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Assessment of Microleakage of Giomer and Nanocomposite, Immersed in Three Beverages: An In Vitro Study

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Introduction

Aim: The objective of the study was to evaluate and compare the effect of fruit drink, fresh fruit juice and soft drink on the microleakage of giomer and nanocomposite.

Materials and Methods: Eighty caries free premolars extracted were used for the study. Class V cavities were prepared and restored with Nanocomposite on buccal surface and giomer on the lingual surface. The teeth were thermocycled following the restoration. The experimental groups comprised of 72 teeth (3 groups comprising 24 teeth each for fruit drink, fresh fruit juice and soft drink), while remaining 8 formed the control group. Each of experimental group was further divided into three subgroups (low, medium and high immersion). The teeth were finally immersed in methylene blue dye, sectioned and evaluated under stereomicroscope.

Results: Statistical analyses used were Mann-Whitney test and ANOVA test. The teeth showed statistically significant microleakage as the immersion regime increased.

Soft drink group showed highest microleakage followed by fresh fruit juice and fruit drink. Giomer exhibited more microleakage but the comparison was not statistically significant.

Conclusion: Low pH soft drink caused highly significant microleakage at the tooth and restorative material interface in medium and high immersion regimes signifying that the leakage pattern was directly proportional to the number of immersions. Thus, the study conclusively proves that the 'sipping habit' associated with commonly available low pH beverages is detrimental to the longevity of restorations.

Keywords: Microleakage, Beverages, Nanocomposite, Giomer.

Introduction

The concept of health has prevailed for centuries and dietary habits are apparently changing with modernization. It has been reported that contemporary

fluid consumption patterns of children are now more diverse than in past years, since carbonated soft drinks and fruit juices have replaced much of previous consumption of water and milk among children.1The sugars in these drinks are metabolized by plaque microorganisms to generate organic acids that bring about demineralization leading to dental caries.[2]

Repeated intake of fresh fruit juice leads to a marked reduction in the salivary pH. This pH is just below the critical pH of 4 needed to cause enamel erosion and microleakage of restorative materials. Cola drinks have an inherent acidity due to the presence of both orthophosphoric acid and carbonic acid, which tends to increase enamel demineralization, erosion and the microleakage around the restoration.[1]

Microleakage may be defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between a cavity wall and restorative material applied to it. Clinically, poor marginal adaptation is discernible as stained margins around restorations, post operative sensitivity and secondary caries.[1]

Thus, the continuing quest for better restorative material, the newer materials were introduced with better biomechanical properties such as better marginal seal, good esthetics, easy polishability, biocompatibility and compressive strength in evolution.[3]

Beautifill II, a type of Giomer is based on prereacted filler technology, when pre reacted glass particles are incorporated in the resin matrix to enhance its strength.[3]

Today, nanotechnology has become a popular discipline in science and technology.

Nanotechnology is the production of functional material and structure in the range of 0.1-100 nanometers by various physical and chemical methods. Inclusion of nanofiller and nanocluster of filler material provides enhanced esthetics, improved polishability and enhancement of certain physical characteristics of the restorative material in the mouth.[1]

One of the recent advancements is the Solare Sculpt, a Nanocomposite which is radiopaque, light curable restorative material being used for restorations.

Thus, this study was aimed for assessment of microleakage of giomer and nanocomposite, immersed in three beverages (fruit drink, fresh fruit juice and soft drink).

Materials and Methods

The present study was conducted for assessment of microleakage of giomer and nanocomposite immersed in three beverages: fruit drink, fresh fruit juice and soft drink.

Tooth selection

For this study freshly extracted young premolars were taken.

Inclusion criteria

- Teeth extracted for orthodontic purpose, teeth without any carious lesion, teeth without cracks on tooth surface.

Exclusion criteria

- Restored teeth, Discoloured teeth, Endodontically treated teeth

Sample size

Eighty human young premolars were used in the study.

Armamentarium

Ultrasonic scaler handpiece, Air rotor handpiece, Straight fissure bur and #2 round diamond bur, Composite filling instrument, LED dental light curing unit, Wet diamond disc, Soflex disc, Straight handpiece, Contra-angle handpiece, William's graduated probe, Micromotor, Stereomicroscope.

Materials used in the study

Solare sculpt (GC Corp), Beautifill II (Shofu), Solare universal bond (GC Corp), Deionised water, Distilled

water, Buffer solution, Frooti (Parle Agro Co.), Cocacola (Coca Cola Co), Fresh fruit juice (sweet lemon and pomengranate), Water, Methylene blue dye.

