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REVIEW ARTICLE

COMPARATIVE EVALUATION OF THE EFFECT OF MOUTHRINSES ON SORPTION AND SOLUBILITY RESISTANCE OF A NEW-BULK FILL ALKASITE AND ZIRCONIA-REINFORCED GLASS IONOMER CEMENT

[1*]Dr. Arshdeep Kaur, [2]Dr. Navjot Singh Khurana, [3]Dr. Jagvinder Singh Mann, [4]Dr. Sergy A, [5]Dr. Mansi Aggarwal and [6]Dr. Bikramjeet Singh

[1]PG Student, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Patiala; [2]Assistant Professor, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Patiala; [3]Professor & Head of department, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Patiala; [4]PG Student, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Patiala; [5]PG Student, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Patiala; [6]Medical Officer, Pcms-1, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Patiala

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***Corresponding author:** *Arshdeep Kaur*

ABSTRACT

Background: Among the various physical properties of a restorative material, water sorption and solubility cannot be neglected as they influence the clinical durability and success of a restoration. These two phenomenon, sorption and solubility, further depend on the immersion time and pH of the solution. ***Objective****:* The purpose of this invitro study was to comparatively evaluate the effect of three different mouthwashes on sorption and solubility of two newly introduced restorative materials, Cention–N and Zirconomer Improved. ***Method****:* A total of 120 cylindrical specimens (4 mm diameter and 2 mm height) were prepared for each material following the manufacturer's instructions. The specimens were stored in a vacuum desiccator with silica gel for 24 hours(hrs) and were evaluated for sorption and solubility, by first weighing them by a precision weighing scale (W1), then immersing them in three different mouthwashes for 7 days and weighing them (W2), and finally dehydrating them in a desiccator for 24 hours and weighing them (W3). ***Results****:* The sorption and solubility values were highest for Zirconomer Improved compared to Cention-N in all three mouhwashes. Low pH alcoholic mouthwash, Listerine, showed the greatest sorption and solubility compared to Aloe Vera mouthwash and Freshclor. ***Conclusion****:* All mouthrinses used in the study affected the sorption and solubility of the restorative materials tested, regardless of the presence or absence of alcohol. Both materials showed higher sorption and solubility values than the recommended values by ISO. This means that either the restorative materials tested need to be improved or the mouthrinses used in the present study were aggressive to the materials tested.

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INTRODUCTION

Restorative dentistry is a combination of art and science. The triumph of restorative dentistry is based on the functional and aesthetic results of a given procedure. The foundation for aesthetics is guided by position, contour, texture and colour. The modern dentist has many direct restorative materials at his disposal, from silver amalgam to light-curing composites (Piwowarczyk *et al*. 2005).

Several modifications of glass ionomer cements were introduced to overcome various drawbacks such as fracture toughness, finish and polish of the restoration, and shade that is not a perfect match to the original tooth color, justifying the constant research efforts to bring about continuous improvements **(**Dhivya, 2020). A newer modification of GIC, Zirconomer Improved (ZI), enhances the restoration's structural integrity, thereby improving mechanical properties and making it appropriate for use in the posterior teeth.

This is a high-strength, zirconia nanofiller reinforced restorative material that has recently emerged as a replacement for conventional glass ionomer cement in dentistry. Zirconia nanofillers are polycrystalline ceramics without a glassy phase and come in several forms **(**Dhivya 2020). Zirconomer Improved contains zirconium oxide, glass powder, tartaric acid (1-10%), polyacrylic acid (20-50%) and deionised water as the liquid. Zirconium oxide, the main powder component of Zirconomer, is derived from baddeleyite (ZrO2), which contains high proportions of zirconia ranging from 96.5 to 98.5% **(**Volpato *et al.* 2011). Therefore, this biomaterial combines and preserves the benefits of both commonly used restorative materials, amalgam and conventional GIC, and promises to provide outstanding strength, durability and permanent fluoride protection (Vemina *et al.* 2016). Cention-N, a tooth colored, radiopaque, novel bulk fill dual cured direct posterior restorative material is based on "alkasite" technology (a subgroup of composite resin). It releases fluoride, calcium and hydroxide ions and contains a special patented filler (isofiller) that acts as a shrinkage stress reliever by neutralising the acid (Deshmukh *et al.* 2020). The advantages of Cention-N include the possibility of bulk placement, optimal physical/mechanical properties, excellent esthetics and the option of light curing (Prasada *et al* 2020).

