Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 07, pp.54745-54750, July, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EFFECT OF TOOTHBRUSH MOUTHRINSE CYCLING ON SURFACE ROUGHNESS AND MICROHARDNESS OF NANOHYBRID COMPOSITE RESIN AND GIOMER

***Beverley Themudo and Annapoorna, B. M.**

JSS Dental College and Hospital, Mysuru, India

ARTICLE INFO

Article History:
Received 02nd April, 2017
Received in revised form
30th May, 2017
Accepted 21st June, 2017
Published online 31st July, 2017

Key words:

Giomer- Fluoride Releasing Nanohybrid Composite, Toothbrush-Mouthrinse Cycling (TMC), Herbal Mouthwash.

ABSTRACT

Title of the article: Effect of Toothbrush Mouthrinse Cycling on the Surface Roughness and Microhardness of Nanohybrid Composite Resin and Giomer (Fluoride releasing Nanohybrid Composite Resin) – An In Vitro Study

Context: Giomer technology offers the advantage of anti-cariogenic property to resin restorations but fluoride release could possibly affect the surface roughness and microhardness. Tooth brushing and mouthrinsing have been known to increase surface roughness and decrease microhardness of resin restoratives and this effect has not been investigated on giomers.

Aim: To evaluate and compare the surface roughness and microhardness of nanohybrid composite resin and fluoride releasing nanohybrid composite resin when subjected to simulated 1 year toothbrushing and mouthwashes of varying alcohol concentrations.

Methods and Materials: 50 specimens of nanohybrid resin composite and 50 specimens of Giomer resin were divided into 5 sub- groups as follows: No Toothbrushing and No Mouthrinsing, Toothbrushing and No Mouthrinsing, Toothbrushing and Mouthrinsing with mouthwash containing 21.6% alcohol, Toothbrushing and Mouthrinsing with mouthwash containing 11.6% alcohol, Toothbrushing and Mouthrinsing with herbal mouthwash containing 0% alcohol. TMC was done over 8 weeks, simulating 1year usage of toothbrushing and mouthrinsing. All specimens were subjected to Surface Roughness and Microhardness Tests.

Statistical analysis: Mean and standard deviation, One way/Two way ANOVA, t-test, Pearsons' correlation

Results: There was increase in surface roughness after brushing giomer group. Mouthwashes in addition to toothbrushing didn't affect the surface roughness. Microhardness increased on brushing but dropped after using alcohol containing mouthrinses. Herbal mouthwashes had no deleterious effect on hardness.

Conclusion: Toothbrushing in association with different types of mouthrinses, did not increase surface roughness of either material. Alcohol containing mouthrinses decreased the microhardness of regular nanohybrid composite and giomer. Herbal mouthwash without alcohol did not affect microhardness. Regular nanohybrid composite showed lesser decrease in hardness and increases in roughness and will thus perform better as a surface layer of restorations.

Citation: Beverley Themudo and Annapoorna, B. M. 2017. "Effect of toothbrush mouthrinse cycling on surface roughness and microhardness of nanohybrid composite resin and giomer", *International Journal of Current Research*, 9, (07), 54745-54750.

INTRODUCTION

With the advent of tooth colored restorative materials due to increasing demand for esthetics, resin-based composites have become the most widely used material in the field of restorative dentistry. (da Silva *et al*., 2014) The addition of surface pre-reacted glass particles with fluoride release and recharge to nanohybrid composite, also known as giomer technology imparts an anti-cariogenic property. But this combination has a limitation as the fluoride release takes place by surface dissolution and diffusion exchange of fluoride ions which could possibly affect the surface roughness and microhardness. (Kooi *et al*., 2012) Resin-based composites undergo degradation when exposed to the oral environment which may lead to several drawbacks, such as an increase in wear and surface roughness which affect the color stability and play a crucial role on the accumulation of dental biofilm, which can lead to periodontitis and secondary caries around the restoration. (Fernanda Regina Voltarelli *et al*., 2010) During placement of composite resin, elaborate methods of caution are undertaken by the operator to ensure long term durability of the restoration and after placement, a major portion of the long term success of the restoration can be attributed to the post operative care enforced by the patient himself, of which diet and oral hygiene are two major factors. Since diet is a highly variable phenomenon which cannot be controlled, emphasis must be placed on standardizing oral hygiene aids since these have been shown to severely impact composite resin restorations. Tooth-brushing has shown to cause both tooth and

