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Comparative Evaluation of Microhardness of Cention-N, Giomer, Zirconomer- An Invitro Study

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Abstract

Aim: This study aimed to evaluate and compare the microhardness of three restorative materials: Cention N, Giomer and Zirconomer.

Materials and Methods: Depending on the type of restorative material used,a total of thirty samples were made for the microhardness evaluation and divided into three groups of ten samples each: Cention N, Giomer and Zirconomer groups. For this study, the samples were made using a specifically designed Teflon moulds that measured 4mm in thickness and 6mm in diameter.For a period of 24 hours, each sample was stored in distilled water. The microhardness of each tested material was assessed using Vickers Microhardness test. Post Hoc Test and ANOVA were used in the statistical analysis. (0.05 as the p-value)

Results:There was a significant difference ($p<0.01$) in the microhardness of all three materials. Cention N had the highest value, which was significantly harder than Giomer. Out of the three test materials, the material with the lowest microhardness value was the Zirconomer.

Conclusion:Cention N has the microhardness that is noticeably higher than that of the other groups, making it suitable for use as a posterior restorative material in stress bearing areas.

Keywords: Cention N, Giomer, Microhardness, Zirconomer

Introduction

Modern dental practices offer a wide range of direct restorative materials. When choosing these materials, it is essential to consider their adherence to tooth structure, sufficient strength, resistance to recurrent caries, and simplicity of application.[1]

Dental amalgam was long favoured for restorations due to its physical properties. However, its drawbacks, such as poor aesthetics, leakage, sensitivity, plaque build-up, tooth discoloration, and cavity preparation challenges, have led to research into alternative materials.[2]

Glass ionomer cement (GIC) has been considered the gold standard for tooth restoration due to its chemical bond with dentin and enamel. Its notable characteristics include minimal cytotoxicity, adherence to moist tooth structure and base metals, anticariogenic properties, thermal compatibility, and biocompatibility. However, its weak mechanical qualities, such as low toughness, wear resistance, and fracture strength, limit its use as a restorative material in stress-bearing regions. Consequently, GIC is no longer suitable for high-stress situations.[3,4]

Research into direct filling materials acknowledges their advancements, alongside the enduring importance of amalgam and glass ionomer. This ongoing research aims to meet the rising demand for superior tooth-coloured restorative options that enhance both functional restoration and facial aesthetics.[5]The demand for aesthetic dentistry has spurred the development of resin composite materials, which now offer enhanced durability, aesthetics, and improved mechanical properties for direct dental restorations.[6]Composite materials consist of different components that collectively determine their properties.Dentists have been searching extensively for an alternative to amalgam or glass ionomer cement. What they really need is a fluoride releasing substance that is affordable, quick to apply, doesn`t require expensive equipment, and provides both strength and good aesthetics.[7]

For direct restorations, Cention Nis a tooth-coloured filling material that combines light-curing and self-curing features. It includes an alkaline filler that releases ions to neutralize acids. Designed for stress-bearing regions, it provides aesthetic appeal, reduces microleakage, and minimizes shrinkage during polymerization.[4,7]

Giomeris a novel resin containing glass ionomer, incorporating fluoride release through pre-reacted glass ionomer (PRG) fillers. It includes key components of glass ionomer cement. By using PRG fillers in a hydrogel phase already reacted, it achieves rapid fluoride release via ion exchange. This distinguishes Giomer from other resin-based fluoride-releasing restorative products.[8]

Zirconomer often referred to as "white amalgam," is a new type of restorative material that combines the strength and durability of traditional amalgam with the protective qualities of glass ionomers. It eliminates mercury concerns and enhances mechanical properties through the use of zirconomer fillers, making it suitable for repairing load-bearing posterior teeth.[6,9]

When evaluating restorative materials, hardness is a key attribute that denotes a material's resistance to indentation and correlates with its stiffness and strength. A dental restoration's surface hardness is crucial for enduring wear over time, as materials with lower surface hardness may be more prone to abrasive wear.[10]

The goal of the current investigation is to determine which restorative material would work best for tooth restoration by comparing the microhardness of Cention N,Giomer and Zirconomer.

Materials And Methods

Thirty samples were prepared for microhardness evaluation, divided into three groups of ten samples each based on the type of restorative material used. Each sample was created using a custom-built cylindrical Teflon mould, 4mm thick and 6mm in diameter.

