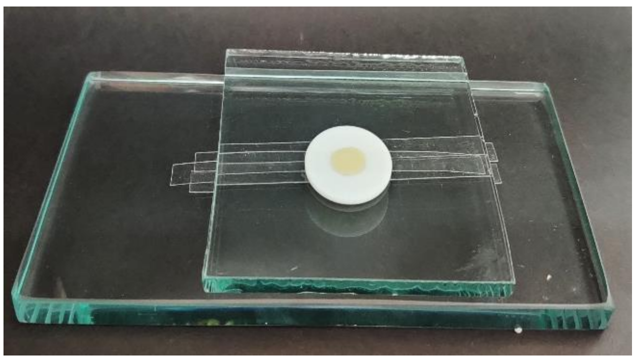
Teflon Mold placed On Mylar Strip



Composite Resin



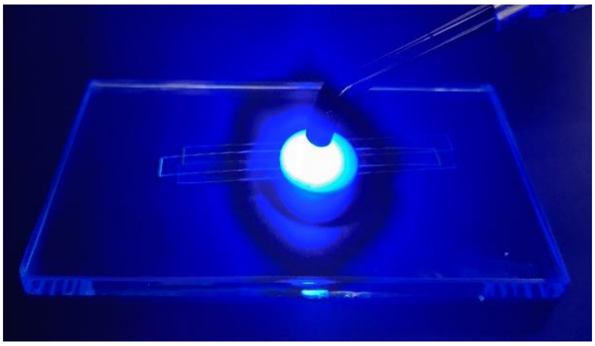
Composite Resin Placed In Teflon Mold



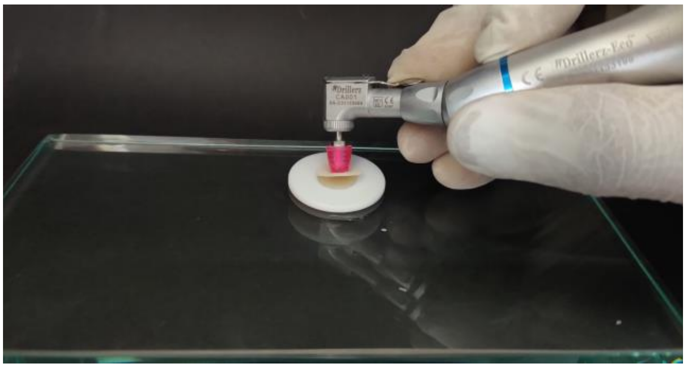
Placement of Mylar Strip and Glass Slide on top of mold

PLATE -XI

Methodology

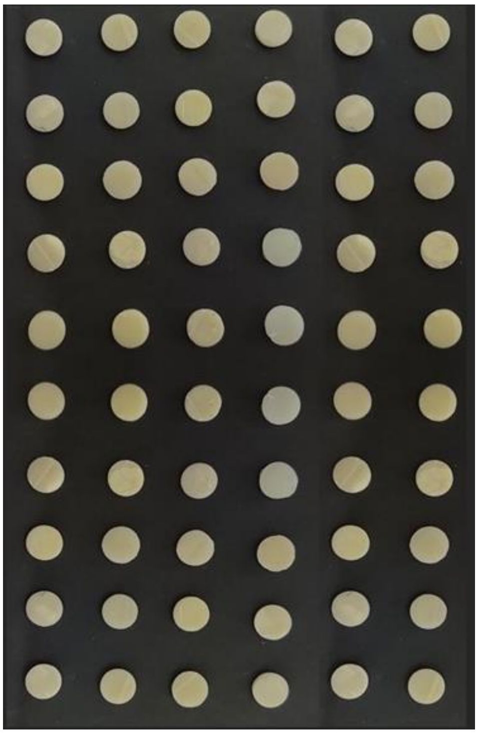


Curing Of Composite Discs

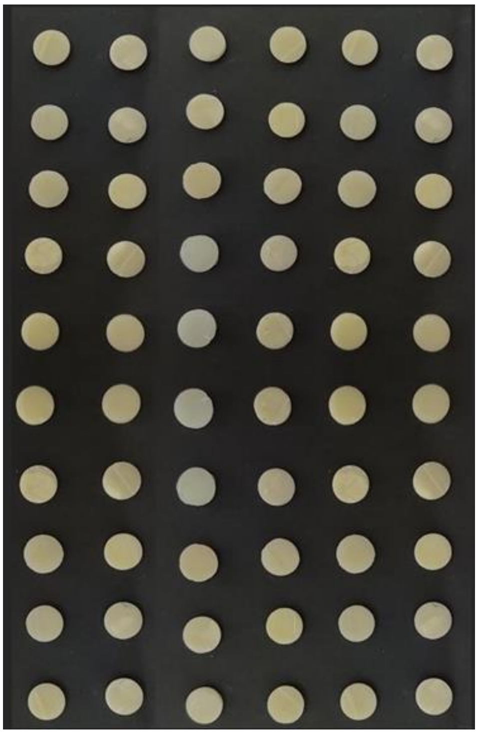


Finishing And Polishing Of Composite Discs

Fabrication of Composite Discs



60 Discs of Bulk Fill Composite Resin
Were Fabricated



60 Discs of Nanohybrid Composite Resin
Were Fabricated

PLATE -X

Immersion Into Beverages

Samples immersed in oral beverages Artificial saliva , Tea, Coffee and Soft Drink

PLATE –XI

EVALUATION OF SURFACE ROUGHNES

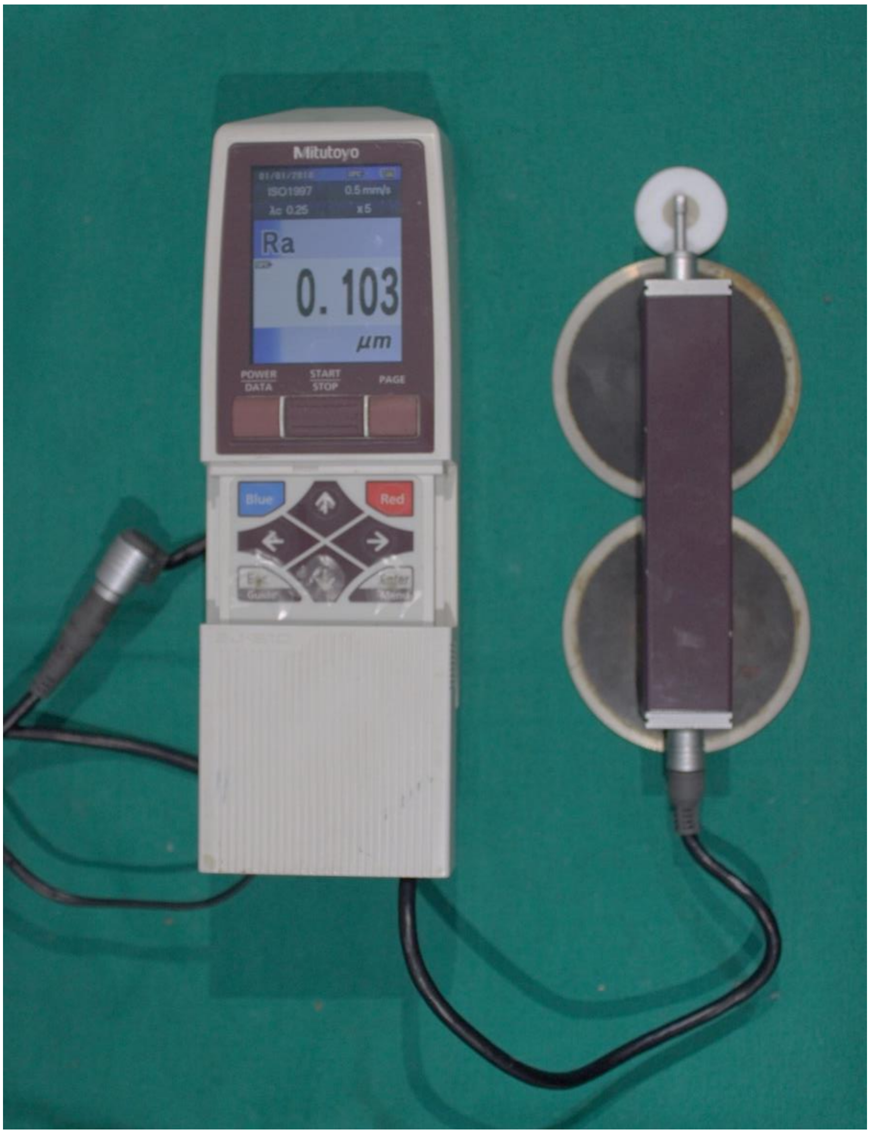


PLATE -XII

EVALUATION MICRHARDNESS

RESULTS

The present study was carried out to evaluate the effects of three different beverages (tea, coffee, soft drink) on surface roughness and microhardness of bulk fill composite resin and nanohybrid composite resin after various time intervals of 3months, 6 months, and 12 months.

Depending on type of material used the samples were divided into two broad groups . Group I :- Bulk fill composite resin

Group II :- Nanohybrid composite resin

Each group was further subdivided into four subgroups according to beverages used :

1) Sub-group IA : Artificial saliva (Control group)
2) Sub -group IB : Tea
3) Sub-group IC : Coffee

4) Sub-group ID : Soft Drink

Each subgroup was again divided into final groups according to different time intervals as follows :

COMPOSITE RESIN	TEST SOLUTIONS	TIME INTERVAL
I] Tetric N-Ceram Bulk-Fill (n = 60)	**IA] ARTIFICIAL SALIVA** (Control) (n = 15)	I Aa) 3 MONTHS (n = 5)
		I Ab) 6 MONTHS (n = 5)
		I Ac) 12 MONTHS (n = 5)
	IB] TEA (n = 14)	I Ba) 3 MONTHS (n = 5)
		I Bb) 6 MONTHS (n = 5)
		I Bc) 12 MONTHS (n = 5)
	IC] COFFEE (n = 15)	I Ca) 3 MONTHS (n = 5)
		I Cb) 6 MONTHS (n = 5)
		I Cc) 12 MONTHS (n = 5)
	ID] SOFT DRINK (n=15)	I Da) 3 MONTHS (n = 5)
		I Db) 6 MONTHS (n = 5)
		I Dc) 12 MONTHS (n = 5)

COMPOSITE RESIN	TEST SOLUTIONS	TIME INTERVAL
II] Tetric N-Ceram (n = 60)	**II A] ARTIFICIAL SALIVA** (Control) (n = 15)	II Aa) 3 MONTHS (n = 5)
		II Ab) 6 MONTHS (n = 5)
		II Ac) 12 MONTHS (n = 5)
	II B] TEA (n = 15)	II Ba) 3 MONTHS (n = 5)
		II Bb) 6 MONTHS (n = 5)
		II Cc) 12 MONTHS (n = 5)
	II C] COFFEE (n = 15)	II Ca) 3 MONTHS (n = 5)
		II Cb) 6 MONTHS (n = 5)
		II Cc) 12 MONTHS (n = 5)
	II D] SOFT DRINK (n=15)	II Da) 3 MONTHS (n = 5)
		II Db) 6 MONTHS (n = 5)
		II Dc) 12 MONTHS (n = 5)

Statistical methods

The data on micro hardness and surface toughness were obtained for two composite resins with four different types of exposures and for three different exposure durations. The parameters were summarized in terms of mean and standard deviation for each exposure type; and before and after each exposure duration. The comparison of micro hardness before and after exposure was performed using paired t-test. The analysis was performed independently for two composite resins. On similar lines, the surface roughness was compared between two times using paired t-test. The change in the micro hardness before and after exposure of each beverage was summarized in terms of mean and standard deviation. The comparison of change in micro hardness between two resins for each exposure type was performed using t-test for independent samples. Further, the comparison of change in micro hardness across exposure types for each resin type was performed using one-way analysis of variance. The paired comparison was carried out using Tukey's post-hoc test. On similar lines, the analysis was performed for surface roughness. The correlation between change in micro hardness and change in surface roughness was performed using Pearson's correlation coefficient at each exposure duration.

All the analyses were performed using SPSS ver 20.0 (IBM Corp, USA) software and the statistical significance was tested at 5% level.

The formulations used in the study are as below:

Measures of central tendency

If x_1, x_2,…x_n are the observations on a random variable X, then following measures of central tendency can be obtained:

- **Mean** for a set of observations is given by

$$\overline{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Measures of dispersion

- **Standard deviation** for a set of observations in given by

$$s = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(x_i - \overline{x})^2}$$

where x_i = observation on each object; n = number of objects

Statistical inference tests

- **Student's t-test for independent samples**

The test is used for comparing the statistical significance of difference in the means of two samples. It compares the sample difference between two means in relation to the variation in the data (expressed as the standard deviation of the difference between the means).

It is given by the formula:

$$t = \frac{(\overline{x}_1 - \overline{x}_2) - (\mu_1 - \mu_2)}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

where $\overline{x}_1$ and $\overline{x}_2$ are the means of sample observations of two different groups, μ_1 and μ_2 are the means of the respective populations from which the samples are derived, and S is the pooled sample standard deviation, which is given by:

$$s^2{}_{pooled} = \frac{(n_1 - 1)s_1{}^2 + (n_2 - 1)s_2{}^2}{n_1 + n_2 - 2}$$

here s_1^2 and s_2^2 are the variance of two samples and n_1 and n_2 are the sample sizes in two groups. If the test statistic results in a *P*-value > 0.05 (level of significance), then the null hypothesis H_0: *There is insignificant difference in the means of two groups* is accepted and the alternative hypothesis H_1: *There is significant difference in the means* is rejected. On the other hand, if *P*-value < 0.05, then the H_1 is accepted and H_0 is rejected.

- **Paired t-test**

The method is typically used for assessing the effectiveness of an experimental procedure that makes used of related observations resulting from dependent samples. The hypothesis test based on this type of data is known as *paired comparison test*.

For *n* sample differences computed from *n* pairs of measurements, which are distributed normally, the test statistic for testing hypothesis about population mean difference μ_d is given by:

$$t = \frac{\bar{d} - \mu_d}{s_d / \sqrt{n}}$$

where $\bar{d}$ is the sample mean, μ_d is the hypothesized population mean difference

- **One-way Analysis of variance**

Analysis of variance (ANOVA) is used to test the significance of difference in the mean of three or more groups. The basic assumption is that the variable of interest is normally distributed in the population under study.

Here the interest is to test the null hypothesis that the population means are same, $H_0 : \mu_1 = \mu_2 = ...\mu_m$ i.e.

against the alternative H_1 that they are not same.

