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Sorption and Solubility of Alkasite Restorative Material - An In Vitro Study

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Abstract: *The aim of the study was to evaluate the solubility and sorption values of alkasite restorative material (Cention N) in various beverages such as tea, coffee, coca-cola and artificial saliva. A total of forty samples of restorative material were prepared using a metallic mould and divided into two groups of twenty samples each (n=20); Group I: Cention N (test group) and Group II: Type IX Glass ionomer cement (GIC) (control group). The weight before immersion in the test media (m_1) was measured using digital analytical scale. Each group was subdivided into four subgroups (n=5) based on the test media they were immersed in; Subgroup 1: Tea, Subgroup 2: Coffee, Subgroup 3: Coca-cola, Subgroup 4: Artificial saliva. Five specimens each of the test material and control were kept immersed in the test media for seven days. The weight of the samples after immersion (m_2) in the test media after seven days and the final dry weight of the samples (m_3) were measured. Sorption and solubility of Cention N and Type IX Glass ionomer cement were calculated using ISO guidelines. The data obtained was statistically analysed and the two groups are compared using student's 't' test.*

Overall conventional GIC showed the maximum sorption and solubility values except in subgroup 3. Both Cention N and type IX GIC showed the highest sorption and solubility values in coffee. Cention N showed the least sorption and solubility values in all the subgroups except in coffee. The present study indicates that Cention N is better suited for permanent direct restoration of teeth compared to type IX GIC. Among the test solutions used coffee and tea had the most degrading effect on Cention N and type IX GIC.

Keywords: *Cention N, Type IX GIC, Sorption, Solubility, Alkasite*

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I. Introduction

The restorative dental materials should withstand the neutral and acidic media in the oral environment without disruption of the surface and loss of material.[1] These materials are tested for strength, however, they are rarely tested following storage in the kind of aqueous media found in the mouth.[2] Ionic restorative materials like glass ionomer cement (GIC) and visible light curable polymeric composites are routinely used in dentistry. Glass Ionomer Cements (GIC) are water based materials that consist of ion-leachable gel which set by a chemical reation.[3] Conventional glass ionomer cements absorb water and may dissolve by surface wash-off, diffusion through pores and cracks in the cement, and diffusion from the bulk.[4,5]

Cention N is a tooth-coloured, dual cure restorative material used for direct posterior restorations. It is an "alkasite" restorative material which is a new category of filling material and is essentially a subgroup of the composite resin.[6] It is radiopaque, releases fluoride, calcium and hydroxide ions. Resin based materials undergo a series of physical changes as a result of the polymerization reaction and the subsequent interaction with the wet oral environment.[7]

Physical property of a material determines how it responds to the environment. Sorption and solubility are two such physical properties that influence the clinical durability of a restorative material. Water sorption can increase the volume of the material and acts as a plasticizer and cause deterioration of the matrix structure of the material.[8] Solubility is the extent to which a material dissolves in a solvent at a given temperature.[9] This may cause dissolution or degradation of surface layers whilst in others the interaction may involve a leaching out of unbound or loosely bound components or an uptake of fluids into the structure of materials.[10]

Materials which are placed for long periods in oral environment will undergo an interaction with oral fluids. In the light of this, the present study was conducted. The clinical performance of Cention N such as microleakage, tightness of proximal contact and hardness of the material have been studied by several authors.[11-13]

Peez et al, Cefaly et al, Cavlo et al and Alzraikat et al have evaluated the sorption and solubility of type IX GIC in distilled water.[1,14-16] Bamise et al have studied the sorption and solubility of type IX GIC in various media like distilled water, coca-cola and Fanta.[17] Since sorption and solubility influences the clinical durability of restorative materials, this study aimed to evaluate the sorption and solubility of Cention N and type IX GIC in tea, coffee, coca-cola and artificial saliva.

II. Materials and methodology

The materials used, manufacturers and composition are described in Table 1. For comparison, type IX GIC was used as control. Twenty disc shaped specimens of each restorative material to be tested, measuring 15 ± 0.1mm in diameter and 2mm thickness were prepared in a stainless steel split mould. Products were handled following the manufacturer's instructions. Five samples of each material were immersed in 10ml of each test media at 37°C for seven days. The test media were grouped as: Subgroup 1: Tea, Subgroup 2: Coffee, Subgroup 3: Coca-cola, Subgroup 4: Artificial saliva. The test media were freshly prepared and replaced, every twenty four hours.