Corresponding author:* **Beverley Themudo,
JSS Dental College and Hospital, Mysuru, India

resin composite abrasion. This abrasion increases the surface roughness, accelerating the staining produced by pigments from beverages and interfering with color stability over time. (Neme *et al*., 2002; Wang *et al*., 2004) In addition, mouthrinses are widely used to complement the cleaning of the oral cavity. (Moran, 2000) Reports in literature state that alcohol in mouthrinses may soften the resin matrix of composite restorations among other negative influences like the properties of water sorption and solubility, roughness, and color change. Herbal mouthwashes on the other hand are free from deleterious chemicals and would be believed to cause less adverse effects to resin composite surface. The study to evaluate and compare the surface roughness and microhardness of nanohybrid composite resin and fluoride releasing nanohybrid composite resin when subjected to simulation toothbrushing and mouthwashes of varying alcohol concentrations.

MATERIALS AND METHODS

50 specimens of each composite resin, Group A: Nanohybrid Composite Resin→ Brilliant NG: Coltene Whaledent and Group B (50 specimens): Fluoride Releasing Nanohybrid Composite Resin (Giomer) →Beautifil II: Shofu, Shade A1 were prepared using Teflon moulds. A mylar strip was placed on a glass slab, followed by placing the teflon mould and the composite resin was slightly over packed into the mould space. A second mylar matrix strip was carefully placed making sure no air bubbles were incorporated over the surface. A second glass slab and a uniform weight of 500 gms was placed above the glass slab for 30 seconds in order to compactly pack the resin. The weight along with the glass slab present above the composite resin was removed, leaving behind just the mylar strip over the material and the composite resin was cured as per the manufacturer's instructions.

All the specimens were stored for 24 hours in artificial saliva at 37^{o}C for completion of the polymerization process. For toothbrush- mouthrinse cycling, all of the samples in group A and group B were randomly divided into 5 sub- groups with 10 specimens in each group as follows:

Sub-Group 1: No Toothbrushing and No Mouthrinsing (negative control)
Sub-Group 2: Toothbrushing and No Mouthrinsing (positive control)
Sub-Group 3: Toothbrushing and Mouthrinsing with mouthwash containing 21.6% alcohol→ Listerine : Jhonson & Jhonson
Sub-Group 4: Toothbrushing and Mouthrinsing with mouthwash containing 11.6% alcohol→Periogard : Colgate Palmolive
Sub-Group 5: 0Toothbrushing and Mouthrinsing with herbal mouthwash containing 0% alcohol→Hiora : Himalaya Drug Company

The composite specimens to be brushed were mounted onto plastic disks with the help of a cyanoacrylate resin. 20 specimens of each corresponding subgroup were attached to a single disc and 4 such disks with attached composites were made. The negative control was not mounted as it did not have to undergo any brushing procedure. Toothbrushing was then done on a pin on disk wear testing machine. The plastic disks with mounted composite specimens were attached onto the disk and the toothbrush was attached on the pin with the help of cyanoacrylate resin. The machine was then adjusted at approximately 110 rpm for 12mins at a constant load of 200gms and toothpaste slurry was added. After the toothbrushing procedure, the disks were de-mounted and the residue of the toothpaste was washed off with thorough rinsing with running water. For the process of mouthrinsing, Listerine, Periogard and Hiora mouthrinses were placed in beakers and the corresponding brushed specimens i.e. the entire disk with attached composite was immersed for 45 minutes while continuously agitating the solution. Sub-group 2, which is the positive control was directly placed in artificial saliva. At the end, the specimens were all washed and dried and placed in artificial saliva solution. This toothbrush and mouthrinse cycling was done once a week over a period of 8 weeks, simulating total one year usage of toothbrushing that is 15-20 cycles per time of brushing and mouthrinsing that is 30 seconds per time mouthrinsing and was divided into 8 parts so as to more closely resemble the in-vivo scenario. Sub Group 1 of both groups was placed in distilled water at 37^{o}C for the entire 8 weeks period and not subjected to any of the above procedures.