Some of the statistics computed to test the hypothesis are as below:

i) Grand mean: It is the mean of set of all observations in the studied groups and is given by:

$$\overline{x}_{GM} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

ii) Total sum of squares: It is the sum of squares of each observation from the grand mean and is given by:

$$TSS = \sum_{i=1}^{N} (x_i - \overline{x}_{GM})^2$$

Total sums of squares is the sum of two components i.e., variation between groups and within groups.

iii) Between group sum of squares

$$SSB = \sum_{j=1}^{m} n_j (\overline{x}_j - \overline{x}_{GM})^2$$

iv) Within group sum of squares

$$SSW = \sum_{j=1}^{m}\sum_{i=1}^{n} (x_{ij} - \overline{x}_j)^2$$

The mean sum of squares is obtained by dividing the above sum of squares with the respective degrees of freedom, i.e. N-1, p-1 and $p(n$-1).

v) F-statistic: It is the ratio of between and within mean sum of squares

$$F = \frac{MS_{Between}}{MS_{Within}}$$

If the p-value based on F-statistic is greater than 0.05, H_0 is accepted, otherwise H_1 is accepted.

vi) Tukey's post-hoc test

After performing ANOVA, if alternative hypothesis H_1 is accepted, then the subsequent interest is to determine the pair wise significance of difference in the means of study groups. This could be carried using Tukey's post-hoc test. The difference between the means of all groups are determined and compared with this critical difference called the honest significant difference (HSD). It is given by: $HSD = q\sqrt{\frac{MS_{within}}{n}}$

where, q is the studentized range statistic derived from the tables, n is the sample size and the mean square value is from the ANOVA analysis. If the critical difference exceeds the absolute difference between any two sample means, then the corresponding means differ significantly.

Correlation

- **Pearson's correlation**

Pearson's correlation coefficient quantifies the relationship between two measurable variables. It measures the linear relationship between two variables. Thus, if *X* and *Y* are two variables taking values $x_1, x_2, \ldots x_n$ and $y_1, y_2, \ldots y_n$, then the correlation coefficient (*r*)between the two variables is given by:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

The value of *r* lies between -1 to +1, with -1 indicating perfect negative correlation and +1 indicating perfect positive correlation.

Overall Results :

The Mean values and standard deviation of surface roughness and microhardness for two different composite resin namely Bulk fill composite resin (Group I) and Nanohybrid composite resin (group II) immersed in Artificial Saliva and three different beverages namely, Tea, Coffee, Soft drink at various time intervals of 3 months, 6 months and 12 months have been described in **Table 1, Table 2, Table 4 and Table 5** .

The change in difference between pre- and post-immersion of bulk fill composite resin and nanohybrid composite resin into the aforementioned beverages at various time intervals of 3 months, 6 months and 12 months have been described in table 3 and table 6 respectively.

The maximum change in surface roughness **(0.42)** was observed in nanohybrid composite resin samples immersed in soft drink for period of after 12 months (**Group II Dc**) whereas minimum change in difference **(0.01)** in surface roughness was observed in bulk fill composite samples immersed in artificial saliva for 3 months **(Group I Aa) .**

The maximum change in difference in microhardness **(- 18.60)** was observed in Nanohybrid composite resin samples immersed in soft drink for period of 12 months **(Group II Dc)** whereas the minimum change in microhardness **(-1.10)** was observed in nanohybrid composite samples immersed in artificial saliva for period of 6 months **(Group II Bb).**

Analysis of surface roughness

The effect of four different beverages on surface roughness of bulk fill composite resin samples before and after the specified duration of four different exposures was determined using paired t-test, as described in **(Table 1).**

Statistically insignificant differences were observed for surface roughness at all time intervals. Statistically significant increase of surface roughness post exposure was observed in samples immersed in tea for 6 months and 12 months as revealed through p-values **0.0475 and 0.0277** respectively. Similar results were observed for samples immersed in coffee for all time exposures indicated by **p-values 0.0399, 0.0012 and 0.0112** respectively. Also, the samples immersed in soft drink for 3 months, 6 months and 12 months showed significantly increased roughness after exposure with p-values **0.0043, 0019 and 0.0001** respectively.

In nanohybrid composite, for salivary exposure, the difference of surface roughness was statistically significant for 3, 6 and 12 months of exposure times, as indicated by **p-values 0.2203, 0.0334** and **0.0299** respectively. Similar finding were observed for tea at 3, 6 and 12 months exposure as revealed through **p-values 0.0363, 0.0050 and 0.0135** respectively. Similarly coffee exposure of 3 months, 6 months and 12 months also resulted into statistically significant increase in surface roughness as indicated by **p-values 0.0342, 0.0036 and <0.0001** respectively. Also soft drink exposure 3months, 6 months and 12 months showed significantly increased roughness after exposure with **p-values 0.0029, 0.0001 and <0.0001** respectively. **(Table 2)**

Table 3 shows the comparison of change in surface roughness between two composite resins subjected to artificial saliva and different beverages for specified times, using t-test for independent samples. It is evident that for salivary exposure of 3 months, 6 months and 12 months. the difference of mean change in surface roughness between two composite resins was statistically significant as indicated by **p-values 0.1580, 0.0036 and 0.0381** respectively. For tea exposure, the difference of mean change for 3 months, 6 months and 12 months exposure between two resin types was statistically significant with **p-value 0.0391, 0.0494 and 0.0369**. Also for coffee exposure, the difference of mean change for 6 months and 12 months exposures between two resin types was statistically significant with **p-value 0.0442 and 0.0433**. For soft drink exposure, the difference of mean change for 6 months and 12months exposure between two resin types was statistically significant with **p-values 0.0440** and **0.036**

Also, the difference of mean change of surface roughness across four exposures corresponding to each exposure duration using bulk-fill composite resin showed statistically significant difference, using one-way analysis of variance (ANOVA) ($p < 0.05$). It is evident that the difference of mean change for 3, 6 and 12 months across exposure types were statistically significant with **p-values < 0.0001, 0.004 and 0.003** respectively. For nano hybrid composite resin, this difference was significant for 3, 6 and 12 months exposure with a p-value of **0.0222, 0.0013 and <0.0001** respectively**.**

Table 4 provides the pair wise comparison of change in surface roughness for different exposure and with different exposure times for each composite resin type, using Tukey's post-hoc test. It shows that the difference of mean change in surface roughness for saliva and tea was statistically significant at 12 months for nanohybrid composite resin with p-value of 0.037.

For comparison between saliva and coffee exposure, with bulk-fill resin, and for 3, 6 and 12 months exposure, the mean change in surface roughness was significant with p-values 0.019, 0.004 and 0.001 respectively. Further, with nanohybrid resin, and for 6 and 12 months exposures, the mean change in surface roughness was significant with p-values 0.047 and 0.024 respectively.

For comparison between saliva and soft drink exposure, with bulk-fill resin, and for 3, 6 and 12 months exposure, the mean change in surface roughness was significant with p-values < 0.0001, 0.003 and 0.021 respectively. Further, with nanohybrid resin, and for 3, 6 and 12 months exposures, the mean change in surface roughness was significant with p-values 0.023, 0.038 and 0.004 respectively.

For comparison between tea and soft drink, with bulk-fill resin, and for 3 months exposures, the mean change in surface roughness was significant with p-values 0.001, while for nanohybrid resin also at 3 months the difference was significant with **p-value of 0.041**.

For comparison between coffee and soft drink, with bulk-fill resin, and for 3 months exposures, the mean change in surface roughness was significant with p-values 0.046, while for nanohybrid resin also at 3 months the difference was significant with **p-value of 0.038**.

Analysis For Microhardness :

In order to determine the effect of four different beverages on microhardness of bulk fill composite resin samples before and after the specified duration of four different exposures, using paired t-test are described in **Table 5.**

For salivary exposure, after 12 months duration, there was significant difference in micro- hardness of samples as indicated by a **p-value of 0.0086**; while the difference was insignificant for 3 and 6 months of exposure times. However, for tea, 3 months, 6 months and 12 months exposure resulted into statistically significant lowering of micro-hardness post exposure as revealed through **p-values 0.0109, 0.0342** and **0.0026** respectively. Similarly, coffee exposure of 3 months, 6 months and 12 months resulted into statistically significant lowering of micro- hardness as indicated by **p-values 0.0052, 0.0011** and **0.0022** respectively. Also, soft drink exposure of 3 months, 6 months and 12 months showed significantly reduced micro-hardness after exposure with **p-values 0.0051, 0.0055** and **0.0002** respectively.

The comparison of micro-hardness of nano hybrid composite resin samples before and after the specified duration of four different exposures, using paired t-test have been described in **Table 6**

For salivary exposure, after 6 months duration, there was significant difference in micro- hardness of samples before and after as indicated by a **p-value** of **0.0109**. Similarly, the difference was statistically significant for 12 months exposure, as indicated by a p-value of **0.0188**, while the difference was insignificant for 3 months of exposure time. However for tea, 3 months, 6 months and 12 months exposure resulted into statistically significant lowering of micro-hardness post exposure as revealed through p-values **0.0231, 0.0016** and **0.0062** respectively. Similarly, coffee exposure of 3 months, 6 months and 12 months resulted into statistically significant lowering of micro-hardness as indicated by **p-values 0.0143, 0.0004** and **0.0008** respectively. Moreover, the soft drink exposure of 3 months, 6 months and 12 months also showed significantly reduced micro-hardness after exposure with **p-values 0.0023, 0.0118** and **0.0014** respectively.

In the present study, changes in difference of micro-hardness i.e the difference between post and pre micro-hardness for two composite resins subjected to four different exposures for specified times, using t-test for independent samples have been described in table 5 . It is evident that for salivary exposure of 3, 6 and 12 months, the difference of mean change in micro-hardness between two composite resins was statistically insignificant as indicated by p- values > 0.05. For tea exposure, the difference of mean change for 6 months and 12 month exposures between the two composites were statistically significant with **p-values 0.0235** and **0.0304** respectively. Also for coffee exposure, the difference of mean change for 6 months and 12 month exposures between two resin types were statistically significant with p-values **0.0017 and 0.0413** respectively. For soft drink exposure, the difference of mean change for 12 month exposures between two composites was statistically significant with **p-values 0.0338**. **(Table 7)**

Also, the difference of mean change in micro-hardness amongst four exposures corresponding to each exposure duration using bulk-fill composite resin showed statistically significant difference, using one-way analysis of variance (ANOVA). It is evident that the difference of mean change for 3, 6 and 12 months across exposure types were statistically significant with **p-values < 0.0001**. Similar findings were observed for nanohybrid composite resin.

Table 8 provides the pair wise comparison of changes in micro-hardness for different beverages with various time intervals for each composite resin, using Tukey's post-hoc test. It shows that the difference of mean change in micro-hardness for 12 month exposure of saliva and 12 month exposure of tea, for nano hybrid composite resin, was statistically significant with a **p-value of 0.048**.

For comparison between bulk-fill composite immersed in saliva and coffee for 6 and 12 months duration, the mean change in micro hardness was significant with **p-values 0.02** and **< 0.0001** respectively. Furthermore, for nanohybrid resin immersed in saliva and coffee for 3, 6 and 12 months, the mean change in micro hardness was significant with **p-value** of **0.049, 0.005** and **0.001** respectively.

For comparison between bulk-fill resin immersed in saliva and soft drink for 3, 6 and 12 months, the mean change in micro hardness was significant with **p-values**

0.001, < 0.0001 and

< 0.0001 respectively. Further, with nanohybrid resin, the mean change in micro hardness at 3, 6 and 12 months exposure was significant with **p-value < 0.0001** each.

For comparison between bulk-fill resin samples immersed in tea and coffee for 12 months exposure, the mean change in micro hardness was significant with **p-values 0.002.**

Significant differences in microhardness values were observed for bulk-fill resin samples immersed in tea and soft drink for all the time intervals with **p-value** of **0.001.**

For comparison between tea and soft drink groups for 3, 6 and 12 months exposures, the mean change in micro hardness was significant Further, with nanohybrid resin, and for 3, 6 and 12 months exposure, the mean change in micro hardness was significant with **p-value < 0.0001, 0.011** and **0.003** respectively.

For comparison between coffee and soft drink exposures, with bulk-fill resin, and 6 months exposure, the mean change in micro hardness was significant with **p-values 0.039**. Further, with nanohybrid resin, and for 3 months exposure, the mean change in micro hardness was significant with **p-value 0.012**.

Co-relation between change in difference in micro hardness and surface roughness

Figure 13 shows the relationship between change in micro hardness and change in surface roughness at three time intervals for both composite resins. At 3 months, the Pearson's correlation coefficient between the two parameters was **-0.1734,** and was statistically insignificant. In other words, as the change in micro hardness was smaller (in absolute sense), the corresponding change in surface roughness was also smaller; however, the relationship was insignificant. At 6 months, the correlation coefficient obtained was **-0.3273,** and was statistically significant with a **p-value of 0.0391**. Similarly, at 12 months, the correlation coefficient obtained was **-0.5375**, and was statistically significant with a **p-value 0.0003**.

DISCUSSION

Composite is the universally used tooth-coloured direct restorative material in contemporary dental practice. It was developed in 1962 by combining dimethacrylates (epoxy resin and methacrylic acid) with silanized quartz powder (Bowen 1963). With advancements in esthetic properties and adhesive technology, composites have replaced traditional amalgam restorations. Composites are constituted of three major components: resin matrix (organic content), fillers (inorganic part) and coupling agents. The resin matrix consists mostly of Bis-GMA (bisphenol-A-glycidyl dimethacrylate), to reduce the viscosity TEGDMA (triethylene glycol-dimethacrylate) is added to Bis-GMA. Lower the Bis-GMA content and higher the proportion of TEGDMA, higher the polymerization shrinkage. Replacing Bis-GMA with TEGDMA increases the tensile strength but reduces the flexural strength of the material.