Specimen Preparation

Standardised class V cavities (3mm in length,2mm in width and 2mm in depth) were prepared on the buccal and lingual surface of all the samples,1mm above CEJ. The cavity preparation was standardised using William's graduated periodontal probe.

For the cavities on buccal surface of all the samples, universal bonding agent (Solare Universal Bond, GC Corp, Tokyo, Japan) was applied and light cured for 10s**.** This was followed by restoring the cavities with Nanocomposite (Solare Sculpt, GC Corp., Tokyo, Japan), light curing it for 20s**.** For the cavities on the lingual surface of all the teeth, universal bonding agent (Solare Universal Bond, GC Corp, Tokyo, Japan) was applied and light cured for 10s. This was followed by restoring the cavities with Giomer (Beautifill ll, Shofu, Kyoto, Japan), light curing it for 20s**.** Finishing and polishing of the restorations was done thereafter.

All the restored teeth were then stored in distilled water at room temperature for 1 week. During this period they were subjected to the thermocycling process of 100 cycles between 5-55°C with dwell time of 30s**.**

80 prepared tooth samples were divided into four groups. Group I- group III comprised of 72 teeth. Group IV comprised of 8 remaining teeth which were used as control(water). These 72 teeth were equally divided into three groups of 24 each and each group was further subdivided into 3 sub-groups with 8 teeth in each. In group I (24 teeth), fruit drink (Frooti, Parle Agro Co.), was used. In group II (24 teeth), fresh fruit juice (sweet lemon and pomegranate) were used. In group III (24 teeth), Soft drink (Coca Cola, Coca Cola Co.) was used**.**

Distribution of samples in groups and subgroups:

Group	Low Immersion (1 time/day)	Medium Immersion (5 times/day)	High Immersion (10 times/day)
Group I (Fruit drink)	8	8	8
Group II (Fresh fruit juice)	8	8	8
Group III (Soft drink)	8	8	8
Group IV (Control)	8 (No Immersion Regimes)		

The samples were subjected to the various immersion regimens. For low immersion regime the restorations were subjected to one immersion lasting five minutes per day**.**

For medium immersion regime they were subjected to 5 immersions per day. Each immersion lasted for five minutes, and the immersions were evenly distributed over a 12 hour period**.** For high immersion regime the samples were subjected to 10 immersions per day. Each immersion lasted for five minutes, and the immersions were evenly distributed over a 12 hour period**.** The whole procedure was carried out for 8 days**(Figure 1).**

After completion of test period apices of teeth were sealed with sticky wax**.** All tooth surfaces were painted with nail varnish except 1mm wide zone around margins of restoration and then suspended in 2% methylene blue dye for 24 hours at room temperature**.(Figure 2)** After that all the samples were rinsed and dried thoroughly.

The specimens were then sectioned bucco lingually using diamond disc under constant water spray. Depth of dye penetration was examined with stereomicroscope under 40x magnification to evaluate the microleakage.

The scores were given according to Stainiee and Holtz (1988) criteria **(Figure 3).**

Score 0: no dye penetration

Score 1: dye penetration along the occlusal wall but less than half way to the axial wall

Score 2: dye penetration along the occlusal wall but more than half way to the axial wall

Score 3: dye penetration along the occlusal wall upto and along the axial wall

Results

The scores obtained were thus evaluated statistically by the use of ANOVA and Mann Whitney test. For nanocomposites(buccal) specimens there was no statistically significant leakage in the specimens of Group-1 (fruit drink) when compared between the low and medium immersion regimes, but statistically significant leakage ($p < 0.05$)

When compared between medium and high immersion regime and statistically significant leakage ($p < 0.05$) when compared between low and high immersion regimes.

Similarly, there was no statistically significant leakage in the specimens of Group-II (fresh fruit juice) when compared between the low and medium immersion regimes, but statistically significant leakage ($p < 0.01$) when compared between medium and high immersion regime and statistically significant leakage ($p < 0.01$) when compared between low and high immersion regimes.

Like-wise, there was no statistically significant leakage in the specimens of Group-III (soft drink) when compared between the low and medium immersion regimes and medium with high, but statistically significant leakage ($p < 0.05$) when compared between low and high immersion regimes.

When low immersion regimes of the three groups were compared with each other, the result was not significant. When medium immersion regimes of the three groups were compared with each other, the result was not significant. Like-wise, when high immersion regimes of the three groups were compared with each other, the result was also non-significant.

The comparisons of low immersions between Group-I v/s Group-II, Group-II v/s Group- III and Group-I v/s Group-III was not significant. The comparisons of medium and high immersions between groups were also not significant in case for other comparisons.