All the forty samples were cleaned and transferred to a desiccator maintained at 37°C with silica gel for 24 hrs. They were stored in a desiccator at 23°C for 1hr, then weighed to an accuracy of 0.1mg in a digital analytic balance. The cycle was repeated till a mass of loss not more than 0.1mg in any twenty four hour period is achieved. This is the sample weight before immersion (M_1).

Two measurements of diameter were taken at right angles to each other using dial caliper and mean diameter was calculated. Area was calculated in millimeter^2 from the mean diameter and volume was calculated in millimeter^3.

After seven days, the specimens were removed, washed in distilled water and the surface adherent water was gently blotted away with a tissue paper. The samples were waved in air for fifteen seconds and weighed in the balance (M_2).This was followed by reconditioning the specimens to constant weight in the desiccator using the earlier cycle. The sample weight after immersion and dessication (M_3) was recorded. The solvent uptake and solubility were determined in μg/mm^3 using the Oysaed and Ruyter formula.

$$\text{Sorption} = \frac{M_2\text{-}M_3}{V} \qquad \text{Solubility} = \frac{M_1\text{-}M_3}{V}$$

Where, M_1 = Sample weight before immersion
M_2 = Sample weight after immersion and
M_3 = Sample weight after immersion and desiccation.

III. Results

The data obtained were statistically analyzed using one way ANOVA and Tukey post hoc test. P values less than 0.05 were considered statistically significant. Both the test materials were soluble in all the four test media. Overall type IX GIC showed the maximum sorption and solubility values except in subgroup 3.

The comparison of solubility values for Group I and Group II in the four subgroups are given in table 2 and graphically represented in fig1. Both the groups showed the highest solubility in subgroup 2 (coffee). Cention N showed a mean solubility value of 223.52 ± 145.03, whereas type IX GIC showed solubility of 204.96 ± 143.42 but the difference was not statistically significant($p>0.05$). In subgroup 1 (tea), the difference in solubility of Group I (2.27 ± 1.39) and Group II (78.44 ± 66.59) was statistically significant ($p<0.05$).

Type IX GIC (17.61±9.86) showed higher solubility in subgroup 3 compared to Cention N (6.62 ±3) and the difference was statistically significant ($p<0.05$).The comparison of sorption values for Group I and Group II in the four subgroups are given in table 3 and graphically represented in fig 2. The highest sorption values for both Cention N (204.22 ± 129.22) and type IX GIC (199.98 ± 146.564) was seen in subgroup 2 (coffee).

Cention N showed a mean sorption value of 43.14 ± 10.71 in subgroup I whereas type IX GIC showed higher solubility (125.28± 78.37) and the difference was statistically significant.Statistically significant difference was observed in the sorption values of Cention N (28.08 ±16.3) and type IX GIC (67.42 ± 12.29) in subgroup 3.

IV. Discussion

The present study was conducted according to ISO 4049: 2009 guidelines. The ISO guidelines specifies the maximum acceptable solubility value for polymer based restorative material to be 7.5 μg/mm^3 and the maximum acceptable sorption value, 40 μg/mm^3.[18] In the present study, the values of water sorption and solubility for Cention N in all the test media except coffee, are within the range of the ISO standard, whereas the values of type IX GIC are far higher than the range of the ISO standard. This signifies that clinical success of

glass ionomer cements depends on early protection from hydration and dehydration since it is weakened by early exposure to moisture, while desiccation on the other hand causes shrinkage and cracks.[20] Deniz et al found that higher levels of solubility of glass ionomer cements were due to its high sensitivity to water contact during the initial minutes after mixing.[21]

The published data on solubility and sorption of Fuji IX are variable due to different mixing methods of these cements, variable sample dimensions and testing method. In the present study, the sorption and solubility values for type IX GIC are higher than the values reported in previous studies. The 24 hr solubility of Fuji IX reported by Peez et al was 0.05%.[1] Bamise et al in their study found that Fuji IX had lower solubility in coke, Fanta and distilled water compared to other test materials.[8] Similar results were observed in the study conducted by Cavlo et al and Cefaly et al.[14,15] The comparisons with other studies are difficult to make due to differences in specimen size; since different sizes of specimen will take different periods of time for water to completely infiltrate throughout a solid specimen. The smaller the specimen, the shorter the period for equilibration with water. The materials which absorb more water takes longer time to stabilize.