In comparison to other glass-based restorative materials, Cention- N is slightly translucent (11% translucency) and radiopaque due to the presence of ytterbium fluoride filler (Hotchandani *et al* 2023). Among the various physical properties of a restorative material, water sorption and solubility are important properties that affect the clinical durability and success of a restoration. When the material is exposed to water, water sorption takes place, resulting in an increase in volume. This can act as a plasticiser and ultimately lead to deterioration of the matrix structure of the material, resulting in its failure**.** The solubility of the restorative material leads to loss of material mass which increases the probability of failure at the tooth/restoration interface, leading to marginal microleakage and restoration failure (Prasada *et al* 2020). Dental caries and periodontal disease can be prevented and controlled by using a mouthwash on a regular basis. The alcohol in mouthwashes affects composite resin degradation and this effect was seen to have direct correlation to alcohol concentration. To overcome this shortcoming, alcohol-free mouthwashes have been introduced in the market (George Kavyashree, 2022). Hence, the aim of the present study was to assess and compare the influence of three different mouthwashes v.i.z, Listerine, AloeDent Aloe Vera mouthwash and Freshclor on sorption and solubility resistance of two newly introduced restorative materials, Cention-N and Zirconomer Improved.

MATERIALS AND METHODS

Following materials were selected for this study (Fig.1)

- Cention-N (Ivoclar vivadent)
- Zirconomer Improved (Shofu)
- Listerine (Alcohol containing mouthwash) (Johnson and Johnson Healthcare Products)
- Freshclor (Non-alcohol containing mouthwash) (Group Pharmaceuticals Ltd.)
- Aloe Vera mouthwash (Herbal mouthwash) (AloeDent)

Fig.1. Materials used in the study

Preparation of Specimens – 120 specimens were prepared using cylindrical Teflon moulds of 4mm diameter and 2mm height and the measurements of the moulds were confirmed with a vernier calliper (Fig. 2).

Fig. 2 Measurements of the moulds confirmed with a vernier calliper

Experimental Groups: The samples were randomly divided into 2 groups of 60 each as per the restorative material used as follows:

Group 1: Cention-N

Group 2: Zirconomer Improved

The ring moulds were filled with Cention -N and Zirconomer Improved respectively, as per manufacturer's instructions. Thereafter, the moulds were held between two glass slides separated by mylar matrix strips to help in producing uniform, even, smooth surfaced cylinders**.** For the samples restored with Zirconomer Improved, powder to liquid ratio in this group was 3.6 / 1.0 (2 Scoops: 1 Drop) with working time of 1min 30 sec and were placed incrementally into the mould and condensed with the help of a plastic instrument. For the samples restored with Cention-N, powder to liquid ratio was 4.6/1 by weight (1Scoop: 1 Drop) and were subjected to light curing from one side for 20 sec to hasten the setting reaction**.** After proper cleaning and polishing of specimens, the samples were removed from the mould and were stored in a vacuum desiccator with silica gel for 24 hours(hrs). They were weighed to an accuracy of 0.1 mg in a digital analytic balance. This was the sample weight before immersion (W_1).

The samples were further divided into subgroups as per the mouthwash they were immersed in:

Subgroup 1a - Cention- N immersed in Listerine.

Subgroup 1b - Cention- N immersed in Aloe Vera mouthwash (AloeDent).