The procedure involved placing a Teflon mould on a glass slide covered with a mylar strip. The restorative material was added to the mould in a single increment using a plastic filling instrument or a Teflon-coated instrument. Another mylar strip and glass slab were placed over the filled Teflon mould, and light pressure was applied to create a flat surface. Any excess material on the samples was then removed using a carver.

Group 1 Cention N(n=10)- For a uniform consistency mix Cention N (Ivoclar Vivadent Ag, Schaan, Liechenstein, Europe) powder and liquid were combined in accordance with manufacturers' specifications. Using plastic filling instrument, the material was placed into the mould and condensed, then exposed to LED light (Woodpecker RTA Mini S, China) for 20 seconds. (Figure 1a)

Group 2 Giomer (n=10)- A micro-applicator was used to apply the dentin bonding agent (Beauti Bond- Shofu Inc., Kyoto, Japan), which was then light cured for 10seconds. Teflon coated instrument was used to insert Giomer (Beautifil II - Shofu Inc., Kyoto,Japan) into the mould and condensed, and it was light cured using LED (Woodpecker RTA Mini S, China)for 20 seconds. (Figure 1b)

<u>Group 3 Zirconomer (n=10)</u>- To obtain a homogeneous condensable mix the powder and liquid of Zirconomer Improved (Shofu Inc., Kyoto, Japan) was mixed in accordance with manufacturers specifications.Plastic filling instrument was used to place the material in mould, and was condensed using a condenser, material was allowed to set. (Figure 1c)

Figure 1- Samples restored with restorative materials

To ensure complete polymerisation of the restored samples without being impacted by passing light, the samples were kept at room temperature in a light-proof container with distilled water for 24 hours.

The Vickers hardness number (VHN) of each sample was measured using a microhardness testing apparatus (RVM-50, Ratnakar Enterprises, India). A diamond indenter with a 100-gram load was applied for 10 seconds per test. Three indentations were made on the top surface of each sample, uniformly spaced around a circle and at least 1mm apart from adjacent indentations or the sample's border. (Figure 2). The Vickers microhardness number was determined using the following formula[1] –

$$\text{VHN: HV} = 1.854\ P / d^2$$

Where, HV was Vickers Hardness in Kgf/mm^2, P was the load applied in Kgf and d was the length of the diagonals in mm and 1.854 was a constant number.

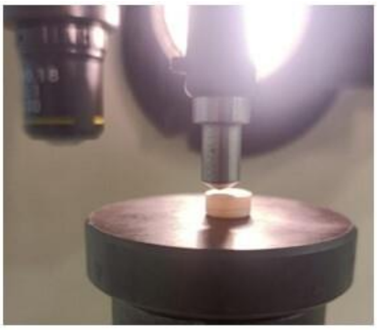

Figure 2- Samples being tested under Vickers microhardness tester

Statistical Analysis

Data was collected and subjected to analysis using the Statistical Package for the Social Sciences (SPSS) version 23.0. Microhardness values were presented as means. Vickers microhardness number (VHN) data was subjected to ANOVA test and Post Hoc test. The level of significance was set at 0.05 ($p < 0.05$)

Results

A statistically significant difference ($p < 0.05$) in the mean microhardness values is seen across all the groups.Descriptive statistics (Table No.1) summarises all of the tested materials hardness values, Cention N (Group 1) 96.03 ± 2.94 MPa has the greatest hardness values in the current research, followed by Giomer (Group 2) 86.56± 2.60 MPaand Zirconomer (Group 3) 68.80 ± 1.93 MPa,(Figure 3).An intragroup analysis of the three materials means hardness evaluations revealed a statistically significant difference (Table No.2). Intergroup analysis (Table No.3) showed that microhardness in Cention N group was significantly higher followed by Giomer group and least was seen in Zirconomer group.

Table No: 1 Descriptive statistic- Mean Microhardness values of all the groups.

					95% Confidence Interval for Mean						
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min.	Max.	F value	P value	Post hoc
Cention N	10	96.0333	2.94580	.93154	93.9260	98.1406	92.67	101.33	298.641	0.000	Cention N > Giomer > Zirconomer
Giomer	10	86.5667	2.60602	.82410	84.7024	88.4309	82.00	89.67			
Zirconomer	10	68.8000	1.93218	.61101	67.4178	70.1822	67.33	73.33			
Total	30	83.8000	11.73840	2.14313	79.4168	88.1832	67.33	101.33			