In the current study, Cention N showed the least sorption and solubility values except in subgroup 3, but the difference was not statistically significant. Cention N is a dual cure restorative material which contains urethane dimethacrylate (UDMA) in the liquid. UDMA create rigid networks, which absorb lower water and release higher unreacted monomer.[19] This could be the reason for the lower solubility and sorption of Cention N in this study.

Glass ionomer cement was chosen in this study because it is routinely used in clinical dentistry. Type IX Glass ionomer cement is said to set extremely hard and is highly wear resistant.[3] Conventional glass-ionomer cements absorb water and may dissolve by surface wash-off, diffusion of water through pores and cracks in the cement, or diffusion from the bulk of the cement.[5] In the present study, the high values of sorption and solubility of conventional glass-ionomer cement in all the test media could be related to these properties.

Both the restorative materials showed least solubility in coca-cola. The ability of cements to resist dissolution was found to vary with the composition of the medium, and not to rely simply on its pH. Coca-Cola contains phosphoric acid, which though capable of chelating with calcium in the restorative material, forms essentially insoluble complexes. Therefore, it is the presence of specific carboxylic acids which gives the beverages their highly damaging character, not simply their low pH.[22]

In the present study, the highest solubility and sorption values of both the restorative materials were observed in coffee. Tea on the other had comparatively lower effect on both the test materials. Sugar-free black tea was used in this study. The pH of black tea is about 5.7. Brunton and Bassiouny in their study found that sugar-free green and black tea have a non-erosive effect on human dentition.[24,25]

The restorative materials are in continuous contact with saliva in the oral cavity. Saliva is known to be composed of organic acids which can lead of dissolution of the dental cements. Artificial saliva of pH 7 was used in this study to simulate the setting similar to oral medium. Yanikoglu et al in their study found that the dental cements seemed to be most stable in the medium with pH 7. This could be the reason for the least solubility and sorption values of both the test materials artificial saliva observed in this study.[23]

V. Figures And Tables

TABLE 1: Description of the test materials used in the study

Group	Material	Type of material	Powder Liquid ratio (g/g)	Composition	Manufactures
I	Cention N	Alkasite	4.6:1	Liquid-UDMA resin, DCP, an aromatic aliphatic-UDMA and PEG-400 DMA. Powder-Ytterbium trifluoride, isofiller, fluorosilicate glass fillers	Ivoclar vivadent
II	Type IX GIC	Conventional glass ionomer	3.6:1	Powder-Aluminosilicate glass Liquid-Polyacrylic acid	GC Corporation Tokyo, Japan

Fig 1: Comparison of solubility between Fuji IX conventional GIC and Cention N in subgroups