Subgroup 1c - Cention – N immersed in Freshclor.

Subgroup 2a – Zirconomer Improved immersed in Listerine.

Subgroup 2b – Zirconomer Improved immersed in Aloe vera mouthwash (Aloe Dent).

Subgroup 2c – Zirconomer Improved immersed in Freshclor
20 samples of each material were immersed in 10 ml of the three mouthwashes at 37°C ±2°C for 7 days (Fig. 3).

Fig. 3. Immersed samples

After 7 days, they were removed and washed. The adherent water was wiped with a tissue paper and the samples were waved in air for 15 seconds and weighed (W_2). Thereafter, for determination of solubility, specimen were then dehydrated in a vacuum desiccator for 24 hours and weighed again; this weight was termed as W_3 (µg) (Fig.4).

Fig.4 Digital analytical weighing scale (Genius Electronic)

By taking the means of the two measurements at right angles to each other made to an accuracy of ±0.01 mm using digital vernier calliper, diameter and thickness of each specimen was measured. The volume (V) of each specimen was calculated as follows in cubic millimetres using the mean thickness and diameter:

$$V = \pi \times r^2 \times h$$

Where, r = mean sample radius (diameter/2) in millimetres and h = mean sample thickness in millimetres.

The difference between the initial and final dry weights of each sample ($W_1 - W_3$) was used to calculate the loss of material (solubility). The difference between the initial and final wet weights ($W_2 - W_1$) was used to calculate water sorption. The solvent uptake and solubility were estimated in µg/mm^3 using the Oysaed and Ruyter formula as follows:

$$\text{Sorption} = (W_2 - W_3)\ V$$

$$\text{Solubility} = (W_1 - W_3)\ V$$

Where, W_1 = Sample weight before immersion
W_2 = Sample weight after immersion
W_3 = Sample weight after immersion and desiccation
V = Volume of test material in mm^3.
The obtained information was statistically analyzed, and based on the findings, comparison within and between groups were made.

RESULTS

The collected data were subjected to statistical analysis. Data were evaluated using the statistical package SPSS 26.0 (SPSS Inc., Chicago, IL), and the level of significance was set at $p<0.05$. Analysis was done using one-way ANOVA, Tukey's post hoc test and t-test.

Table 1 shows comparison of solubility of restorative materials in mouthwashes using t-test, where Zirconomer Improved showed higher solubility in all three mouthwashes compared to Cention-N.

Table 1. Comparison of Solubility of restorative materials in three mouthwashes using t-test

		Mean	S.D	P value*
Listerine	Cention- N	72.85	10.01	<0.001
	Zirconomer	86.58	8.65	
Aloe vera	Cention- N	29.66	8.11	<0.001
	Zirconomer	50.36	13.44	
Freshclor	Cention- N	16.12	13.64	0.001
	Zirconomer	34.43	18.41	

*level of significance at p<0.05

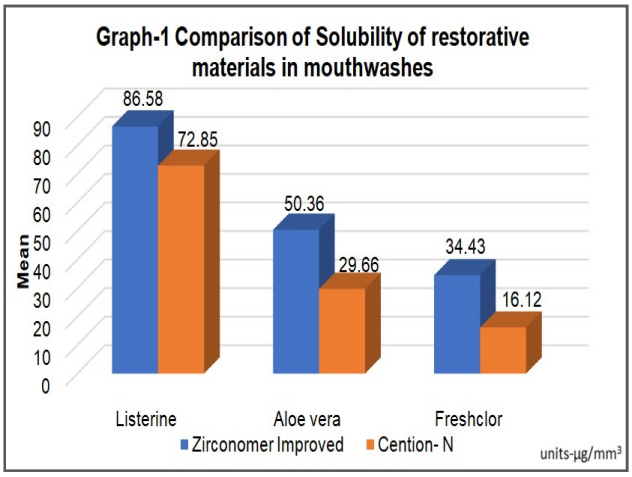
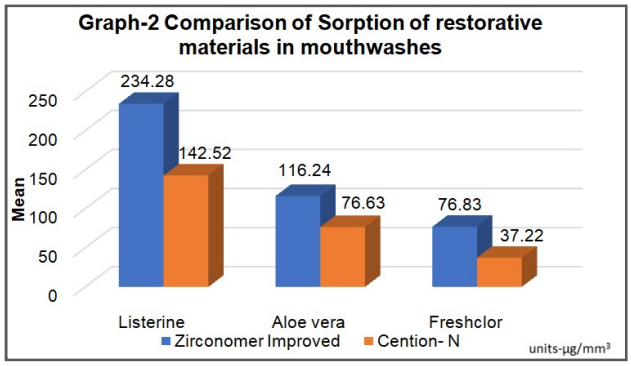