For giomer(lingual) specimens there was no statistically significant leakage in the specimens of Group-1 (fruit drink) when compared between the low and medium immersion regimes, but statistically significant leakage ($p < 0.05$) when compared between medium and high immersion regime and statistically significant leakage ($p < 0.01$) when compared between low and high immersion regimes.

Similarly, there was no statistically significant leakage in the specimens of Group-II (fresh fruit juice) when compared between the low and medium immersion regimes, but statistically significant leakage ($p < 0.01$) when compared between medium and high immersion regime and statistically significant leakage ($p < 0.01$) when compared between low and high immersion regimes.

Like-wise, there was no statistically significant leakage in the specimens of Group-III (soft drink) when compared between the low and medium immersion regimes, but statistically significant leakage ($p < 0.05$) when compared between medium and high immersion regime and statistically significant leakage ($p < 0.01$) when compared between low and high immersion regimes.

When low immersion regimes of the three groups were compared with each other, the result was not significant. When medium immersion regimes of the three groups were compared with each other, the result was not significant. Like-wise, when high immersion regimes of the three groups were compared with each other, the result was also non-significant. However, mean leakage

score of all the three groups differ significantly from each other when all the specimens compared together.

The comparisons of low immersions between Group-I v/s Group-II, Group-II v/s Group- III and Group-I v/s Group-III was not significant. The comparisons of medium and high immersions between groups was also not significant in case of all other comparisons.

When mean scores of Buccal (Nanocomposite) and Lingual (Giomer) were compared, Lingual (Giomer) showed higher scores than Buccal (Nanocomposite) in all the three groups. The mean score of Buccal (Nanocomposite) and Lingual (Giomer) in Group-I (Fruit drink) worked out to be statistically significant only in case of medium immersion regime. However, the comparisons of mean scores between Buccal (Nanocomposite) and Lingual (Giomer) were statistically non-significant in case all other regimes in the three groups. The results also found to be statistically significant when mean score Buccal (Nanocomposite) and Lingual (Giomer) were compared by taking into account all the all the specimens together **(Table 1 and graph 1).**

Discussion

There are many complex factors that contribute to the total acidogenic potential on the enamel. The increased awareness of the population about health has led to an increased consumption of natural food products especially fruits and fruit juices. But healthy diet has also been proven to contain substantial acids, which has the potential to cause loss of tooth structure. Acidified sugar – containing drinks have shown to be cariogenic and erosive in rats in an experimental study by **Hartles RL et al(1962)4.**

Foods and beverages, especially fruits and fruit juices, can contain a variety of acids that have the potential to damage the teeth **Birkhed D (1984)5.**

So our study was conducted to evaluate the microleakage of giomer and nanocomposite immersed in three beverages at three different immersion regimes.

The study was conducted in the department of Pediatric and Preventive dentistry after approval of the ethical committee of Sri Guru Ramdass Institute of Dental Sciences and Research, Amritsar.

In our study young freshly extracted sound premolars were chosen because of to delete the effect of carious exposure to the tooth to view the ideal property of restorative materials and beverages used in the study.

Brannstrom et al.(1976)6 stated that microleakage remains a problem with the commonly used restorative materials. Gap formation and concomitant leakage of bacterial fluids, molecules and ions of restorative material are brought about by dimensional change such as polymerisation shrinkage, thermal expansion, incomplete hygroscopic expansion and chemical degradation.

The choice of restorative materials being giomer and nanocomposite in this study is due to some unique properties. Giomer is a unique class of restorative material. It has been introduced as the true hybridization of glass ionomer (GI) and composite resin and has the distinguishing feature of a stable surface prereacted glass ionomer (SPRG), which is coated with an ionomer lining incorporated in a resin matrix. This arrangement aids in the protection of the glass core from moisture, adding to longstanding aesthetics, durability, physical and handling properties of composite resins with fluoride release, and recharge property like the GI cement **Bollu PI et al(2016)7.**

Clinical studies demonstrated the excellent aesthetics and clinical stability of Giomer materials. They are employed with success: in class V noncervical lesions restorations of permanent teeth, in class I and II occlusal

restorations of posterior primary and permanent teeth, as enamel and protective coatings like pit and fissure sealants, and as a coadjuvant restorative material in the treatment of gingival recession **Walia R al(2016)8.** Beautifill II, a type of Giomer is based on prereacted filler technology, when pre reacted glass particles are incorporated in the resin matrix to enhance its strength.