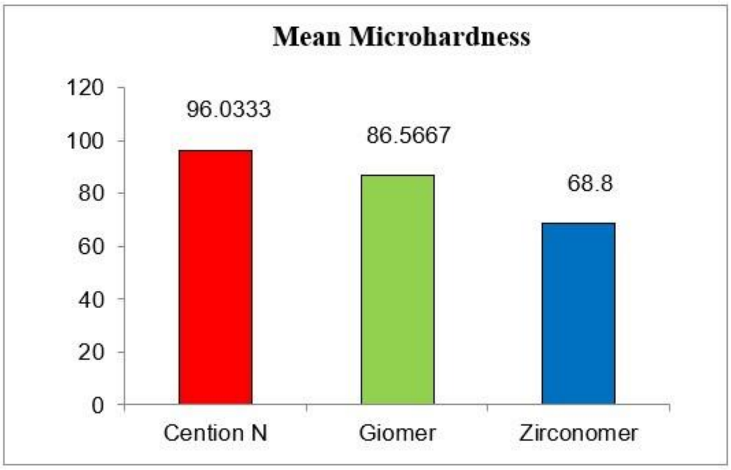

Figure 3-Mean microhardness values of the three experimental groups

Table No. 2: ANOVA TEST – Comparison between the three experimental groups

	Sum of Squares	df	Mean Square	F value	P value
Between Groups	3823.088	2	1911.544	298.641	0.000*
Within Groups	172.822	27	6.401		
Total	3995.910	29			

*Significant ($p < 0.05$)

Table No. 3: POST HOC – Pairwise comparison between any two experimental groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	P value	95% Confidence Interval	
					Lower Bound	Upper Bound
Cention N	Giomer	9.46666	1.13144	0.000*	6.6613	12.2720
	Zirconomer	27.23333	1.13144	0.000*	24.4280	30.0386
Giomer	Cention N	-9.46666	1.13144	0.000*	-12.2720	-6.6613
	Zirconomer	17.76667	1.13144	0.000*	14.9613	20.5720
Zirconomer	Cention N	-27.23333	1.13144	0.000*	-30.0386	-24.4280
	Giomer	-17.76667	1.13144	0.000*	-20.5720	-14.9613

*Significant ($p < 0.05$)

Discussion

In today's market, there is a wide range of restorative materials available. Key requirements for excellent materials include degradation resistance, biocompatibility, and non-irritating properties towards surrounding tissues. These materials must withstand the harsh conditions of the oral cavity immediately after placement while also providing aesthetic appeal.[11]According to Ulvestad, a hardness test may be used to assess a materials resistance to attrition.[12]Hardness is crucial for the effectiveness of dental restorative materials in the oral cavity, defining their resistance to surface penetration or indentation. Materials with lower hardness may lead to early restoration failures, requiring sooner replacement. Thus, maintaining optimal hardness is essential for ensuring the longevity and performance of dental restorations.[5]Different methods are used to evaluate hardness, which determines the hardness number of a material. Common techniques include Vickers, Knoop, and Brinell tests. The Vickers test is particularly effective for assessing the hardness of relatively brittle materials.[13] A diamond pyramid-shaped indenter used in the Vickers hardness test is honed into squared pyramid shape with a 136^0 angle between the faces. The depth of indentation is approximately 1/7 of the diagonal length of the final imprint. [7]

For many years, dental amalgam has been a versatile restorative material, with drawbacks like poor adherence, aesthetics, and mercury concerns. This drives the ongoing search for restorative materials with better biocompatibility, fracture resistance, aesthetics, and adhesion to tooth surfaces.[14]

Glass ionomer cements (GIC) have highest fluoride ion release among dental materials, were developed to meet the demand for improved adhesive and aesthetic properties. Despite their advantages, GICs have drawbacks such as lower resistance to chewing forces, longer setting and working times, and sensitivity to moisture.[15]

Composite is a popular dental material due to its aesthetic appeal but has drawbacks like shrinkage during polymerization, which can cause recurrent caries, poor marginal seal, and staining, reducing restoration lifespan. A stronger, easier-to-replace material is needed due to composite's limitations and the declining popularity of amalgam.[16]To address limitations of conventional glass ionomers, hybrid restorative materials blending resin composite and glass ionomer technologies have been introduced.[14]

Cention N is an alkasite restorative material, belonging to a novel class of fillings known for their alkaline fillers that release ions neutralizing acids. It is a self-curing, tooth-coloured filling material based on resin, with the additional option of light-curing.[17]Cention N was selected to meet the needs of dentists and patients alike by offering durability, ease of bulk placement, dual curing, and aesthetic appeal. Its components include: Powder- barium aluminium silicate for strength; ytterbium trifluoride for radiopacity; isofiller(Tetric N-Ceram technology) to relieve shrinkage stress; calcium barium aluminium fluorosilicate glass for strength and fluoride release; calcium fluorosilicate for the release of fluoride, hydroxide and calcium ions[18]and Liquid contains dimethacrylate`s and initiators. [17]