Different type of fillers like quartz, ceramic and silica increase the strength of material. An increase in the filler content causes less polymerization shrinkage, reduced linear expansion coefficient, and less water absorption. Moreover, the compressive, tensile strength, the modulus of elasticity and wear resistance are increased. Longer light polymerization improves the rate of conversion (chain-linking of the monomers) and thus leads to less monomer release.[44]

The changes in the resin matrix and the filler have led to significant changes in resin restorations. The most crucial changes that have evolved in reinforcing filler, is reduction in size, filler particle distribution and filler content to produce materials, that are more easily and effectively polished and demonstrate greater wear resistance. The latter was especially necessary for materials used in posterior applications, but the former has been important for restorations in all areas of the mouth.[45]

Nanotechnology, known as nano-science or molecular engineering, is defined as the creation of functional materials and structures with characteristic dimensions in the range of 0.1-100 nm. The advent of nanotechnology has led to optimization of mechanical properties of composites such as strength, good polishability and better simulation of natural tooth appearance.[46]

When inorganic phases in an organic/inorganic composite become nanosized, they are called nanocomposite. Because extremely small filler particles have dimensions below the wavelength of visible light (0.4-0.8 μm), they are unable to scatter or absorb visible light. Thus, nanofillers are usually invisible and offer the advantage of optical property improvement, and are capable of increasing the overall filler level due to their small particle sizes. More filler can be accommodated if smaller particles are used for particle packing. The increase in filler level results in a lower amount of resin in nanocomposites, decreases polymerization shrinkage and dramatically improves the physical properties of nanocomposites.[47]

The nanohybrid composite used in the present study was Tetric N-Ceram which consists of Bis-GMA, Bis-EMA and UDMA. The organic matrix accounts for approximately 21% of the mass. Bis-GMA, Bis-EMA and UDMA exhibit low polymerization shrinkage by volume. It incorporates several different types of filler (barium aluminium silicate glass with two different mean particle sizes, an Isofiller, ytterbium fluoride and spherical mixed oxide) in order to achieve the desired composite properties. It has an overall standard filler content of approximately 61%(vol.) and 17% polymer fillers or Isofillers. Glass fillers result in low wear and favorable polishing properties i.e. low surface roughness and high gloss. Isofillers are instrumental in lowering the polymerization shrinkage and associated stress. It utilizes a specially designed shrinkage stress relieving Isofiller. Ytterbium fluoride confers high radiopacity to dental materials and is capable of releasing fluoride. Spherical mixed oxide provides the basis for reduced wear and favourable consistency.[48]

Patel et al. 2016[49] evaluated the effects of various polishing systems on the surface texture of Tetric N Ceram and Filtek Z350. After finishing and polishing, Tetric N Ceram showed better surface finish when compared to the Filtek group**.**

Enone LL et al. 2020[50] evaluated the clinical performance of nanohybrid composites in a Nigerian adult population and stated that resin composites with nanoparticles are characterised by low incidences of roughness and wear after finishing and polishing.

Currently, Bulk-fill composites are widely used for posterior teeth restoration because of their simplicity of filling in single increment. The bulk-fill Resin-based Composites (RBCs) are claimed to have a lower polymerization contraction stress, deeper depth of cure 4–5 of mm, exhibit higher light transmission properties due to light scattering at the filler-matrix interface by either reducing the filler amount or increasing the filler size. In addition, they reduced cuspal deflection and possess time-saving restorative materials when compared with conventional resin based composites filled by the multi-incremental layering technique.

The newly developed bulk-fill RBCs include two types of materials based on their viscosity: low-viscosity (flowable) and high-viscosity (sculptable) types. Flowable bulk-fill RBCs have low-viscosity which reduce air entrapment and can be restored in 4 mm increments. They permit intimate adaptation to the prepared cavity walls. However, when using flowable bulk-fill RBCs, the manufacturers recommend to finish the restoration by the placement of a final capping layer made of regular RBCs. Nevertheless, high-viscosity bulk-fill RBCs can fill up the occlusal area in a single bulk step and sculpt, thus eliminating the need of an additional top capping layer. They have high viscosity and high filler content and their handling properties are similar to regular hybrid RBCs.[51]

Tetric N-Ceram Bulk Fill composite used in the present study is composed of resin matrix (Bis-GMA, UDMA) fillers (Ba-Al-Si glass, pre-polymerized filler monomer, glass filler, and ytterbium fluoride, spherical mixed oxide and filler content is 75 – 77 % wt .[52]

Jhang J et al. 2015[53] conducted an invitro study comparing polymerisation shrinkage and depth of cure of bulk fill composite resin and filled flowable resin and reported that bulk fill composite resin showed less polymerisation shrinkage and high depth of cure upto 4mm.

Van Ende et al [54], evaluated depth of cure of bulk fill composite resin stated that bulk fill composite resin showed high depth of cure 4-5mm and high degree of conversion than other composite resins.

In the present study tea, coffee and soft drink were used as they are the most preferred and commonly consumed beverages in India .

According to Tea Board, India, around 80% of population consumed tea. 73% percent of the population in India consumes coffee as per the consensus by Coffee Board, India. Furthermore, there is higher consumption of aerated beverages such as Coca-cola among the younger generation with India being the world's third largest consumer. [1]

In study conducted by **Chowdhury et al in 2020**[1]**,** they stated that various commonly consumed beverages such as soft drinks, coffee and tea can lead to discoloration of the composite material. Frequent, consumption of these beverages can ultimately hamper the physical properties and thus affecting the clinical performance of material.

Ozkanoglu et al. 2019[35] investigated the effects of distilled water, tea, coffee, cola on the color stability and microhardness of two composite resins (Filtek Z250, Filtek Z550);After one week samples were tested for microhardness and they reported that the highest values of hardness were observed in the Z550 group. The highest level of changes in microhardness was observed in the coffee and cola groups.

Sadeghi M et al in 2016[27], studied effects of coffee, and cola on the roughness of nanohybrid and microhybrid resin composites. After 7 days of immersion microhybrid composite showed a greater surface roughness than nanohybrid in all solutions . Specimens immersed in coffee exhibite significantly greater surface roughness than that of distilled water and cola. They concluded that nano-hybrid composite showed a significantly smoother surface than microhybrid.

There is scarcity of research on the effect of comely used beverages on surface roughness and microhardness of Bulk fill composite resin and nanohybrid composite resin. Hence, the following study was carried out to evaluate effect of three different beverages on surface roughness and microhardness of Bulk fill composite resin and nanohybrid composite resin at various time intervals of 3months, 6 months and 12 months.

For sample size estimation, a study by **Badra et al. 2005**[13] was referred. Higher Surface roughness and microhardness was seen in soft drink along with Hybrid Composite. Assuming that similar difference could be obtained in the present study, the estimated sample size that could provide 80% power and 95% confidence interval was 5 samples per group. Therefore, the total sample size for current research was kept 120.

The formulation used for calculating the sample size was:

$$n = 2\left(\frac{Z_{1-\alpha/(2\tau)} + z_{1-\beta}}{\mu_A - \mu_B}\sigma\right)^2$$

where $Z_{1-\alpha/(2\tau)}$ is standard normal value for α=5% error and τ, the number of comparisons, $z_{1-\beta}$ is the standard normal value for β=20% and σ is the pooled standard deviation.

A Teflon mold of 10mm internal diameter and 2mm thickness was used to make the disc‑shaped composite specimens of diameter 10 mm and thickness 2 mm as suggested by **Tanthanuch et al.**[26]

The sample was then light cured using LED curing unit (Bluephase N, IvoclarVivadent) for 40 seconds. The tip was kept in close contact and perpendicular to the surface of composite specimen. During curing of composite specimen, the specimens were carefully centred at the tip of curing gun.

In the present study light curing unit used was LED unit as suggested by **Kramer Norbert et al**. **2008**[55]. They considered LED curing unit superior to QTH because of longer lasting bulbs with fewer maintenance concerns, emit radiation only in blue part of visible spectrum, they do not require filters, are less energy consuming and require less wattage, generates no heat, they are quite as cooling fan is not needed, produces higher power intensity, thus reducing polymerization time. Specimens were irradiated for 40 second as it gives better results.

Price et al. 2003[56] compared two irradiation time 20sec and 40 sec by using LED curing light and they have reported that 40 sec exposure can polymerised all the composite resin.

The specimens were stored in Artificial saliva at 100% humidity for 24 hours at 37 ^{0}C in an incubator. **Rai et al. 2018**[57] determined surface roughness of esthetic materials after finishing and polishing and reported that super snap aluminium oxide disc provides adequate surface smoothness as they do not displace composite fillers. So, all the samples were finished and polished with Shofu finishing and polishing kit as specified by the manufacturer. The coarse, medium, fine and super fine sequentially used for 20 sec each, as specified by the manufacturer and the number of strokes were standardized for each specimen.

In the present study after composite disc preparation block randomisation was done into two groups and four subgroups corresponding to composite material and beverages used respectively at various time intervals.

Two resin composites were be used for study:

Group I: Bulk fill composite resin.

Group II: Nanohybrid composite resin.

Each group was further subdivided into four sub-groups according to beverages used.

For Group I: Bulk Fill composite resin

IA : Artificial saliva (Control group).

IB :Tea.

IC : Coffee.

ID : Soft Drink (Coca-Cola)

For Group II: Nanohybrid composite resin

IIA : Artificial saliva (Control group).

IIB : Tea.

IIC : Coffee

IID : Soft Drink (Coca-Cola)

Each subgroup contained 15 samples which were further subdivided into 5 samples for 3 time intervals 3 month, 6 months, 12 months.

Time of immersion was calculated according to von Fraunhofer . To simulate the period of 3 months, 6 months and 12months exposure of restorative material to the beverages in oral condition, time of immersion for samples is calculated as 4min in 24hr for 7 days, 15 days and 30 days.

The most commonly consumed brands of oral beverages viz. Tea, Coffee and Coca - Cola were used to evaluate the surface roughness and microhardness of composite resins after immersion in them for a period of 7 days, 15 days and 30 days. Artificial saliva was kept as a control to simulate the in-vivo conditions as performed in the study by **Badra VV et al. 2005**[13].

According to **Von Fraunhofer et al. 2004**[43]**,** exposure time for a beverage on the dentition is closer to 20 seconds before salivary clearance occurs; this would make the annual exposure of dental enamel to beverages approximately 90,000 seconds (that is, 1,500 minutes or 25 hours) per year. To simulate the period of 3 months, 6 months and 12months exposure of restorative material to the beverages in oral condition, time of immersion for samples is calculated as 4min in 24hr, which shows that 7 days will be considered as 1 month, 15 days as 6 months and 30 days as 12 months.

The surface quality or texture of a restoration is an important factor determining their clinical success in the oral environment. The surface roughness value is denoted by (Ra) which is defined as the arithmetic average height of roughness component irregularities from the mean line measured within the sampling length .

Surface profilometers have been used for years to measure surface roughness in laboratory investigations. There are two types of profilometers available which are contact profilometer and non‑contact profilometer. The contact profilometer can be further classified as manual or digital.

Average surface roughness in this study was measured with the help of profilometer. According to **Whitehead SA et al. 2014**[58] it is a more desirable and accurate way of detecting and assessing surface roughness than scanning electron microscopy images. Also minor difference in surface roughness could not be corroborated by SEM evaluation but that could be easily done with the help of profilometer readings.

In the present study second parameter tested was microhardness. It is defined as the resistance of a material to indentation and is an important mechanical property that predicts the polymerization degree of cure of restorative materials. Changes in microhardness reflect the state of the setting reaction of a material and the presence of an ongoing reaction or maturity of the restorative material.

In study conducted by **Contreras et al. 2005**[59] they stated that Vickers hardness tester is commonly used to evaluate the microhardness of composite resin.

Microhardness was evaluated pre- and post-immersion with help of a Vickers microhardness tester using 100 grams of load and a dwell time for 15 seconds.

I) Effect of different beverages on surface roughness :-

The change in difference between pre- and post-immersion of bulk fill and nanohybrid composite resin into three beverages and artificial saliva as control at various time intervals of 3 months, 6 months and 12 months have been described in table 1 and table 2 respectively

In the present study, significantly increased roughness was observed in bulk fill composite samples immersed in soft drink for 3, 6 and 12 months with p**-values 0.0043, 0.0019 and 0.0001** respectively. **(Table no 1)**. Maximum roughness was observed in the following increasing order saliva< tea <coffee< soft drink.

These results are in accordance to findings of **Corriea et al. 2020**[36] where they stated that Bulk fill resin showed highest surface roughness in cola and acidic drinks (Coca-Cola, acai juice and red wine) had a negative influence on the physical and mechanical properties of bulk-fill composite resins.

The results of the present research are also in accordance with **Meenakshi CM et al. 2020**[38] who reported that Coca-Cola resulted in high surface roughness than orange juice in bulk fill composite due to its high acidic nature. It was also observed that Coca-Cola resulted in more structural defects than orange juice.

On observation in nanohybrid composite resin samples , the soft drink exposure of 3, 6 and 12 months showed significantly increased roughness after exposure with p-values **0.0029, 0.0001 and < 0.0001** respectively.**(Table 2)**

In study conducted by **Münchow EA et al. 2014**[60] , they stated that acidic solutions increase the roughness of composites, probably because they soften their surface, leading to the leachability of resin components and, consequently displacement of filler particles which contribute to the formation of a rough surface.

In the present study maximum surface roughness was observed in coco cola > coffee> tea> saliva. These results are similar to observations of **Lee SY et al. 2014**[20] **,** who found that propionic and acetic acids softened the nanohybrid composites and increases surface roughness .

Similar results were reported by **Reddy PS et al. 2013**[24] who concluded that cola showed more surface roughness changes than coffee and tea after 30 days.

Kumavat V et al. 2014[25] also found similar results as maximum roughness was seen in Cola drink followed by Jamun Juice, Energy drink and least in Sparkling Wine.

On Comparison of surface roughness of Bulk-fill composite resin and nanohybrid composite resin samples

The maximum change in difference **(0.43)** in surface roughness was observed in nanohybrid composite **s**amples immersed in coca cola for time interval of 12 months **(Group II Dc)**.The minimum change in difference **(0.01)** in surface roughness was observed in bulk fill composite samples immersed in artificial saliva for 3 months **(Group I Aa) . (Table 3)**

Amongst the four groups tested, surface roughness (Ra) value was maximum in the samples exposed to Coca-cola followed by coffee and tea. The least surface roughness value was observed in the control group (artificial saliva).[1]

Coca-cola is a popular soft drink with the lowest pH (2.7) among the beverages in the present study. It has been reported that a low pH in acidic food and drink induces erosive wear in materials. Higher acidic property of cola might have a greater softening effect on the resin matrix, thus promoting the dislodgement and leaching out of filler particles and thereby increasing the surface roughness of composite resin. Although the pH of coffee is nearly 7, coffee is composed of water, and the effect of water uptake can degrade polymer materials. When polymer materials absorb water, coupling agents cause hydrolysis and loss of chemical bond between filler particles and the resin matrix. Filler particles dislodge from the outer surface of the material causing surface roughness. Although tea is acidic having a pH of 5.38, it has higher polarity components that are eluted first and does not readily penetrate inside which might have resulted in its lower surface roughness values when compared to coffee and Coca-cola.[1]

Regarding surface roughness, bulk-fill composite resin showed less change in difference in surface roughness than nanohybrid. This observation is similar to prior study **by Meenakshi CM et al. 2020**[38] where bulk-fill exhibited less surface roughness than microhybrid. The composite resins containing Bis-GMA exhibited higher surface roughness than composites containing UDMA. Bulk-fill contains aromatic dimethacrylate, additional fragmentation molecules, urethane dimethacrylate, and 1,12-dodecane dimethacrylate, whereas nanohybrid contains bisphenol-A-diglycidyl-dimethacrylate, urethane dimethacrylate, and ethoxylated bisphenol-A-glycol-dimethacrylate.