At the end of 8 weeks all specimens were removed from the disks, rinsed with water, dried and subjected to: Surface Roughness Test with the help of digital Surface roughness tester (SURFCOM FLEX, Germany, 2 µm diamond stylus, 0.75mN measuring force with 4mm traversing length at a drive speed of 1.5mm/s) Ra values were obtained by taking 3 values per sample and the mean were used for statistical analysis. Vickers hardness was calculated using the digital Vickers hardness testing machine (HWMMT – XT; Highwood, 100g load, 10 second dwell time) and Vickers hardness formulae. VHN values were obtained by taking 3 measurements per sample and the mean were used for statistical analysis. The data obtained was analyzed by using Mean and Standard Deviation for Descriptive statistics. Independent samples t-Test, ANOVA (Analysis of Variance) – One way, ANOVA (Analysis of Variance)– Two way.

RESULTS

Statistical analysis revealed that there was a statistical increase in surface roughness after brushing the giomer group, whereas no significant increase was seen in the regular nanohybrid composite group. However, the use of different mouthwashes in addition to toothbrushing didn't significantly affect the surface roughness. The microhardness values increased on brushing but dropped drastically after using alcohol containing mouthrinses and alcohol concentration was a significant factor for the regular nanohybrid composite group. Herbal mouthwashes didn't have any deleterious effect on the hardness of composite resin surface. The comparison between both groups indicated that giomer group performed poorly with higher surface roughness values and lower microhardness values as compared to regular nanohybrid composite group.

DISCUSSION

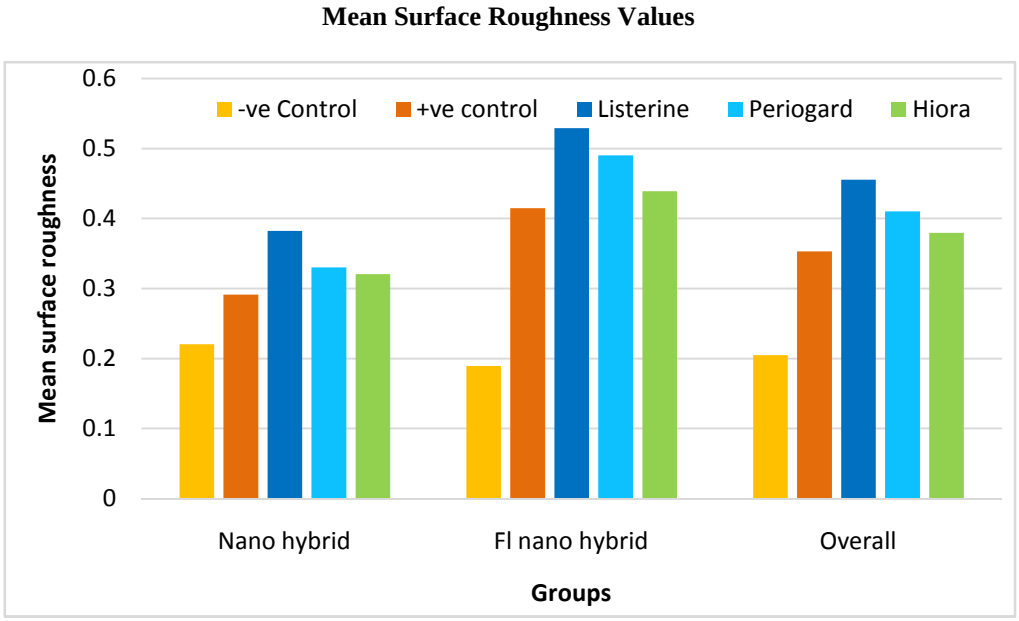
Since composite resin materials undergo polymerization shrinkage, microleakage makes these areas highly susceptible to secondary caries. Giomer technology, with fluoride release would be advantageous especially in patients of high caries susceptibility. Based on several studies, giomers have a reported caries inhibiting effect of 14%-35% compared to non–fluoride-releasing tooth colored restorative materials.

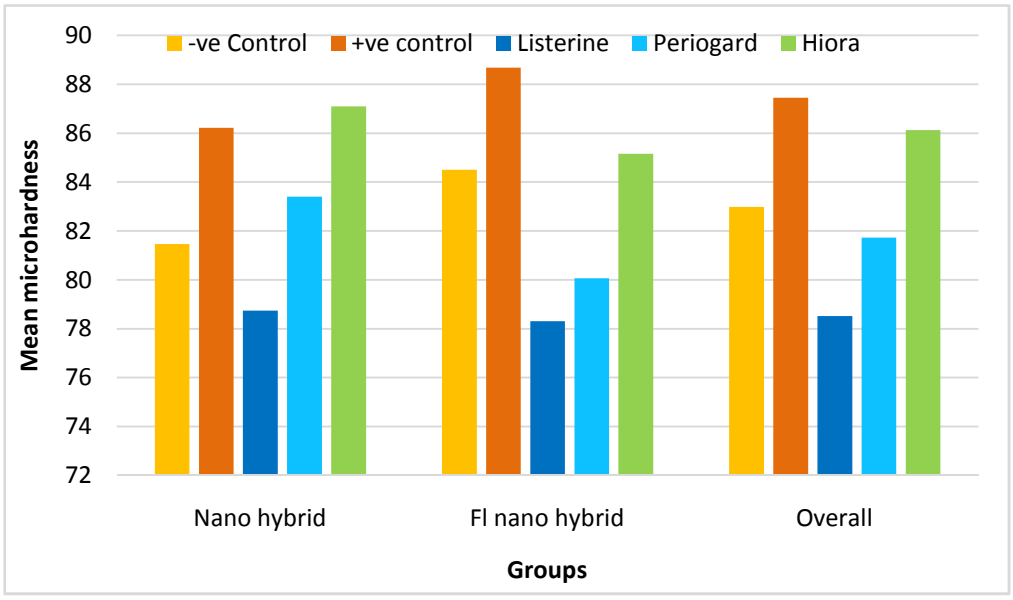
Composition of mouthwashes used

Mouthwash	pH	Composition	Manufacturer	Batch No
Listerine (alcohol based)	3.69	Thymol – 0.06% w/v, Eucalyptol-0.09% w/v, Menthol-0.04%w/v, Ethanol-21.6%v/v	Johnson and Johnson Ltd, Kolhapur, India	BN6016
Periogard (alcohol and chlorhexidine containing)	4.54	Chlorhexidinegluconate- 0.12% w/v, Ethyl alcohol-11.6% v/v	Colgate Palmolive Ltd, Mumbai, India	4121USC11M
Hiora (Alcohol free, herbal)	4.26	Pilu (salvadorapersica) – 5mg Bibhitaka(terminalibellerica)- 10mg Nagavalli(piper betle) -10mg Gandhapurataila (Gaultheria fragrantissima)-1.2mg Ela (Elettariacardamomum) - 0.2mg Peppermint satva (Mentha spp.) – 1.6mg Yavanisatva (Trachyspermumammi)- 0.4mg	The Himalaya Drug Company, Bangalore, India	L-108

Legends:

1. Composition Table
2. Graph representing average Mean Surface Roughness Values
3. Graph representing average Mean Vickers Microhardness Values





(Sunico *et al*., 2015) Information regarding the influence of toothbrushing or mouthrinsing on the surface properties of giomer restoratives is still not widely available in literature. By virtue of their pre-reacted glass ionomer fillers, these materials may behave differently when compared to regular composite resin restorations. The regular nanohybrid composite resin had the similar filler size, loadings and monomer composition. These affect wear and roughness of resin composites (Toshimitsu *et al*., 2012) and in this way, these confounding factors to surface abrasion of the materials, were eliminated. Many conducted studies have shown HiOra to be clinically as effective as chlorhexidine containing mouthrinses for the prevention and control of periodontal disease. (Nagesh Bhat *et al*., 2013) In the same way as the chemical degradation, toothbrushing might provide some superficial changes on resin composite materials. Toothbrushing causes abrasion and loss of filler particles of the surface of resin composite. (Moraes *et al*., 2009; Heintze *et al*., 2010; PisolSenawongse and Pong Pongprueksa, 2007) Many published studies have separately analyzed the in vitro influence of brushing and mouthrinses on the surface changes of resin composites. However, it is well known that the degradation of resin-based materials in the oral environment is a complex process, which involves both mechanical and chemical mechanisms. This was the rationale to employ TMC in the present study. This was performed in an endeavor to simulate actual conditions in the oral environment. Toothbrushing was done with the help of a pin on disk wear testing machine which has the advantage of standardizing load and number of cycles. For this purpose, a medium bristle brush was used since this is recommended for all healthy adults, and besides, soft bristle brushes reportedly cause more abrasion which is explained with increased retention of toothpastes by smaller diameter filaments and denser tufts in addition to the greater flexion of filaments increasing the area of contact of specimens. (Dyer *et al*., 2000; Tellefsen *et al*., 2011) A flat ended brush was chosen since only composite resin disks were used and a flat ended brush would contact the surface evenly. The toothpaste used was Colgate total as it has a relatively low abrasive index of 70.

The load for the toothbrushing was kept constant for all specimens at 200gm which is the standard load of toothbrushing. (VvanDijken and Ruyter, 1987) Similarly, even during mouthrinse simulation, all samples were stored in their respective mouthwash for a designated period of time. The clinical relevance of surface roughness can be demonstrated in two ways. Firstly, this property is strongly related to the bacterial colonization in the oral environment. Also, a higher surface roughness provides a reduced possibility of dislodging the oral biofilm, a periodontal health concern. Secondly, an increase in roughness can interfere with changes in color, contour and gloss of composite restorations, an esthetic concern. (Park *et al*., 2012; Quirynen and Bollen, 1995) Hardness, the other test parameter, is important for long-term durability of restoration in the oral cavity. It may be defined as the resistance of a material to indentation or penetration. Strength, proportional limit and ductility are related to hardness. Hardness has also been used to predict the wear resistance of a material and its ability to abrade or be abraded by opposing dental structures and materials. So a decrease in the hardness of a material may result in premature failure of a restoration requiring its replacement. (Festuccia *et al*., 2012) The evaluation of surface roughness revealed the least surface roughness value for the negative control of both groups. In the nanohybrid composite group, toothbrushing alone didn't cause a significant increase in surface roughness but a highly significant increase was seen in the same subgroup of giomer. This could be explained by the fact that the filler composition of the giomer includes S-PRG filler. This S-PRG filler probably has inferior chemical bonding to the resin matrix, due to the heterogeneous nature of these milled filler particles, where due to the process of milling the uniformity of the ground particles cannot be assured and it may comprise of either organic component or inorganic component or could also be a combination of both. Even though coupling agents are used, the interface would be not stable as in regular composite resin and hence cause faster or perhaps greater amount of debonding of filler particles and hence this result. Also, giomers are designed for release and recharge of which could also be contributing factors for the increase in surface roughness as a loss of these ions would mean more peaks and valleys on the surface.

Another factor adding to this result could be that, giomers have been shown to absorb a greater percentage of water, as compared to regular composite resin. (Sideridou and Karabela, 2011; NihanGonulol *et al*., 2015) The reason for this is absorption of some amount of water necessary for reaction with the polyacrylic acid. When exposed to water, there is swelling of resin matrix due to water sorption and radial tensile stresses at the aluminosilicate filler- resin matrix interfaces are created. These strained Si-o-Si bonds makes the glass particles/fillers more susceptible to stress corrosion attack. Complete or partial debonding of the fillers may occur on surface layers, and could be the reason behind the increased surface roughness of giomer material. In all experimental sub-groups, where, toothbrushing was followed by respective mouthrinsing, there was a further increase in the surface roughness, with the highest value of both the regular composite resin and the giomer groups being Listerine mouthwash with the highest alcohol content and lowest pH. Periogard had comparatively lesser roughness values which can be attributed to lower alcohol content and higher pH compared to Listerine and the least values were obtained from the HiOra subgroup of both groups since it contained no alcohol. However, this difference was not significant between groups. This indicates that in the present study the type of mouthwash and its alcohol content or pH of solution are not relevant factors that determine the surface roughness.

This is in accordance with a study conducted by Ana Carolina de Carvalho Rocha where there wasn't any significant difference between the mouthrinses used for TMC, regardless of the alcohol concentration. (Ana Carolina de Carvalho Rocha *et al*., 2010) In case of microhardness values, the VHN was significantly lesser in the negative control of materials as compared to the values after brushing of specimens. The reason for this is that in subgroup 1, the samples have an intact and continuous unfilled resin layer which is softer. On brushing the samples, this topmost layer would have been abraded off exposing the deeper layers with the filler particles. Hardness values of both groups were observed to have drastically dropped on TMC with Listerine. Although TMC with Periogard showed a slightly higher microhardness value in both groups, it was not significantly higher in case of the giomer group, that is, in case of giomer group, the presence or absence of alcohol was the relevance and not the alcohol%. TMC with HiOra showed no decrease in microhardness values as compared to the +ve control indicating that the addition of HiOra to an oral hygiene regimen will not significantly

decrease the microhardness value of composite resin. This is in accordance with the study conducted by Jyothi KN and colleagues where the least reduction in microhardness of nanofilled composite resin was shown to be in the herbal mouthwash group after immersion for 24h. (Jyothi *et al*., 2012) Listerine was the agent that produced the greatest reduction in microhardness and increase in roughness in both groups A and B and amongst all 3 mouthrinses. In addition to the greater content of ethanol (21.6%), it is possible that its low pH (3.69) contributed to this result.

The effect of alcohol in the mouthwash can be explained by the plasticizing effect of ethanol. This polar solvent penetrates into the resin composite and causes material swelling, which manifests as decreased hardness. (da Silva *et al*., 2014) In terms of low pH, it is well established that the ester groups present in dimethacrylate monomers, such as those present in the resin composites in the current study undergo degradation through hydrolysis in environments with low pH. This hydrolysis produces surface erosion and dissolution, negatively affecting the wear, hardness, and surface integrity by softening the matrix and causing a loss of structural ions. (da Silva *et al*., 2014; Kooi *et al*., 2012; Fernanda Regina Voltarelli *et al*., 2010) It is possible that these aspects of mouthwashes act synergistically to potentiate the negative effects of toothbrushing on resin restorative material surface, thereby increasing the roughness and decreasing the hardness of the resin composites. The findings of Almeida and others may reinforce this discussion. These authors found that the water sorption and solubility of resin composite were higher after immersion in alcohol-containing mouthrinses and claimed that this was due to the degradation of their polymeric matrixes produced by the ethanol through the mechanism explained above. (Almeida *et al*., 2010) Even though the pH of HiOra (4.26) is slightly lower than that of periogard (4.54), the significantly higher hardness value can be attributed to the fact that it is an herbal mouthwash containing 0% alcohol. Hence, in this case, the alcohol content had a more significant effect on the hardness value than the pH of the solution. Perhaps the low pH acts synergistically only in the presence of alcohol thus accelerating the degradation process. Hence the long-term, regular use of alcohol based mouthrinses with higher alcohol content plus low pH may be detrimental to the resin composites used in the present study. It can be argued that the results of this *in vitro* study may not be directly related to the clinical situation but in this study artificial saliva was used as it may dilute or buffer the mouthrinses thus more closely resembling an in-vivo scenario. However, further *in vivo* studies are recommended to confirm these results.

Conclusion

Within the limitations of this present study, it could be concluded that:

Toothbrushing alone did not affect the surface roughness of nanohybrid composite resin but increased the surface roughness of fluoride releasing nanohybrid composite resin restorative material. Toothbrushing in association with different types of mouthrinses, whether alcohol containing or alcohol free, did not increase the surface roughness of either material. Alcohol containing mouthrinses decreased the microhardness of both regular nanohybrid composite resin and giomer, whereas herbal mouthwash without alcohol did not affect the microhardness. This should be a deciding factor in prescribing mouthwashes to patients having Composite resin restorations. Regular nanohybrid composite show lesser decrease in hardness and increases in roughness and will thus perform better as a surface layer of restorations.

REFERENCES

Almeida GS, Poskus LT, Guimaraes JG, & da Silva EM. 2010. The effect of mouthrinses on salivary sorption, solubility and surface degradation of a nanofilled and a hybrid resin composite *Operative Dentistry*, 35(1) 105-111.

Ana Carolina de Carvalho Rocha, Cecília Santiago Araújo de Lima, Maria do Carmo Moreira da Silva Santos, Marcos Antonio Japiassú Resende Monte. 2010. Evaluation of Surface Roughness of a Nanofill Resin Composite after Simulated Brushing and Immersion in Mouthrinses, Alcohol and Water. *Journal of Materials Research*, 13(1): 77-80.

da Silva EM *et al*. 2014. Effect of Toothbrushing mouthrinse-cycling on Surface Roughness and Topography of Nanofilled, Microfilled, and Microhybrid Resin Composites. *Journal of Operative Dentistry*, 39(5): 521-529.

Dyer D, Addy M, Newcombe RG. 2000. Studies in vitro abrasion by different manual toothbrush heads and a standardized toothpaste. *Journal of clinical Periodontology*, 27: 99-103.

Fernanda Regina Voltarelli *et al*. 2010. Effect of chemical degradation followed by toothbrushing on the surface roughness of restorative composites. *Journal of Applied Oral Sciences*, 18(6):585-90.

Festuccia MSCC, Garcia LFR, Cruvinel DR, Pires-de-Souza FCP. 2012. Color stability, surface roughness and microhardness of composites submitted to mouthrinsing action. *Journal of Applied Oral Science*, 20: 200-205.

Heintze, S.D., M. Forjanic, K. Ohmiti, V. Rousson. 2010. Surface deterioration of dental materials after simulation of toothbrushing in relation to brushing time and load. *Dental Materials Journal*, 26: 306–319.

Jyothi KN, ShanolCrasta, Venugopal P. 2012. Effect of five commercial mouth rinses on the microhardness of a nanofilled resin composite restorative material: An *in vitro* study. *Journal of Conservative Dentistry*, 15 (3): 214-217.

Kooi, TJM., QZ Tan, AUJ Yap,WGuo, KJ Tay, MS Soh. 2012. Effects of Food-simulating liquids on Surface Properties of Giomer Restoratives. *Journal of Operative Dentistry*, 37(6): 665-671.

Moraes RR. *et al*. 2009. Nanohybrid Resin Composites: Nanofiller Loaded Materials or Traditional Microhybrid Resins? *Journal of Operative Dentistry*, 34(5): 551-557.

Moran J M. 2000. Home use oral hygiene products: Mouthrinses. *Journal of Periodontology*, 15: 109-117.

Nagesh Bhat *et al*. 2013. Evaluation of Efficacy of Chlorhexidine and a Herbal Mouthwash on dental plaque-an in vitro study. *Int J of Pharmaans Bio Sciences*, 4(3): 625-632.

Neme A L *et al*. 2002. Effect of prophylactic polishing protocol on the Surface Roughness of esthetic restorative materials. *Journal of Operative dentistry*, 27: 50-58.

NihanGonulol, SezinOzer, EmineSenTunc. 2015. Water Sorption, Solubility, and Color Stability OfGiomer Restoratives. *Journal of Esthetic and Restorative Dentistry*, 27 (5): 300–306

Park J W. *et al*. 2012. The Effects of Surface Roughness of Composite Resin on Biofilm Formation of Streptococcus

mutans in the Presence of Saliva. *Journal of Operative Dentistry*, 37-5, 532-539.

PisolSenawongse, Pong Pongprueksa, 2007. Surface Roughness OfNanofill and Nanohybrid Resin Composites After Polishing And Brushing. *Journal of Esthetic and Restoative Dentistry*, 19:265–275.

Quirynen M, & Bollen CM 1995. The influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man. A review of the literature *Journal of Clinical Periodontology*, 22(1) 1-14.

Sideridou ID, & Karabela MM 2011. Sorption of water, ethanol or ethanol/water solutions by light-cured dental dimethacrylate resins *Dental Materials*, 27(10) 1003-1010.

Soares LES, Cortez LR, Zarur RO, Martin AA. 2012. Scanning electron microscopy and roughness study of dental composite degradation. *Microscopy and Microanalysis*, 18: 289-29.

Sunico, MC., K Shinkai, Y Katoh. 2015. Two-year clinical performance of occlusal and cervical Giomer restorations. *Journal of Operative Dentistry*, 30(3): 282-289.

Tellefsen G *et al*. 2011. The role of toothbrush in the abrasion process. *International Journal of Dental Hygiene*, 9: 284-290.

Toshimitsu S, Hideaki K, Yasuyuki A, Werner JF, Masafumi K. 2012. Tooth brush abrasion of resin composites with different filler concepts. *World J Dent*., 3:184-93.

VvanDijken JW, Ruyter IE. 1987. Surface characteristics of posterior composites after polishing and toothbrushing. *ActaOdontol Scand*., 45:337-46.

Wang L *et al*. 2004. Wear resistance of packable resin composites after simulated toothbrushing test. *Journal of Esthetic and Restorative Dentistry*, 16: 303-314.

****