Giomer utilize inorganic fillers formed from polyalkenoic acids reacting with ion-leachable fluoroboroalumino silicate glasses in water. This process creates stable glass-ionomer phases around glass cores, producing pre-reacted glass ionomer (PRG) fillers through an acid-base reaction with polycarboxylic acid and fluoride-containing glass. Depending on the reaction extent, fillers can be surface reaction type (S-PRG) or full reaction type (F-PRG), with S-PRG preserving the glass core's integrity. S-PRG technology is utilized in Beautifil, enhancing stability and controlled fluoride release in dental restorations.[13]

Zirconomer is a glass ionomer restorative material that combines the strength and durability of amalgam without the harmful mercury properties and the bonding and fluoride-releasing properties of glass ionomer cement. It incorporates zirconia as a filler particle, enhancing the mechanical qualities and structural integrity of restorations, especially in load-bearing areas. Zirconomer's superior strength, durability, continuous fluoride protection, and chemical bonding make it an ideal choice for permanent posterior restorations in caries-prone patients.[16]

The current investigation compared the microhardness of Cention N, Giomer, and Zirconomer restorative materials. The findings indicated that Cention N (Group 1) exhibited the highest mean microhardness values, followed by Giomer (Group 2), and the lowest mean values were observed with Zirconomer (Group 3). Significant differences were noted among all three groups. This was identical to the research carried by Mazumdar P et al. [7] found that Cention N showed the highest microhardness values likely due to the inorganic filled nanoparticle size may be related to their improved microhardness.In a similar investigation by Vishakha Verma et al. [19] where Cention N includes a patented silane-functionalized filler that minimizes shrinkage stress and force. Its low volumetric shrinkage is due to the specific organic/inorganic ratio and monomer composition. Kiran N.K et al.[4] found that UDMA is the major component of the monomer matrix, contributing to stronger crosslinking during the polymerization reaction.

Giomer had a greater hardness value than other restorative materials, according to research by Prashant Babaji et al.[13]and Mukundan Vijayan et al.[10]whereGiomer has the most filler, content (83.3 wt.%)[20] making it the hardest material. Giomer integrated with bis-GMA and TEGDMA resin base, it reduces polymerization shrinkage, increases strength and wear resistance, and enhances abrasion resistance and surface hardness.[21] Research by MA Mohamed Tahir et al.[22] examined the effect of pH on the microhardness of resin-based materials, including composite, giomer, and compomer. They proposed that the pre-reacted glass ionomer particles in giomer were more resistant to acid destruction compared to compomers.

An investigation by Shrutika Somani et al.[6] was accordance to our study, compared the mechanical properties of Zirconomer, Filtek Z350, and amalgam. They concluded that Zirconomer showed the lowest values, possibly due to the improper bonding of zirconia particles to the glass ionomer matrix. In Shameera Asafarlal et al.'s study,[23] Fujii IX extra GC was found to have greater hardness than Ketac Molar, while Zirconomer showed the lowest hardness among the materials examined. This difference may be attributed to the incorporation of large filler particles in the cement formulations.A study by Dinah Rachel Bethapudy et al.[11] was contradictory to our investigations, that Zirconomer exhibited the highest microhardness in their study, attributed to a balanced mix of large and small particles within the matrix. This suggests strong particle-matrix bonding. Additionally, the unique properties of zirconia, such as transformation toughening, contribute to its enhanced hardness, corrosion resistance, strength, and toughness.

This study has limitations, including focusing solely on microhardness as a physical property and conducting tests in cylindrical moulds, which may not accurately reflect clinical tooth preparation conditions. Variations in cavity designs for different restorative materials also pose a challenge in assessing restoration hardness comprehensively. Moreover, the study underscores the need for additional in vivo research to evaluate the clinical effectiveness of these materials.

Conclusion

In conclusion, the study highlights Cention N’s superior microhardness compared to Giomer and Zirconomer, making it a strong candidate for bulk fill restorative applications. Its high resistance to wear and surface deformation, along with its ion-releasing properties, positions it as a promising material for areas subjected to high masticatory forces. However, while Cention N shows great potential, it is essential to consider the study’s limitations, such as its in vitro nature and the need for further clinical research to confirm these findings in real-world settings.

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