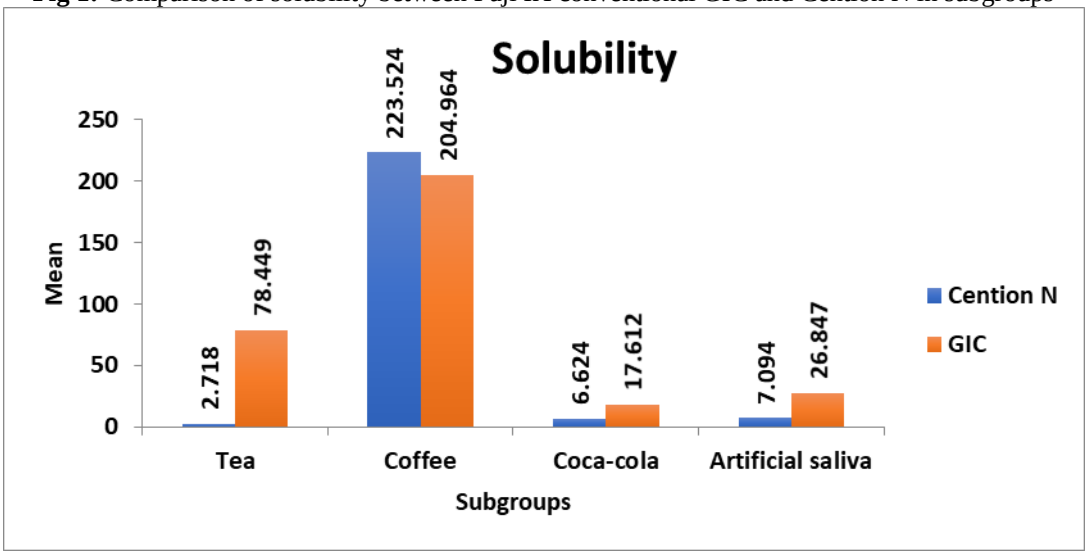
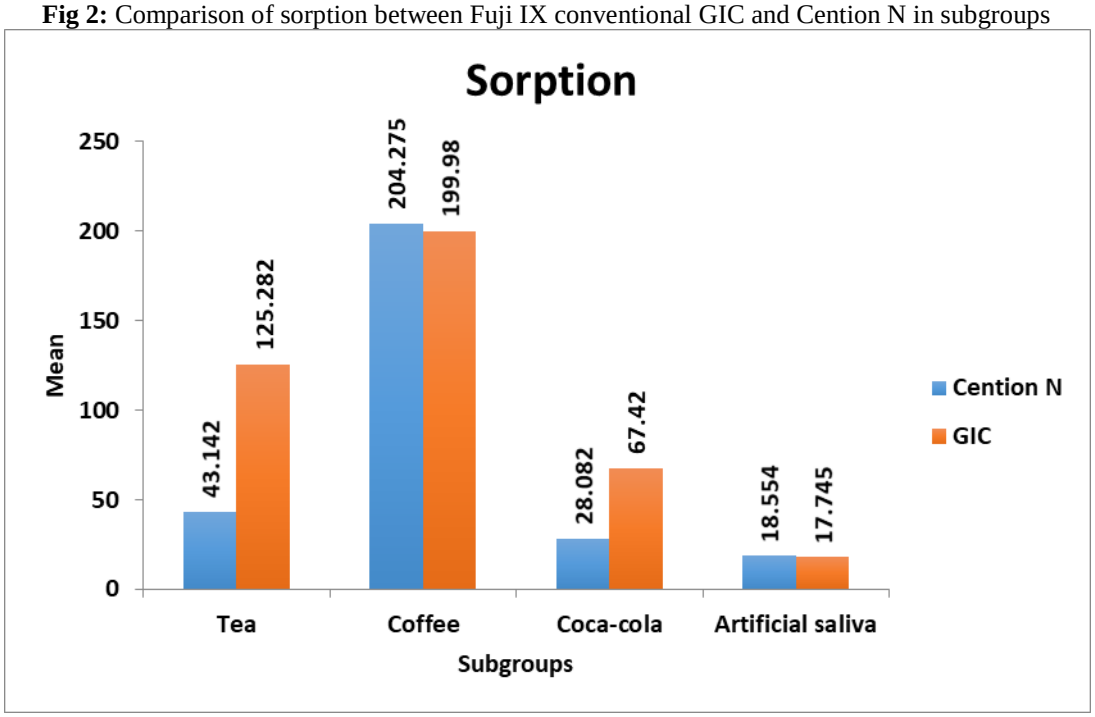


Fig 2: Comparison of sorption between Fuji IX conventional GIC and Cention N in subgroups



VI. Conclusion

Within the limitations of this study it can be concluded that Cention N is better suited for permanent direct restoration of teeth since it showed the least solubility and sorption values compared to Type IX GIC. Among the test solutions used, tea and coffee had the most degrading effect on the test materials used. Therefore, the patients with these restorative materials must be warned of the deleterious effects of coffee. However, this result cannot be generalized since the study was conducted only for a period of seven days and the restorative materials are only intermittently exposed to these beverages. So further studies have to be conducted to know the effect of these beverages on the restorative materials.

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