On the other hand Nanocomposites like Solare Sculpt are popular disciple in sciences and technology. **Katge et al.(2016)1** in his study stated that nanotechnology is the production of functional material and structure in the range of 0.1-100 nanometers by various physical and chemical methods. Inclusion of nanofiller and nanocluster of filler material provides enhanced esthetics, improved polishability and enhancement of certain physical characteristics of the restorative material in the mouth. **Mitra et al. (2003)9** reported that compressive and diametral tensile strengths and the fracture resistance of nanocomposites were equivalent to or higher than those of the other commercial composites that they tested. The nanocomposites also showed better polish retention than the hybrids and microhybrids tested after extended brushing periods. **Watanabe et al. (2008)10** demonstrated that the fracture toughness values of hybrid and nanoparticle resin composites are significantly higher than those of microfilled resin composites. However, **Yesil et al.(2008)11** reported that nanocomposites did not significantly improve wear resistance or the amount of opposing cusp wear when compared with the traditional materials tested.

In our study, we used commonly consumed beverages, i.e carbonated drink, fruit drink as well as fresh fruit juice. Similar steps were followed by **I. RYTOMAA et al(1988)12** who stated that the acidogenic potential of the commonly consumed fresh fruit juice(pH 3.98) and carbonated drink (Coca Cola pH < 3.5) was less than 4. Whereas **Tahmassebi et al.(2006)13** described phosphoric acid is a common constituent of most of the soft drinks. The acid content of the cola soft drink, which is added to give a peculiar tangy taste and has a preservative property, is known to play a well established role in the erosive process. Substances in cola soft drinks absolutely affect the integrity of the enamel surface.

In a study by **Bollu PI et al (2016)7** it was inferred that restoration of Class V cavities which are usually located in cervical area of the tooth, presents a special challenge to the clinician. The coronal margins of these Class V cavities are in enamel while the gingival margin is usually located in cementum or dentin. Despite several improvements in adhesive systems, the adaptation and bonding of these adhesive systems to cementum and dentin is less predictable. The cyclic flexure of tooth in these cervical areas along with polymerization shrinkage of adhesive material may also lead to loss of marginal adaptation. In our research as mentioned in the study by **Maganur PC et al. (2010)2** , Class V cavities were prepared on the buccal and the lingual surfaces of extracted human premolars 1 mm above the CEJ so as to avoid the exaggerated effect of leakage property of restorative material if placed far away from CEJ or quite close to CEJ, this is done to reduce the microleakage because cavities place 1 mm below the CEJ have shown significantly more leakage due to the inadequate bonding of the restorative material to the tooth structure. The teeth were stored in normal saline at room temperature to prevent their dehydration till the study was conducted. In a study by **Walia et al.(2016)8** class V cavities were selected because of its configuration or "C" factor which is 5 which corresponds to the ratio

between the number of bonded to unbonded surfaces which is responsible for the internal bond disruption as well as marginal gaps around the restorations.

Before and after each immersion in three beverages, the specimens and pellets were copiously rinsed in 0.1 M phosphate buffered saline (PBS, pH 7.2) to buffer the effect of fruit drink, Cola drink (Coca Cola®) and fresh fruit juice (orange) after the prescribed exposure time. This was done to return pH to a neutral level once the exposure was over and to avoid prolonged insult to the materials while they were stored in the deionized water. The study by **Maganur PC et al. (2010)2** followed the same criteria.

However, as stated by **Rytomaa et al.(1988)12** it is inappropriate to extrapolate the findings of our research to the conditions existing in vivo in humans. In the oral cavity, any drink or foodstuff will be instantaneously mixed with saliva with a subsequent rise in its pH. After consuming a low pH drink, the pH on the tongue stays low only for a short duration. In addition, acidic drinks have also been shown to stimulate salivary secretion, which in turn facilitates the buffering systems.

Conclusion

Thus it could be concluded that giomers exhibited more microleakage than nanocomposites in relation to restorative materials used in the study. For beverage consumption pattern high immersion regime specimens showed greater leakage followed by medium immersion and then further followed by low immersion regime specimens. The type of beverage which presented highest microleakage results was soft drink followed by fresh fruit juice and then by fruit drink.