Table 2 shows comparison of sorption of restorative materials in mouthwashes using t-test, where Zirconomer Improved showed higher sorption in all three mouthwashes compared to Cention-N.

Table 2. Comparison of Sorption of restorative materials in three mouthwashes using t-test

		Mean	S.D	P value*
Listerine	Cention- N	142.52	26.24	<0.001
	Zirconomer	234.28	27.38	
Aloe vera	Cention- N	76.63	10.16	<0.001
	Zirconomer	116.24	10.22	
Freshclor	Cention- N	37.22	11.28	<0.001
	Zirconomer	76.83	9.32	

*level of significance at p<0.05



DISCUSSION

The longevity of a dental restoration is largely dependent on various factors, including the properties of the dental material used, the age of the patient and the rate of wear and tear**.** An ideal restorative material should be biocompatible, non-irritating to the surrounding tissues, and resistant to degradation. In addition to being aesthetically pleasing, it should also be able to withstand various oral cavity conditions soon after its placement. Water sorption and solubility are two such physical properties which are of paramount importance in evaluating the clinical durability of restorative materials. It can lead to degradation of a restorative material, resulting in dislodgment of the restoration, recurrent caries, postoperative hypersensitivity, pulpal inflammation and periodontal disease. Water sorption and solubility can lead to change in dimensions that ultimately result in restoration failure. According to ISO 4049 (2009), restorative materials should have a water sorption of less than 40µg/ mm^3 and a solubility of less than 7.5µg/ mm^3 when stored for 7 days. There have been reports/reviews that comparisons may be difficult due to variations in sample sizes. The smaller the sample, the lesser time it takes for the water to equilibrate, and the materials which absorb more water take longer to stabilise.

One of the shortcomings of the water sorption test is that it assumes that a gain in the weight of the sample represents an increase in water. In reality, however, it is the difference between the gain in water and the dissolution of the low molecular weight monomers in the sample. therefore, there is a possibility that the true water sorption values may be slightly higher than the reported values. In this study, a standard sorption and solubility test was used in which cylindrical samples of materials were exposed to three different mouthwashes for a period of 7 days and the result was determined by weight gain or weight loss of the sample respectively. The result showed that water sorption and solubility was higher for Zirconomer Improved in comparison to Cention- N in all mouthwashes. It can be explained that Cention-N contains UDMA, which is more hydrophobic than hydrophilic BisGMA, HEMA or TEGDMA, which are not present in Cention-N. Urethane dimethacrylate (UDMA) forms rigid networks and absorbs less water as it is hydrophobic in nature.

A study by *Mese et al*, found sorption and solubility values to be dependent on filler type and content, concentration of filler, mean particle size, coupling agents, type of filler particles and type of solvent. Cention-N has a special patented filler (Isofiller) that has the property of shrinkage stress relieving, which minimizes shrinkage forces during polymerisation. Large filler size, poor working consistency, comparatively longer setting time, and the rough surface may contribute to low sorption and solubility resistance of Zirconomer Improved**.** Zirconomer, which is chemically set, has no resin matrix phase which also accelerates material's dissolution**.** The Zirconia filler particles also affect the chelating reaction between the Ca+2 ions of hydroxyapatite and the carboxyl group of polyacrylic acid, which reduces sorption and solubility resistance and further increases microleakage. *Prasada K and Vidhyadhara H T* concluded that Cention-N showed less sorption and solubility in comparison to Amalgomer-CR which was in agreement with our study. Also, *Raman V et al* concluded that Ziconomer showed highest dissolution rate followed by Cention-N and composite which, could be attributed to the higher filler content of composite. In similar studies by *Nayak M et al, Shenoy V et al and Deshmukh G et al*, least sorption and solubility was seen in Cention-N as in comparison to other restorative materials and the results were in agreement with our study.

Oral mouthwashes are liquid preparations intended to be applied to the teeth and mucous membranes of the mouth and throat to provide a local antimicrobial, astringent or soothing effect. The alcohol in mouthwashes is believed to be a good solvent for the polymer chain of the resins and at high concentrations can cause a substantial deterioration in their properties and an increase in composite wear. In our study, among the mouthwashes, Listerine showed values which were significantly higher in comparison to Freshclor and AloeDent. This can be attributed to the low pH (4.2) and 30% alcohol content of the mouthwash compared to the other two mouthwashes. *Zhang and Xu* also detected two times higher sorption values in ethanol/water (75:25 v/v%) than in artificial saliva, and were of the opinion that this could be due to the easier penetration of ethanol into the resin matrix. A previous study *(Cavalcanti A N et al)* suggested that by lowering the pH of solutions, there is production of methacrylic acid, resulting in sorption and hygroscopic expansion as a result of enzymatic hydrolysis and biodegradation.

Therefore, Listerine with a low pH of around 3.8, may influence the sorption and solubility of the materials used. AloeDent, a new herbal aloe vera based mouthrinse and Freshclor, a newly formulated alcohol-free mouthwash, showed less sorption and solubility in comparison to Listerine, which could be due to the absence of alcohol in it and also the fact that its pH is close to neutral pH. In a study by *Pereira et al, Prado V et al, Carvalho* ***et al*** and *Almeida* ***et al***, the authors were of the opinion that sorption and solubility of the composites that were tested were higher in the rinses that contained alcohol in their composition and were in agreement with our study.

A study by *de Moraes Porto I C et al* was not in agreement with our study as Listerine, despite having twice the alcohol

content of Perio Gard, showed a better performance compared to PerioGard in the properties studied, i.e. hardness, sorption and solubility. As per *Catani-Lorente et al,* since clinical scenario is quite different from in vitro conditions, dental practitioners may need to be cautious about the manipulation and application of these restorative materials. Hence, the results of this study cannot be generalised because the study was conducted over a short period of seven days only. Therefore, more research is required to ascertain how these mouthwashes effect restorative materials.

CONCLUSION

Within the limitations of this study, it can be concluded that

- Both the restorative materials tested showed varying degrees of water sorption and solubility in all three mouthwashes.
- Cention-N showed comparatively better sorption and solubility resistance compared to Zirconomer Improved.
- The monomer composition and properties of filler particles have a significant effect on the physico-mechanical properties of restorative materials.
- All mouthrinses used in the study affected the sorption and solubility of the restorative materials tested, regardless of the presence or absence of alcohol.
- Low pH alcoholic mouthwash, Listerine, showed the greatest sorption and solubility compared to Aloe Vera mouthwash and Freshclor. There was significant difference among the tested materials.
- Freshclor and Aloe Vera mouthwash showed intermediate effects on the tested materials.
- Alcohol-free mouthwashes should not be preferred as a mouthwash in patients with extensive restorations.
- Both materials showed higher sorption and solubility values than the recommended values by ISO. This means that either the restorative materials tested need to be improved or the mouthrinses used in the present study were aggressive to the materials tested.

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