The influences of chemical and thermal factors are related to the clinical success and long-term performance of dental composite restorations. Chemical factors play a fundamental role in the degradation process of the composite resins surface. The pH is a very important factor to determine the erosive potential of a solution.[27]

In a study conducted by **Silva M et al. 2016**[6]**,** it was reported that low pH and soft drink may affect the surface integrity of composite resins. Absorption of soft drink molecules contained in coca cola into the resin matrix could result in softening of composite resins surface. This explains the change in surface roughness of the dental composites immersed in soft drink. Nanohybrid composite resin showed exposed filler particles after chemical degradation process, creating voids and leaving them dental composite surface more irregular.

The nanohybrid composite resin has a combination of zirconia and silica nanoparticles. Furthermore, these particles form nanoclusters (0.6 to 1.4 μm). These nanoclusters act like a single filler. Despite the neutral pH, the soft drink molecules may have been diffused into resin matrix providing hydrolysis between silane and filler removing these nanoclusters. The nanohybrid composite resin has a higher percentage of diluent monomer (TEGDMA). This monomer shows poor wear resistance in contact with alcohol or acid solutions.[6]

The chemical degradation acts also on resin matrix due to the heterogeneous polymerization process of the methacrylate-based monomers. Moreover, the low pH of a solution causes damage to the mechanical performance of composite resins.

As reported by **Scribante A et al**. 2010[61] the degradation of the composites polymer network, as well as the falling out of the filler due to the continuous action of acidic beverages like coco cola, are responsible for the surface degradation and increase irregularities on composites resin .

According to **Khan et al**. **2013**[62] the higher content of organic matrix in nanofilled composites could be the reason behind higher susceptibility to water absorption and material disintegration. Since this nanohybrid material had used the same polymeric matrix i.e. Bis-EMA, UDMA and TEGDMA, this may be the reason of highest change in difference in surface roughness in nanohybrid composite than bulk fill composite resin.

This result supports the findings of **da Costa et al. 2010**[63] **and Turssi et al. 2002**[64], who reported that composite resins with smaller average filler particles showed an increase in surface roughness than did materials with larger filler particles. This result may be related to the chemical composition of resin matrix and filler loading. Also, the hydrolytic degradation of silane may lead over time to surface degradation on composite materials and affect the material’s abrasion resistance.

According to **Paolone G et al**. **2020**[65] surface gloss was also found to be affected by filler size and filler–matrix homogeneity, with the following observation: the lower the filler–matrix homogeneity, the lower the light reflectivity. When relating gloss to roughness in the present study, it emerged that an inverse linear relationship existed between the two properties. Bulk fill composites has shown a significant less surface rough ness as compared to nanohybrid on the basis of resin

II) Effect of different beverages on microhardness :-

The change in difference between pre- and post-immersion of bulk fill composite resin and nanohybrid composite resin into three beverages and artificial saliva as control at various time intervals of 3 months, 6 months and 12 months have been described in table 4 and table 5 respectively.

Maximum change in difference in microhardness was observed in the following increasing order artificial saliva< tea <coffee< soft drink. Thus, in the present study, significantly reduced micro-hardness was observed in bulk fill composite samples immersed in soft drink for 3, 6 and 12 months with p-**values 0.0051, 0.0055 and 0.0002** respectively. A continuous decrease in the microhardness was observed in all the beverages with a marked significant difference. **(Table 4)**

The results are in accordance with study conducted by **Colombo M et al. 2014**[66] who found microhardness of bulk fill composite resin samples significantly reduced after immersion into coca cola for 7 days and they reported that the degradation of the composites polymer network, as well as the falling out of the filler due to the continuous action of acidic beverages, are responsible for the composites loss of micro-hardness.

Similar results were found in study by **Gezawi et al. 2012**[28] where they stated that coca cola showed highest reduction in microhardness of bulk fill composite resin compared to orange juice and least changes seen in distilled water .

In the present study, significantly reduced micro-hardness was observed in nanohybrid composite samples immersed in soft drink for 3, 6 and 12 months with p-

values 0.0023, 0.0118 and 0.0014 respectively.**(Table 5).** A continuous decrease in the microhardness was observed in all the beverages with a marked significant difference.

Maximum change in difference in microhardness was observed in the following increasing order artificial saliva< tea <coffee< soft drink.

The results of present study are in accordance with earlier studies by **Kazak et al**. **2020**[67] where they reported detrimental effects of low pH drinks on the longevity of a restorative material; significant reduction of microhardness of nanohybrid composite materials when immersed in different beverages such as cola , citric juice and wine for 24 hours.

Similarly, **Gupta R et al. 2018**[32] stated that low pH beverages adversely affected the properties of nanohybrid composite resin. Microhardness of nanohybrid composite resin was significantly decreased after immersion in various beverages and highest reduction was seen in cola due its lowest acidic pH (2.7) compared to other beverages tested.

Comparison of change in difference in microhardness of Bulk-fill composite resin and nanohybrid composite resin *:*

The maximum change in difference in microhardness **(- 18.60)** was observed in Nanohybrid composite resin samples immersed in soft drink for period of 12 months **(Group II Dc)** whereas the minimum change in microhardness **(-1.10)** was observed in nanohybrid composite samples immersed in artificial saliva for period of 6 months **(Group II Bb). (Table 6)**

Munoz et al. 2015[68] stated that the higher organic matrix of nanohybrid materials may be the reason for higher susceptibility to water absorption and material disintegration. Conversely, the hydrophobic matrix of the resin bulk fill composite material may have prevented water absorption, thus contributing to less change in the microhardness of the material itself.

The results of present study are in accordance with study conducted by **Henrique et al. 2019**[69] who stated that bulk fill composite resin showed less change in microhardness than nanohybrid composite resin after immersion into cola after 30 days. The higher content of organic matrix in nanohybrid composites could be the reason behind higher susceptibility to water absorption and material disintegration. Since this nanohybrid material had used the same polymeric matrix i.e. Bis-EMA, UDMA and TEGDMA, this may be the reason of highest change in difference in microhardness in nanohybrid composite than bulk fill composite resin .

III) Correlation between surface roughness and microhardness:

In the present study, statistically significant differences were observed between correlation of surface roughness and microhardness of both the composite resins after immersion into three different beverages.

Maximum value for change in difference in surface roughness and microhardness was observed in the group where both the composite resins were immersed in coca cola for time interval of 12 months. It has been reported that a low pH in acidic food and drink induces erosive wear in restorative materials due to enhanced softening effect on the resin matrix. This promoted dislodgement and leaching out of filler particles and thereby increased surface roughness of composite resin.[15]

Also the microhardness of composite resin depends on filler load, the mechanism of hydrolytic degradation is enhanced if the filler particles have metallic ions in their composition. Some ions in the filler particles, such as zinc and barium, are electropositive and tend to react with water. With the loss of these elements into water, the charge balance inside the silica network is changed and re-established with the penetration of hydrogen ions of the water in the spaces occupied by the zinc and barium. As a result of the increase of the concentration of hydroxy ions, the siloxane (Si-O-Si) bonds of the silica network start to break, and there is an autocatalytic cycle of surface degradation finally causing reduction in microhardness. [70]

The surface roughness is increased after immersion into beverages there is reduction in microhardness after immersion into beverages for period of 12 months. It shows that surface roughness and microhardness are inversely proportional to each other, thus showing a close relationship between surface roughness and microhardness.

Presently, there is scarcity of literature on effect of beverages on surface roughness and microhardness of bulk fill and nanohybrid composite resin at various time intervals and further research is needed for analysing correlation between surface roughness and microhardness .

In the present study, the null hypothesis that there is no significant difference on surface roughness and microhardness of Bulk-Fill composite resin with nanohybrid composite resin after exposure to three different beverages i.e. tea, coffee, soft drink at 3months , 6 months and 12 months was rejected.

The surface roughness and microhardness of Bulk-Fill composite resin and nanohybrid composite resin after exposure to three different beverages i.e. tea, coffee, soft drink at various time interval of 3month , 6 month and 12 months differed significantly.

Therefore, within the limitations of the study it can be concluded that bulk fill composite resin has better resistance to surface degradation as compared to nanohybrid composite resin and acidic beverages highly affect the physical properties of both composite resin. Hence, periodic finishing and polishing after every 6 months is necessary for longevity of composite restoration .

LIMITATIONS

1. Current study was carried out to check only the effects of various beverages on surface roughness and microhardness of resin composites, further research required to check other properties.

2. As this was an in vitro study, exact simulation of the oral conditions was not possible. Therefore, the results cannot be directly extrapolated to the clinical situation.

3. In present study masticatory forces and temperature were not considered, hence further research is needed to be considered.

SUMMARY AND CONCLUSION

In the past decade, several experimental and clinical studies established that consumption of acidic beverages have shown to alter the surface properties of composite restorations. Despite all precautions and guidelines being scrupulously followed by clinicians, surface alteration of the composite resin is a challenge regularly faced in clinical practice.

The present in vitro study was thus carried out to evaluate the effect of three different beverages (tea, coffee, and soft drink) and artificial saliva as control on surface roughness and microhardness of bulk fill and nanohybrid composite resin at various time interval of 3 months , 6 months and 12 months .

In present study, total of 120 composite discs of dimensions 10 mm X 2 mm were made from a custom made teflon mould , 60 discs of Tetric N-Ceram Bulk Fill (Ivoclar Vivadent) 60 discs of Tetric N-Ceram (Ivoclar Vivadent)

Both resin material samples randomly divided into four subgroups 15 samples for each subgroups (artificial saliva, tea, coffee, soft drink) and each subgroup was divided into 5 samples each for different time intervals (3 months, 6 months 12 months).

Before immersion into beverages baseline values of surface roughness and microhardness for both composite resins was taken

Group I: Bulk fill composite resin.

Group II: Nanohybrid composite resin.

Each group was further subdivided into four sub-groups according to beverages used.

For Group I: Bulk Fill composite resin

IA : Artificial saliva (Control group).

IB :Tea.

IC : Coffee.

ID : Soft Drink (Coca-Cola)

For Group II : Nanohybrid composite resin

IIA : Artificial saliva (Control group).

IIB : Tea.

IIC : Coffee

IID : Soft Drink (Coca-Cola)

Each subgroup contained 15 samples which were further subdivided into 5 samples for 3 time intervals 3 month, 6 months, 12 months.

Time of immersion was calculated according to von Fraunhofer. To simulate the period of 3 months, 6 months and 12 months exposure of restorative material to the beverages in oral condition, time of immersion for samples is calculated as 4min in 24hr for 7 days, 15 days and 30 days.

All samples were evaluated for surface roughness by using roughness tester and microhardness by using Vickers hardness testing machine.

The results obtained indicated that there is a highly significant difference in surface roughness and microhardness of both bulk fill and nanohybrid composite resin after immersion into beverages at various time intervals of 3 months, 6months and 12 months.(p-value <0.001).

Within the limitations of the study, following conclusions can be drawn:

1. The surface roughness and microhardness of bulk fill and nanohybrid composite resin is affected by the type of beverages as well as time intervals of immersion.

2. Surface roughness for both the composites significantly increased after immersion into beverages in the following order artificial saliva < tea < coffee < soft drink.

3. Microhardness for both the composites significantly reduced after immersion into beverages in the following order Soft drink > Coffee > Tea > Artificial

Saliva

4. Bulk fill composite resin exhibited less change in microhardness and enhanced resistance to surface degradation upon exposure to various beverages as compared to nanohybrid composite resin.

Thus, the findings of the present study elucidate the need for periodic finishing and polishing of composite resins after every 6 months for enhancing the clinical performance and longevity of restorations .

However, further clinical investigations which could give a conclusive remark on the long-term effect of beverages on mechanical properties of composite resins in oral cavity are needed.

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Table 1: Comparison of surface roughness of Bulk-fill composite resin samples subjected to four different exposures for different time periods

Exposure	Bulk-fill composite resin – Surface roughness [Mean ± SD]								
	Pre - 3M	Post - 3M	P-value*	Pre - 6M	Post - 6M	P-value*	Pre - 12M	Post - 12M	P-value*
Saliva	0.25 ± 0.11	0.26 ± 0.10	0.7540	0.30 ± 0.26	0.31 ± 0.28	0.6619	0.14 ± 0.07	0.15 ± 0.08	0.8387
Tea	0.28 ± 0.07	0.34 ± 0.09	0.2731	0.20 ± 0.05	0.29 ± 0.07	**0.0475**	0.23 ± 0.06	0.37 ± 0.10	**0.0277**
Coffee	0.18 ± 0.07	0.34 ± 0.13	**0.0399**	0.25 ± 0.12	0.47 ± 0.09	**0.0012**	0.17 ± 0.06	0.38 ± 0.13	**0.0112**
Soft Drink	0.21 ± 0.08	0.48 ± 0.15	**0.0043**	0.21 ± 0.08	0.44 ± 0.08	**0.0019**	0.18 ± 0.04	0.45 ± 0.07	**0.0001**

*Obtained using paired t-test; Bold p-values indicate statistical significance

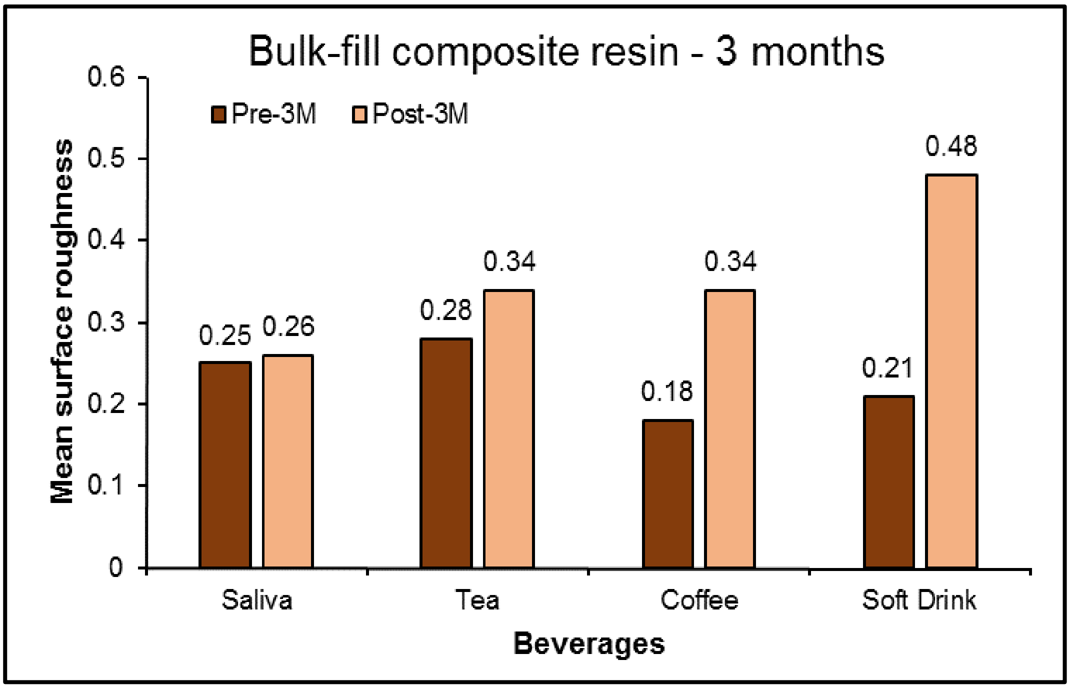

Figure 1: Column chart showing mean surface roughness for samples treated with bulk fill composite resin with exposure to different beverages for 3 months

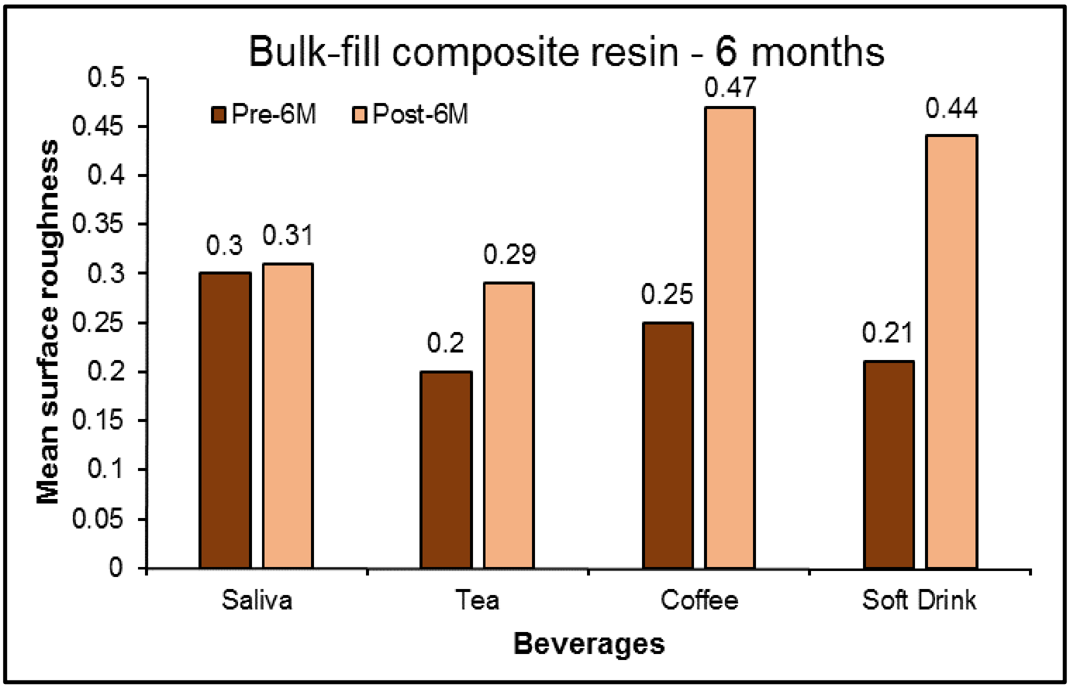

Figure 2: Column chart showing mean surface roughness for samples treated with bulk fill composite resin with exposure to different beverages for 6 months

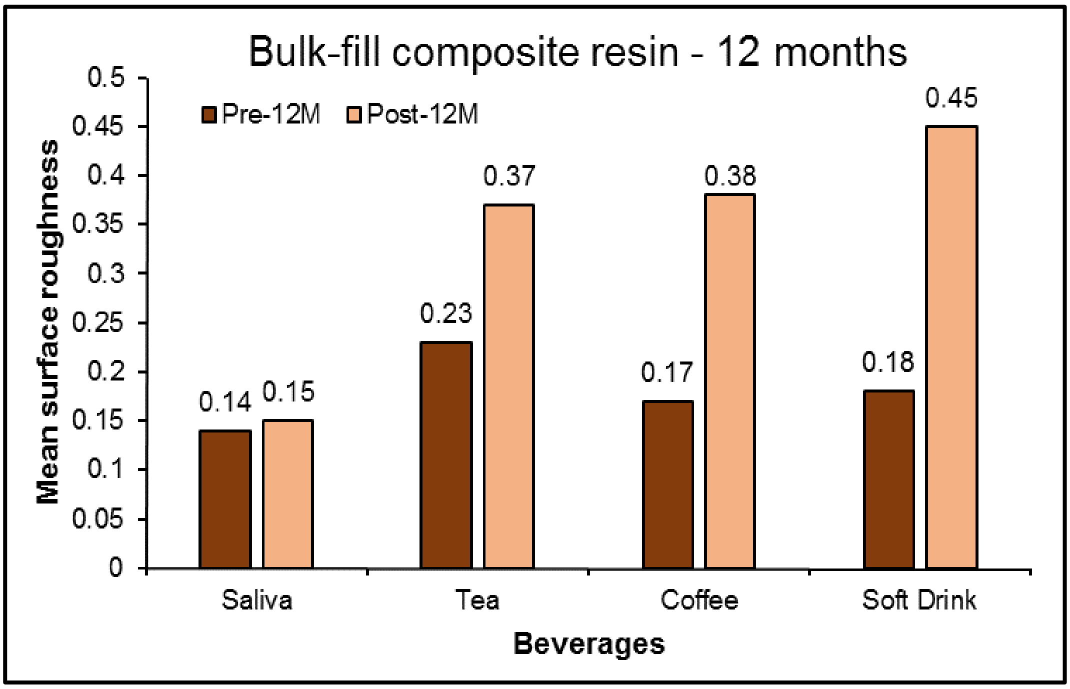

Figure 3: Column chart showing mean surface roughness for samples treated with bulk fill composite resin with exposure to different beverages for 12 months

Table 2: Comparison of surface roughness of *Nano hybrid composite resin* samples subjected to four different exposures for different time periods

Exposure	Nanohybrid composite resin– Surface roughness [Mean ± SD]								
	Pre - 3M	Post - 3M	P-value*	Pre - 6M	Post - 6M	P-value*	Pre - 12M	Post - 12M	P-value*
Saliva	0.28 ± 0.09	0.36 ± 0.1	0.2203	0.14 ± 0.07	0.28 ± 0.1	**0.0334**	0.18 ± 0.03	0.23 ± 0.03	**0.0299**
Tea	0.18 ± 0.02	0.35 ± 0.15	**0.0363**	0.19 ± 0.06	0.39 ± 0.1	**0.0050**	0.26 ± 0.08	0.50 ± 0.15	**0.0135**
Coffee	0.21 ± 0.09	0.34 ± 0.07	**0.0342**	0.18 ± 0.06	0.56 ± 0.2	**0.0036**	0.20 ± 0.04	0.57 ± 0.08	< **0.0001**
Soft Drink	0.19 ± 0.08	0.58 ± 0.19	**0.0029**	0.20 ± 0.05	0.59 ± 0.07	**0.0001**	0.17 ± 0.06	0.60 ± 0.13	< **0.0001**

*Obtained using paired t-test; Bold p-values indicate statistical significance

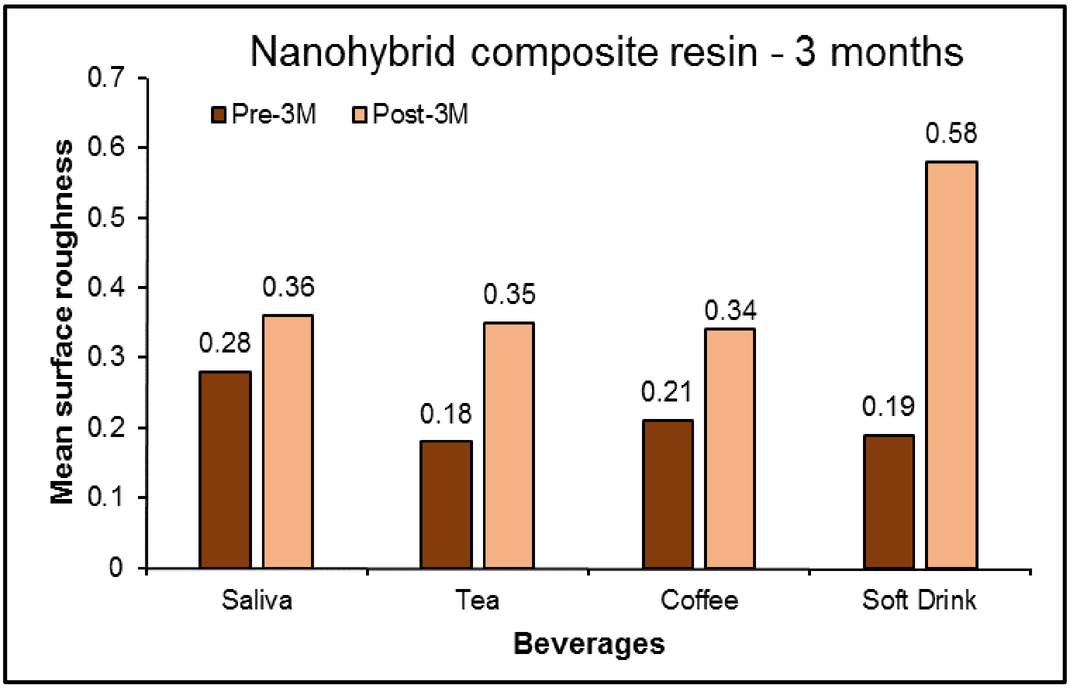

Figure 4: Column chart showing mean surface roughness for samples treated with nano hybrid composite resin with exposure to different beverages for 3 months

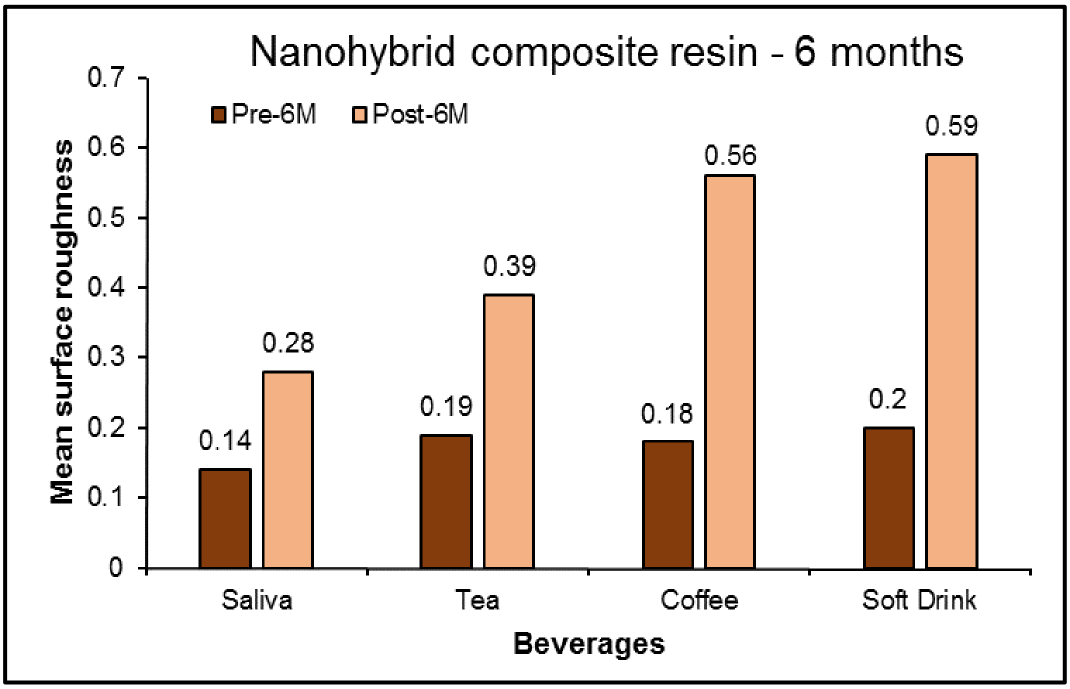

Figure 5: Column chart showing mean surface roughness for samples treated with nano hybrid composite resin with exposure to different beverages for 6 months

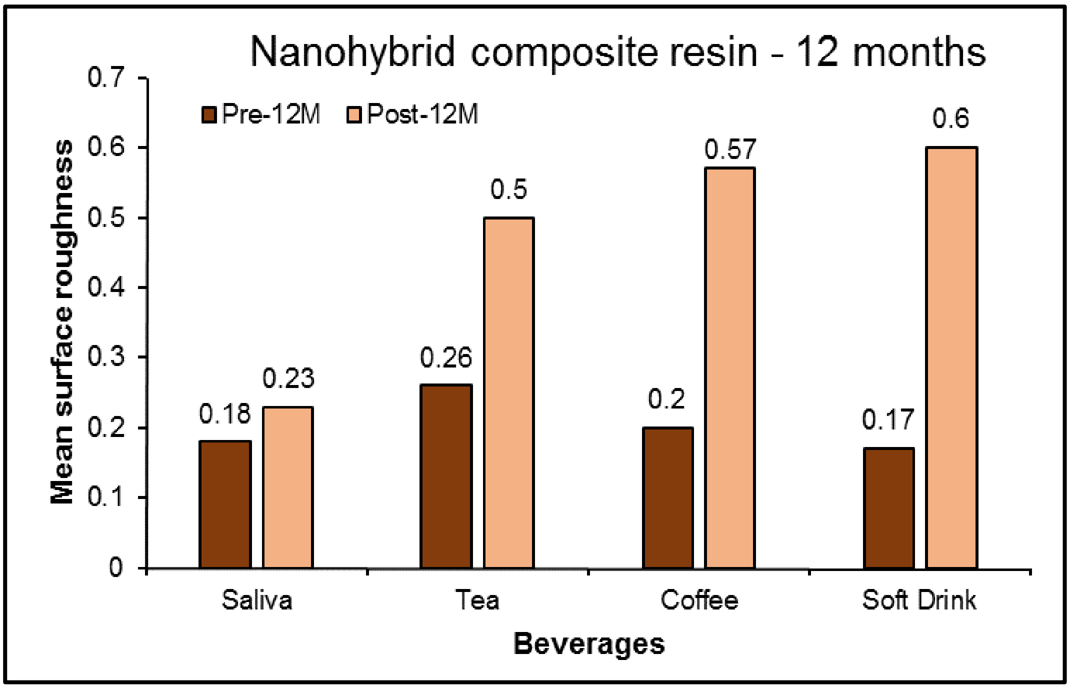

Figure 6: Column chart showing mean surface roughness for samples treated with nano hybrid composite resin with exposure to different beverages for 12 months

Table 3: Comparison of change in surface roughness between two composite resins subjected to four different exposures for different time periods

Exposure	Bulk-fill composite resin – Surface roughness			Nanohybrid composite resin – Surface roughness			P-value*		
	3M	6M	12M	3M	6M	12M	3M	6M	12M
Saliva	0.01 ±0.01	0.003±0.02	0.01 ±0.03	0.08 ± 0.13	0.14 ± 0.05	0.05 ± 0.02	0.1580	**0.0036**	**0.0381**
Tea	0.06 ±0.04	0.09 ± 0.07	0.14 ±0.04	0.17 ± 0.03	0.20 ± 0.08	0.24 ± 0.08	**0.0391**	**0.0494**	**0.0369**
Coffee	0.16 ±0.08	0.22 ± 0.09	0.21 ±0.10	0.13 ± 0.09	0.38 ± 0.12	0.37 ± 0.11	0.6018	**0.0442**	**0.0433**
Soft Drink	0.27 ±0.11	0.23 ± 0.09	0.27 ±0.10	0.39 ± 0.25	0.39 ± 0.12	0.43 ± 0.09	0.3547	**0.0440**	**0.0360**
P-value**	**< 0.0001**	**0.0004**	**0.0003**	**0.0222**	**0.0013**	**< 0.0001**			

*Obtained using t-test for independent samples; Bold p-value indicates statistical significance

Table 4: Pairwise comparison of different beverages for surface roughness using Tukey's post-hoc test for both the composite resin at various time intervals.

Exposure groups	Bulk-fill composite resin – Surface roughness			Nanohybrid composite resin – Surface roughness		
	3M	6M	12M	3M	6M	12M
Saliva – Tea	0.668	0.283	0.470	0.718	0.667	**0.037**
Saliva - Coffee	**0.019**	**0.004**	**0.001**	0.544	**0.047**	**0.024**
Saliva – Soft drink	**< 0.0001**	**0.003**	**0.021**	**0.023**	**0.038**	**0.004**
Tea – Coffee	0.165	0.657	0.299	0.114	0.141	0.411
Tea – Soft drink	**0.001**	0.562	0.121	**0.041**	0.139	0.343
Coffee – Soft drink	**0.046**	0.885	0.490	**0.038**	0.998	0.836

Bold p-value indicates statistical significance

Table 5: Comparison of micro-hardness of *Bulk-fill composite resin* samples subjected to four different exposures for different time periods

Exposure	Bulk-fill composite resin – Micro hardness [Mean ± SD]								
	Pre - 3M	Post - 3M	P-value*	Pre - 6M	Post - 6M	P-value*	Pre - 12M	Post - 12M	P-value*
Saliva	62.24 ± 4.80	60.24 ± 4.97	0.0937	61.18 ± 4.70	60.98 ± 4.11	0.7431	63.29 ± 5.01	61.49 ± 4.89	**0.0086**
Tea	61.46 ± 6.23	59.26 ± 6.90	**0.0109**	57.20 ± 5.60	54.36 ± 7.16	**0.0342**	63.48 ± 5.71	60.08 ± 6.65	**0.0026**
Coffee	57.03 ± 7.35	51.41 ± 5.98	**0.0052**	58.25 ± 7.14	52.75 ± 6.03	**0.0011**	57.64 ± 7.21	49.23 ± 6.87	**0.0022**
Soft Drink	55.51 ± 7.01	45.29 ± 5.54	**0.0051**	62.36 ± 5.20	52.10 ± 7.40	**0.0055**	60.86 ± 4.38	49.58 ± 3.82	**0.0002**

*Obtained using paired t-test; Bold p-values indicate statistical significance

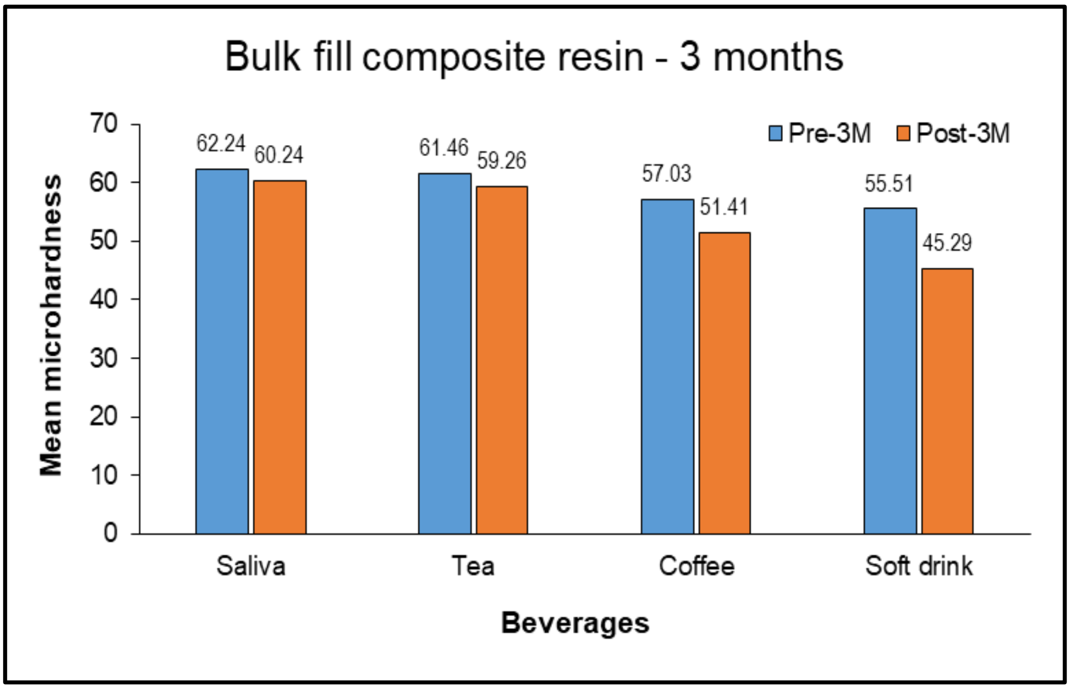

Figure 7: Column chart showing mean micro-hardness for samples treated with bulk fill composite resin with exposure to different beverages for 3 months

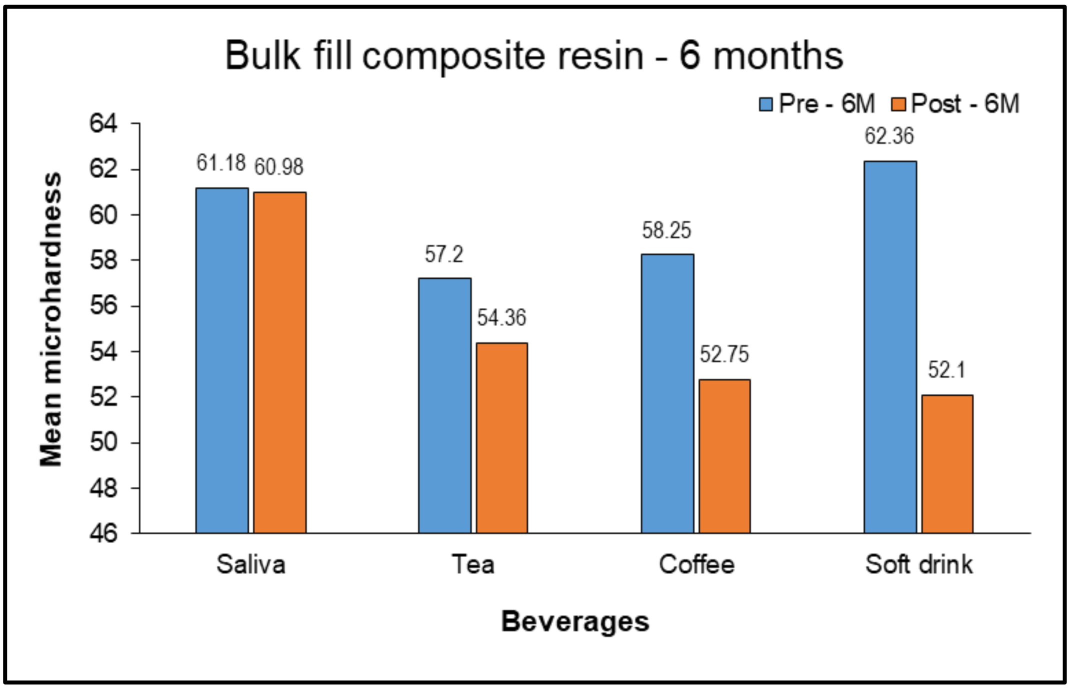

Figure 8: Column chart showing mean micro-hardness for samples treated with bulk fill composite resin with exposure to different beverages for 6 months

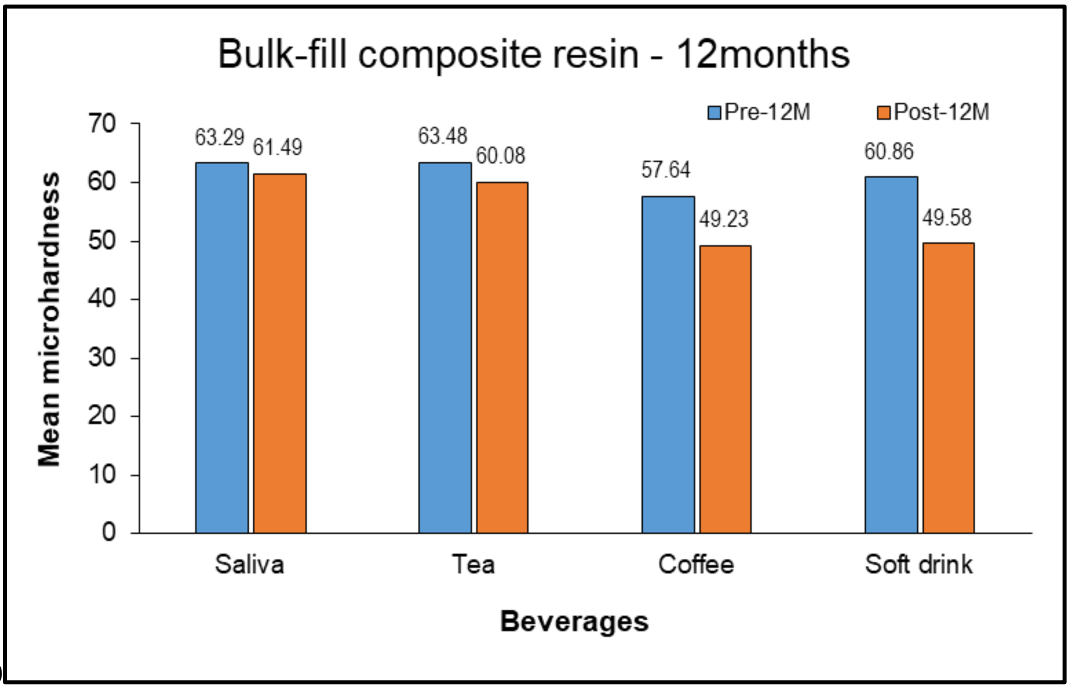

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Figure 9: Column chart showing mean micro-hardness for samples treated with bulk fill composite resin with exposure to different beverages for 12 months

Table 6: Comparison of micro-hardness of *Nano hybrid composite resin* samples subjected to four different exposures for different time periods

Exposure	Nanohybrid composite resin– Micro hardness [Mean ± SD]								
	Pre - 3M	Post - 3M	P-value*	Pre - 6M	Post - 6M	P-value*	Pre - 12M	Post - 12M	P-value*
Saliva	63.65 ± 6.71	62.25 ± 6.16	0.1079	58.65 ± 8.57	57.55 ± 8.41	**0.0109**	53.25 ± 5.17	51.29 ± 6.13	**0.0188**
Tea	64.36 ± 12.05	61.36 ± 10.7	**0.0231**	62.65 ± 9.40	56.41 ± 10.4	**0.0016**	62.55 ± 6.52	53.95 ± 5.89	**0.0062**
Coffee	57.25 ± 11.76	49.45 ± 8.31	**0.0143**	61.18 ± 4.54	48.48 ± 3.19	**0.0004**	57.66 ± 9.32	44.71 ± 7.99	**0.0008**
Soft Drink	58.84 ± 6.19	43.06 ± 5.86	**0.0023**	55.66 ± 8.93	39.02 ± 2.70	**0.0118**	65.55 ± 9.00	46.95 ± 5.97	**0.0014**

*Obtained using paired t-test; Bold p-values indicate statistical significance

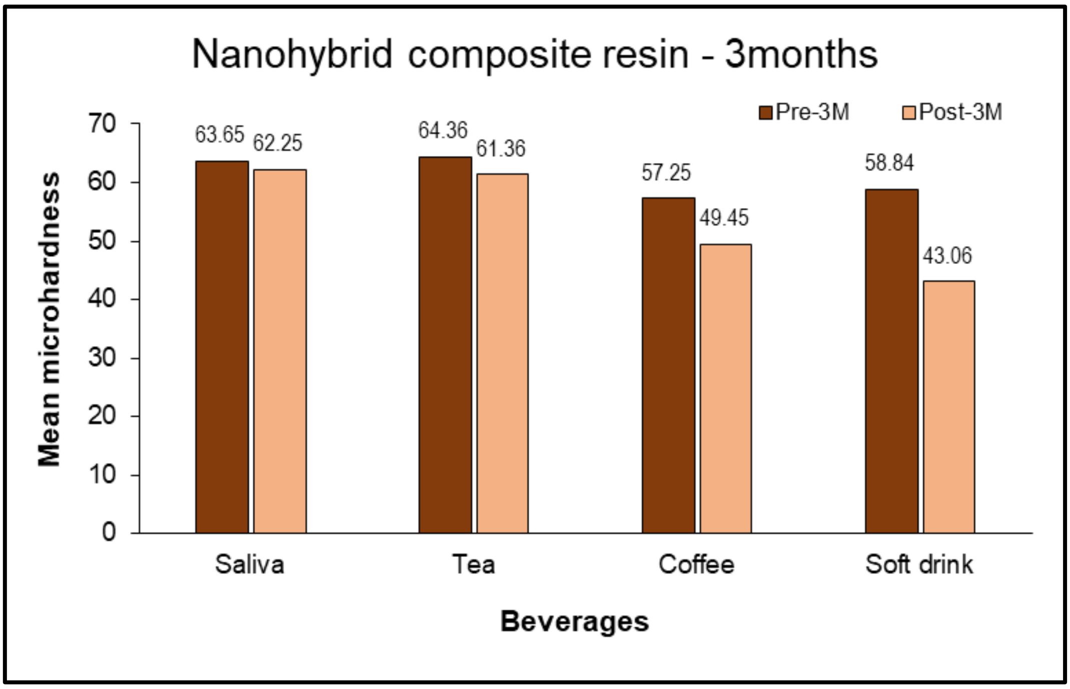

Figure 10: Column chart showing mean micro-hardness for samples treated with nano hybrid composite resin with exposure to different beverages for 3 months

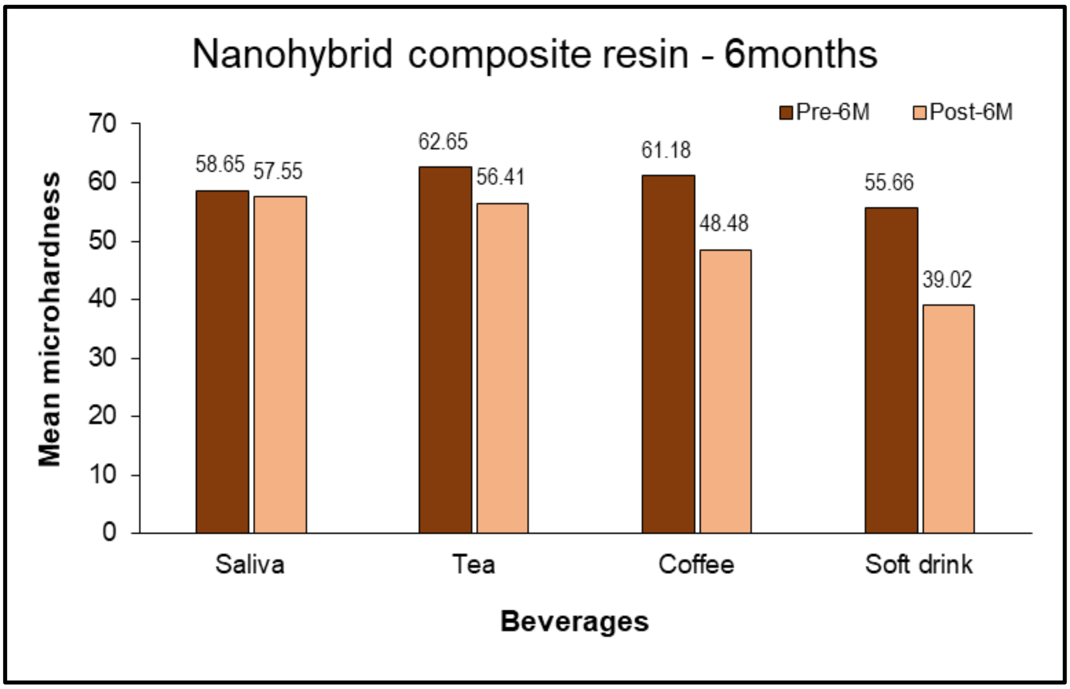

Figure 11: Column chart showing mean micro-hardness for samples treated with nano hybrid composite resin with exposure to different beverages for 6 months

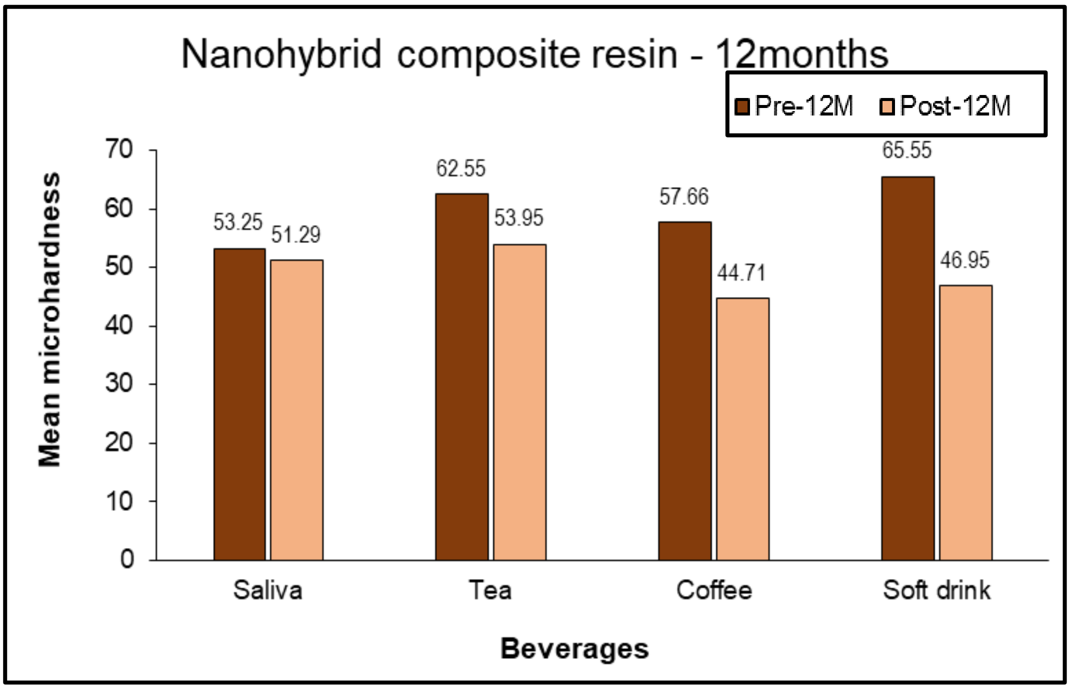

Figure 12: Column chart showing mean micro-hardness for samples treated with nano hybrid composite resin with exposure to different beverages for 12 months

Table 7: Comparison of change in micro-hardness between two composite resins subjected to four different exposures for different time periods

Exposure	Bulk-fill composite resin - Microhardness			Nanohybrid composite resin - Microhardness			P-value*		
	3M	6M	12M	3M	6M	12M	3M	6M	12M
Saliva	-2.00 ± 2.04	-0.20 ± 1.27	-1.80 ± 0.84	-1.40 ± 1.52	-1.10 ± 0.55	-1.97 ± 1.15	0.6136	0.2016	0.7993
Tea	-2.20 ± 1.09	-2.83 ± 2.00	-3.40 ± 1.14	-3.00 ± 1.87	-6.24 ± 1.84	-8.60 ± 3.65	0.4387	**0.0235**	**0.0304**
Coffee	-5.62 ± 2.27	-5.50 ± 1.45	-8.41 ± 2.69	-7.80 ± 4.21	-12.7 ± 2.68	-12.95 ± 3.17	0.3465	**0.0017**	**0.0413**
Soft Drink	-10.23 ± 4.12	-10.26 ± 4.20	-11.28 ± 1.93	-15.78 ± 5.13	-16.64 ± 8.49	-18.60 ± 5.32	0.0974	0.1842	**0.0338**
P-value**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**			

*Obtained using t-test for independent samples; Bold p-value indicates statistical significance;
**Obtained using one-way ANOVA

Table 8: Pairwise comparison of different beverages for microhardness using ukey's post-hoc test for both the composite resin at various time intervals.

Exposure groups	Bulk-fill composite resin - Microhardness			Nanohybrid composite resin - Microhardness		
	3M	6M	12M	3M	6M	12M
Saliva – Tea	0.999	0.379	0.514	0.889	0.316	**0.048**
Saliva - Coffee	0.170	**0.020**	**< 0.0001**	**0.049**	**0.005**	**0.001**
Saliva – Soft drink	**0.001**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**	**< 0.0001**
Tea – Coffee	0.207	0.369	**0.002**	0.179	0.154	0.271
Tea – Soft drink	**0.001**	**0.001**	**< 0.0001**	**< 0.0001**	**0.011**	**0.003**
Coffee – Soft drink	0.058	**0.039**	0.094	**0.012**	0.536	0.106

Bold p-value indicates statistical significance

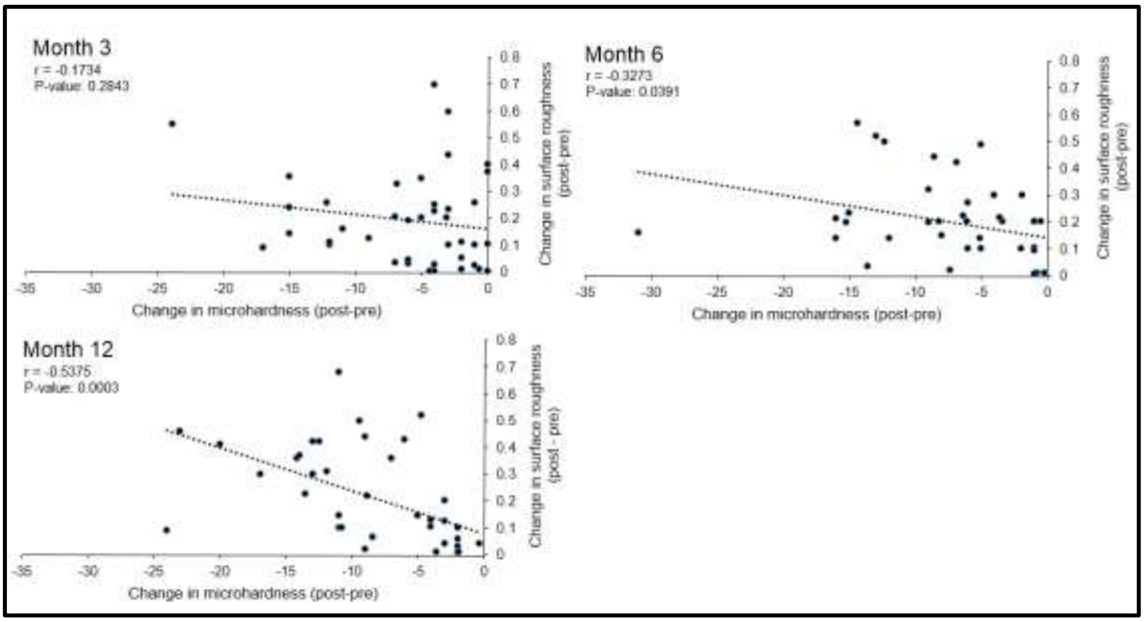

Figure 13: Scatter plots showing relationship between change in micro hardness and change in surface roughness at three time points

ANNEXURE I

Surface roughness of bulk fill composite before immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group I A a: ARTIFICIAL SALIVA 3 months (Control)		
Sr.No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.114
2	No.2	0.118
3	No.3	0.213
4	No.4	0.222
5	No.5	0.316

Group I A b: Artificial saliva 6 months (Control)		
Sr. No.	Sample No.	Micro Tensile Bond Strength (MPa)
1	No.1	0.331
2	No.2	0.084
3	No.3	0.236
4	No.4	0.368
5	No.5	0.254

Group I A c: Artificial saliva 12 months (Control)		
Sr. No.	Sample ID.	Surface Roughness, Ra (in µm)
1	No.1	0.729
2	No.2	0.142
3	No.3	0.110
4	No.4	0.158
5	No.5	0.381

ANNEXURE II

Surface roughness of bulk fill composite after immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group I A a: ARTIFICIAL SALIVA 3 months (Control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.116
2	No.2	0.120
3	No.3	0.222
4	No.4	0.245
5	No.5	0.320

Group I A b: Artificial saliva 6 months (Control)		
Sr. No.	Sample No.	Micro Tensile Bond Strength (MPa)
1	No.1	0.340
2	No.2	0.090
3	No.3	0.245
4	No.4	0.337
5	No.5	0.276

Group I A c: Artificial saliva 12 months (Control)		
Sr. No.	Sample ID.	Surface Roughness, Ra (in µm)
1	No.1	0.789
2	No.2	0.172
3	No.3	0.150
4	No.4	0.128
5	No.5	0.331

ANNEXURE III

Surface roughness of bulk fill composite before immersion in Tea at different intervals (3 months, 6 months and 12 months)

Group I B a:TEA 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.321
2	No.2	0.284
3	No.3	0.136
4	No.4	0.238
5	No.5	0.224

Group I B b: TEA 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.121
2	No.2	0.214
3	No.3	0.256
4	No.4	0.338
5	No.5	0.224

Group : Group I B c: TEA 12 months		
Sr. No.	Sample ID.	Surface Roughness, Ra (in µm)
1	No.1	0.329
2	No.2	0.242
3	No.3	0.310
4	No.4	0.258
5	No.5	0.321

ANNEXURE IV

Surface roughness of bulk fill composite after immersion in Tea at different intervals (3 months, 6 months and 12 months)

Group I B a:TEA 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.421
2	No.2	0.294
3	No.3	0.246
4	No.4	0.265
5	No.5	0.276

Group I B b: TEA 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.321
2	No.2	0.414
3	No.3	0.456
4	No.4	0.238
5	No.5	0.524

Group : Group I B c: TEA 12 months		
Sr. No.	Sample ID.	Surface Roughness, Ra (in µm)
1	No.1	0.457
2	No.2	0.387
3	No.3	0.410
4	No.4	0.459
5	No.5	0.445

ANNEXURE V

Surface roughness of bulk fill composite before immersion in coffee at different intervals (3 months, 6 months and 12 months)

Group I C a:COFFEE 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.121
2	No.2	0.284
3	No.3	0.336
4	No.4	0.438
5	No.5	0.224

Group I C b:COFFEE 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.239
2	No.2	0.242
3	No.3	0.110
4	No.4	0.418
5	No.5	0.321

Group I C c: COFFEE 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.131
2	No.2	0.214
3	No.3	0.326
4	No.4	0.238
5	No.5	0.124

ANNEXURE VI

Surface roughness of bulk fill composite after immersion in coffee at different intervals (3 months, 6 months and 12 months)

Group I C a:COFFEE 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.321
2	No.2	0.474
3	No.3	0.367
4	No.4	0.564
5	No.5	0.474

Group I C b:COFFEE 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.376
2	No.2	0.457
3	No.3	0.598
4	No.4	0.438
5	No.5	0.542

Group I C c: COFFEE 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.631
2	No.2	0.574
3	No.3	0.766
4	No.4	0.547
5	No.5	0.643

ANNEXURE VII

Surface roughness of bulk fill composite before immersion in soft drink at different intervals (3 months, 6 months and 12 months)

Group I D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.121
2	No.2	0.387
3	No.3	0.314
4	No.4	0.132
5	No.5	0.323

Group I D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.136
2	No.2	0.153
3	No.3	0.266
4	No.4	0.189
5	No.5	0.328

Group I D C: SOFT DRINK 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.341
2	No.2	0.257
3	No.3	0.119
4	No.4	0.325
5	No.5	0.275

ANNEXURE VIII

Surface roughness of bulk fill composite after immersion in soft drink at different intervals (3 months, 6 months and 12 months)

Group I D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.476
2	No.2	0.487
3	No.3	0.572
4	No.4	0.458
5	No.5	0.672

Group I D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.457
2	No.2	0.387
3	No.3	0.689
4	No.4	0.756
5	No.5	0.598

Group I D C: SOFT DRINK 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.568
2	No.2	0.356
3	No.3	0.798
4	No.4	0.392
5	No.5	0.698

ANNEXURE IX

Surface roughness of Nanohybrid composite before immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group II A a: ARTIFICIAL SALIVA 3 months (control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.336
2	No.2	0.253
3	No.3	0.363
4	No.4	0.133
5	No.5	0.324

Group II A b: ARTIFICIAL SALIVA 6 months (control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.141
2	No.2	0.157
3	No.3	0.219
4	No.4	0.025
5	No.5	0.175

Group II A c : ARTIFICIAL SALIVA 12 months (control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.126
2	No.2	0.183
3	No.3	0.277
4	No.4	0.125
5	No.5	0.275

ANNEXURE X

Surface roughness of nanohybrid composite after immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group II A a: ARTIFICIAL SALIVA 3 months (control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.536
2	No.2	0.263
3	No.3	0.463
4	No.4	0.237
5	No.5	0.424

Group II A c : ARTIFICIAL SALIVA 12 months (control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.128
2	No.2	0.193
3	No.3	0.287
4	No.4	0.165
5	No.5	0.285

Group II A a: ARTIFICIAL SALIVA 3 months (control)		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.536
2	No.2	0.263
3	No.3	0.463
4	No.4	0.237
5	No.5	0.424

ANNEXURE XI

Surface roughness of Nanohybid composite before immersion in Tea at different intervals (3 months, 6 months and 12 months)

Group II B a: TEA 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.165
2	No.2	0.176
3	No.3	0.192
4	No.4	0.187
5	No.5	0.155

Group II B b: TEA 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.121
2	No.2	0.213
3	No.3	0.254
4	No.4	0.137
5	No.5	0.224

Group : Group II B c: TEA 12 months		
Sr. No.	Sample ID.	Surface Roughness, Ra (in µm)
1	No.1	0.235
2	No.2	0.242
3	No.3	0.320
4	No.4	0.158
5	No.5	0.221

ANNEXURE XII

Surface roughness of Nano-Hybrid composite after immersion in Tea at different intervals (3 months, 6 months and 12 months)

Group II B a: TEA 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.265
2	No.2	0.376
3	No.3	0.592
4	No.4	0.784
5	No.5	0.852

Group II B b: TEA 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.221
2	No.2	0.313
3	No.3	0.454
4	No.4	0.437
5	No.5	0.374

Group : Group II B c: TEA 12 months		
Sr. No.	Sample ID.	Surface Roughness, Ra (in µm)
1	No.1	0.255
2	No.2	0.345
3	No.3	0.467
4	No.4	0.458
5	No.5	0.651

ANNEXURE XIII

Surface roughness of Nanohybrid composite before immersion in coffee at different intervals (3 months, 6 months and 12 months)

Group II C a:COFFEE 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.121
2	No.2	0.222
3	No.3	0.334
4	No.4	0.123
5	No.5	0.227

Group II C b:COFFEE 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.145
2	No.2	0.243
3	No.3	0.124
4	No.4	0.137
5	No.5	0.239

: Group II C c: COFFEE 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.245
2	No.2	0.237
3	No.3	0.185
4	No.4	0.162
5	No.5	0.148

ANNEXURE XIV

Surface roughness of Nanohybrid composite after immersion in coffee at different intervals (3 months, 6 months and 12 months)

Group II C a:COFFEE 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.346
2	No.2	0.265
3	No.3	0.367
4	No.4	0.265
5	No.5	0.432

Group II C b:COFFEE 6 months		
Sr.No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.356
2	No.2	0.276
3	No.3	0.567
4	No.4	0.637
5	No.5	0.759

Group II C c: COFFEE 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.345
2	No.2	0.457
3	No.3	0.545
4	No.4	0.532
5	No.5	0.448

ANNEXURE XV

Surface roughness of Nanohybrid composite before immersion in soft drink at different intervals (3 months, 6 months and 12 months)

Group II D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.189
2	No.2	0.147
3	No.3	0.314
4	No.4	0.122
5	No.5	0.163

Group II D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.235
2	No.2	0.210
3	No.3	0.172
4	No.4	0.259
5	No.5	0.141

Group II D c: SOFT DRINK 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in µm)
1	No.1	0.268
2	No.2	0.122
3	No.3	0.190
4	No.4	0.125
5	No.5	0.160

ANNEXURE XVI

Surface roughness of Nanohybrid composite after immersion in soft drink at different intervals (3 months, 6 months and 12 months)

Group II D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in μm)
1	No.1	0.347
2	No.2	0.257
3	No.3	0.554
4	No.4	0.672
5	No.5	0.253

Group II D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in μm)
1	No.1	0.433
2	No.2	0.348
3	No.3	0.333
4	No.4	0.458
5	No.5	0.281

Group II D c: SOFT DRINK 12 months		
Sr. No.	Sample No.	Surface Roughness, Ra (in μm)
1	No.1	0.568
2	No.2	0.532
3	No.3	0.280
4	No.4	0.545
5	No.5	0.620

ANNEXURE XVII

Microhardness of bulk fill composite before immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group I A a: ARTIFICIAL SALIVA 3 months (Control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	57.40
2	No.2	68.00
3	No.3	64.60
4	No.4	64.10
5	No.5	57.08

Group I A b: Artificial saliva 6 months (Control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	56.80
2	No.2	67.00
3	No.3	64.20
4	No.4	61.80
5	No.5	56.09

Group I A c: Artificial saliva 12 months (Control)		
Sr. No.	Sample ID.	Microhardness in HV
1	No.1	58.00
2	No.2	69.00
3	No.3	65.00
4	No.4	66.40
5	No.5	58.07

ANNEXURE XVIII

Microhardness of bulk fill composite after immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group I A a: ARTIFICIAL SALIVA 3 months (Control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	53.00
2	No.2	64.00
3	No.3	64.0
4	No.4	63.10
5	No.5	57.08

Group I A b: Artificial saliva 6 months (Control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	56.00
2	No.2	66.00
3	No.3	64.00
4	No.4	60.80
5	No.5	58.09

Group I A c: Artificial saliva 12 months (Control)		
Sr. No.	Sample ID.	Microhardness in HV
1	No.1	56.00
2	No.2	67.00
3	No.3	62.00
4	No.4	65.40
5	No.5	57.07

ANNEXURE XIX

Microhardness of bulk fill composite before immersion in Tea at different intervals (3 months, 6 months and 12 months)

Group I B a:TEA 3 months		
Sr.No.	SampleNo.	Microhardness in HV
1	No.1	66.30
2	No.2	66.10
3	No.3	53.28
4	No.4	56.20
5	No.5	65.40

Group I B b: TEA 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	51.57
2	No.2	54.62
3	No.3	61.27
4	No.4	64.82
5	No.5	53.70

Group : Group I B c: TEA 12 months		
Sr. No.	Sample ID.	Microhardness in HV
1	No.1	66.1
2	No.2	53.28
3	No.3	66.2
4	No.4	65.4
5	No.5	66.4

ANNEXURE XX

Microhardness of bulk fill composite after immersion in Tea at different intervals (3 months, 6 months and 12 months)

Group I B a:TEA 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	65.30
2	No.2	64.10
3	No.3	51.28
4	No.4	52.20
5	No.5	63.40

Group I B b: TEA 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	45.50
2	No.2	51.22
3	No.3	60.27
4	No.4	63.02
5	No.5	51.80

Group : Group I B c: TEA 12 months		
Sr. No.	Sample ID.	Microhardness in HV
1	No.1	62.1
2	No.2	48.28
3	No.3	64.2
4	No.4	62.4
5	No.5	63.4

ANNEXURE XXI

Microhardness of bulk fill composite before immersion in coffee at different intervals (3 months, 6 months and 12 months)

Group I C a:COFFEE 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	48.60
2	No.2	52.06
3	No.3	56.25
4	No.4	67.20
5	No.5	61.05

Group I C b:COFFEE 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	50.10
2	No.2	54.14
3	No.3	58.00
4	No.4	69.10
5	No.5	59.90

: Group I C c: COFFEE 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	49.35
2	No.2	53.10
3	No.3	57.12
4	No.4	68.15
5	No.5	60.47

ANNEXURE XXII

Microhardness of bulk fill composite after immersion in coffee at different intervals (3 months, 6 months and 12 months)

Group I C a:COFFEE 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	45.50
2	No.2	46.06
3	No.3	50.25
4	No.4	58.20
5	No.5	57.05

Group I C b:COFFEE 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	45.00
2	No.2	50.54
3	No.3	53.00
4	No.4	61.70
5	No.5	53.50

: Group I C c: COFFEE 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	39.95
2	No.2	46.10
3	No.3	48.12
4	No.4	56.25
5	No.5	55.73

ANNEXURE XXIII

Microhardness of bulk fill composite before immersion in soft drink at different intervals (3 months, 6 months and 12 months)

Group I D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	58.60
2	No.2	52.06
3	No.3	66.25
4	No.4	48.60
5	No.5	52.06

Group I D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	56.80
2	No.2	67.00
3	No.3	64.20
4	No.4	56.80
5	No.5	67.00

Group I D C: SOFT DRINK 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	61.80
2	No.2	56.09
3	No.3	59.20
4	No.4	59.40
5	No.5	67.80

ANNEXURE XXIV

Microhardness of bulk fill composite after immersion in soft drink at different intervals (3 months, 6 months and 12 months)

Group I D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	43.60
2	No.2	40.06
3	No.3	54.05
4	No.4	41.70
5	.No.5	47.02

Group I D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	47.80
2	No.2	52.00
3	No.3	57.30
4	No.4	42.40
5	No.5	61.00

Group I D C: SOFT DRINK 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	48.30
2	No.2	45.09
3	No.3	48.20
4	No.4	51.00
5	No.5	55.30

ANNEXURE XXV

Microhardness of nanohybrid composite before immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group II A a: ARTIFICIAL SALIVA 3 months (control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	69.00
2	No.2	55.00
3	No.3	66.40
4	No.4	58.07
5	No.5	69.80

Group II A b: ARTIFICIAL SALIVA 6 months (control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	59.00
2	No.2	65.00
3	No.3	46.40
4	No.4	68.07
5	No.5	54.80

Group II A c : ARTIFICIAL SALIVA 12 months (control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	55.00
2	No.2	48.00
3	No.3	49.40
4	No.4	61.07
5	No.5	52.80

ANNEXURE XXVI

Microhardness of nanohybrid composite after immersion in artificial saliva at different intervals (3 months, 6 months and 12 months)

Group II A a: ARTIFICIAL SALIVA 3 months (control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	66.00
2	No.2	55.00
3	No.3	63.40
4	No.4	57.07
5	No.5	69.80

Group II A b: ARTIFICIAL SALIVA 6 months (control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	58.00
2	No.2	64.50
3	No.3	45.40
4	No.4	66.07
5	No.5	53.80

Group II A c : ARTIFICIAL SALIVA 12 months (control)		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	53.00
2	No.2	46.00
3	No.3	45.80
4	No.4	60.73
5	No.5	50.90

ANNEXURE XXVII

Microhardness of nanohybrid composite before immersion Tea at different intervals (3 months, 6 months and 12 months)

Group II B a: TEA 3 months		
Sr.No.	Sample No.	Microhardness in HV
1	No.1	66.80
2	No.2	67.00
3	No.3	44.20
4	No.4	76.80
5	No.5	67.00

Group II B b: TEA 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	59.00
2	No.2	55.00
3	No.3	56.40
4	No.4	78.07
5	No.5	64.80

Group : Group II B c: TEA 12 months		
Sr. No.	Sample ID.	Microhardness in HV
1	No.1	69.00
2	No.2	55.00
3	No.3	56.40
4	No.4	68.07
5	No.5	64.30

ANNEXURE XXVIII

Microhardness of nanohybrid composite after immersion Tea at different intervals (3 months, 6 months and 12 months)

Group II B a: TEA 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	63.80
2	No.2	62.00
3	No.3	44.20
4	No.4	73.80
5	No.5	63.00

Group II B b: TEA 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	53.00
2	No.2	50.00
3	No.3	48.20
4	No.4	74.07
5	No.5	56.80

Group : Group II B c: TEA 12 months		
Sr. No.	Sample ID.	Microhardness in HV
1	No.1	60.00
2	No.2	51.00
3	No.3	45.40
4	No.4	55.07
5	No.5	58.30

ANNEXURE XXIV

Microhardness of nanohybrid composite before immersion in Coffee at different intervals (3 months, 6 months and 12 months)

Group II C a:COFFEE 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	45.00
2	No.2	56.40
3	No.3	48.07
4	No.4	74.30
5	No.5	62.5

Group II C b:COFFEE 6 months		
Sr. No.	SampleNo.	Microhardness in HV
1	No.1	61.27
2	No.2	64.82
3	No.3	53.70
4	No.4	61.27
5	No.5	64.82

: Group II C c: COFFEE 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	64.10
2	No.2	47.08
3	No.3	59.50
4	No.4	49.10
5	No.5	68.50

ANNEXURE XXX

Microhardness of nanohybrid composite after immersion in Coffee at different intervals (3 months, 6 months and 12 months)

Group II C a:COFFEE 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	41.00
2	No.2	50.40
3	No.3	41.07
4	No.4	59.30
5	No.5	55.5

Group II C b:COFFEE 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	45.27
2	No.2	51.22
3	No.3	45.10
4	No.4	48.97
5	No.5	51.82

Group II C c: COFFEE 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	53.33
2	No.2	38.23
3	No.3	45.34
4	No.4	35.11
5	No.5	51.53

ANNEXURE XXXI

Microhardness of nanohybrid composite before immersion in Soft drink at different intervals (3 months, 6 months and 12 months)

Group II D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	52.42
2	No.2	65.31
3	No.3	53.33
4	No.4	65.11
5	No.5	58.05

Group II D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	54.10
2	No.2	47.08
3	No.3	69.50
4	No.4	49.10
5	No.5	58.50

Group II D c: SOFT DRINK 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	54.10
2	No.2	77.04
3	No.3	69.30
4	No.4	59.20
5	No.5	68.10

ANNEXURE XXXII

Microhardness of nanohybrid composite after immersion in Soft drink at different intervals (3 months, 6 months and 12 months)

Group II D a: SOFT DRINK 3 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	41.42
2	No.2	53.31
3	No.3	38.33
4	No.4	41.21
5	No.5	41.05

Group II D b: SOFT DRINK 6 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	38.9
2	No.2	35.08
3	No.3	38.50
4	No.4	40.10
5	No.5	42.50

Group II D c: SOFT DRINK 12 months		
Sr. No.	Sample No.	Microhardness in HV
1	No.1	41.10
2	No.2	57.04
3	No.3	45.30
4	No.4	46.20
5	No.5	45.10