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Legend Table, Graph & Figures

Table 1: Comparisons between Buccal (Nanocomposite) and Lingual (Giomer) in different immersion regimes

Groups	Immersion regimes	N	Buccal (Nanocomposite)	Lingual (Giomer)	p-value	Interpretation
Group-I: Fruit drink	Low	8	0.250	0.750	0.120	NS (P>0.05)
	Medium	8	0.375	0.875	0.046	S (P< 0.05)**
	High	8	1.125	1.750	0.094	NS (P>0.05)
Group-II: Fresh fruit juice	Low	8	0.375	0.875	0.046	S (P< 0.05)
	Medium	8	0.500	1.000	0.085	NS (P>0.05)
	High	8	1.375	2.000	0.084	NS (P>0.05)
Group-III: Soft drink	Low	8	0.625	1.250	0.061	NS (P>0.05)
	Medium	8	0.875	1.625	0.090	NS (P>0.05)
	High	8	1.750	2.625	0.052	NS (P>0.05)
Overall	Low	24	0.417	0.958	0.002	S (P< 0.01)***
	Medium	24	0.583	1.167	0.003	S (P< 0.01)***
	High	24	1.417	2.125	0.003	S (P< 0.01)***

Graph 1: Comparisons of mean score of micro leakage between Buccal surface restorations(Nanocomposite) and Lingual surface restorations(Giomer)

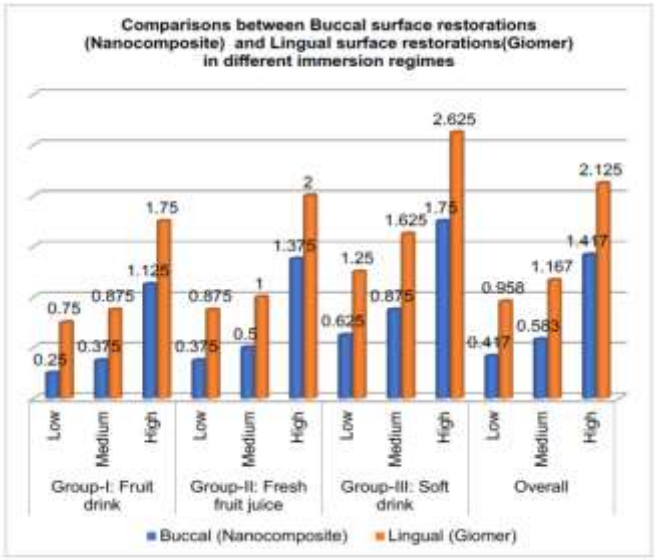

Figure 1:

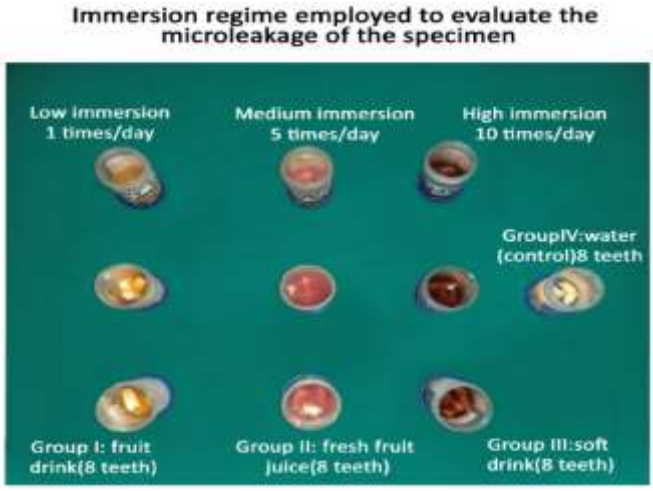

Figure 2:

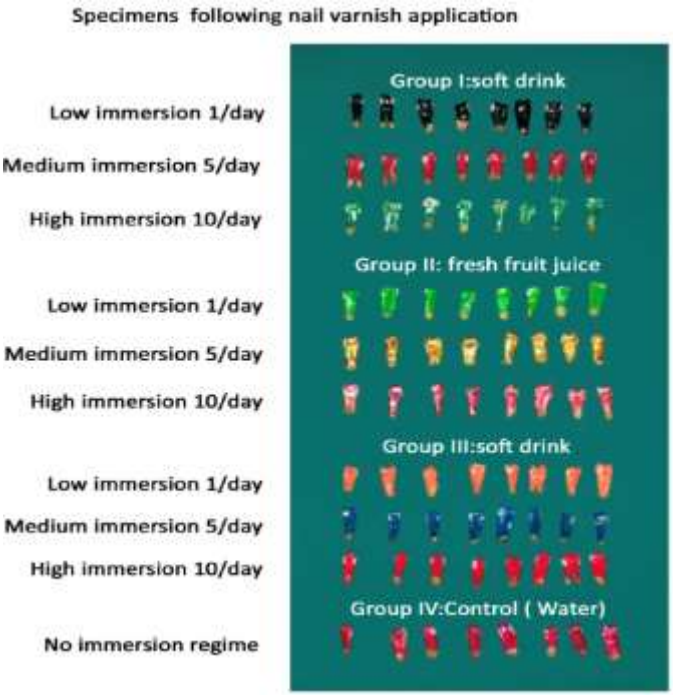

Figure 3: