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A comparative evaluation of microleakage of three restorative materials

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Abstract— **Introduction**: Many restorative dental materials have been introduced to restore the lost tooth structure while conserving its form and function. Glass ionomer cements (GIC) are known for their chemical bond to enamel and dentin. Cention N is a new type of resin composite filling materials, and Tetric N-Ceram is a radiopaque nanohybrid resin composite for direct restorative procedures. **Aim**: The purpose of this study was to evaluate and compare the microleakage of two resin composites (Bulk fill resin composite, Nanohybrid resin composite) with a resin-modified glass ionomer cement). **Materials and Methods**: Thirty specimens were divided into three groups (10 samples each). Bulk fill resin composite (group I), nanohybrid resin composite (group II), and resin-modified glass ionomer cement (group III). For evaluation of microleakage, class V cavities were prepared on the buccal surface of 30 premolars. These restorative materials were inserted into the cavities and subjected to thermocycling. The microleakage assessment was performed under a digital microscope following immersion of the teeth in 0.5% methylene blue dye. **Results**: Cention N displayed significantly less microleakage than did nanohybrid composite and GC Fuji II LC at occlusal as well as the gingival margins. **Conclusions**: In this in vitro evaluation, Cention N consistently performed better than the nanohybrid composite as well as GIC Fuji II LC.

Key words: Cention N, Tetric N-Ceram, Resin-modified glass ionomer and microleakage.

Introduction: A variety of restorative materials have been introduced to restore the missing tooth structure, preserving shape, function, and aesthetics. Strong dentinal adhesion, to withstand various dislodging forces while in service are of prime importance for a successful restoration .(1) The modern dental practitioner has access to a wide range of direct filling materials for posterior load-bearing restorations, from silver amalgam to recent bulk-fill composites. An obvious leap in the direct restorative dentistry was made with the introduction of light-cured composites. Resin composites were introduced in the 1960s, showing large polymerization shrinkage as a main drawback, which most probably results in marginal microleakage, postoperative sensitivity, and secondary caries.(2) Due to the increasing demand for cosmetic dentistry, resin composite materials have even been developed for direct posterior restorations

with improved physical properties, esthetics, and durability.(3) Nano-filled resin composites show physical and mechanical properties at least as good as those of universal hybrids, and are possibly used for the same clinical indications along with anterior restorations due to their high esthetic properties.(4) Tetric N-Ceram® is a direct, radiopaque, light-cured nano-hybrid composite restorative material.(5) Cention N® (Ivoclar Vivadent, Liechtenstein) was introduced in 2016 in powder/liquid form, as a radiopaque, self-curing direct filling material with light-curing options.(6) Resin-modified glass-ionomer cements was developed to achieve desired physical properties while preserving the major characteristics of the conventional glass-ionomer cement of chemical bond to tooth structure. The materials were mainly developed to overcome the problems of moisture sensitivity and inferior physical properties associated with conventional glass ionomer cements.(7) Success of a restoration depends greatly on its marginal seal, to prevent marginal leakage. Microleakage is the clinically undetectable passage of bacteria, fluid, or ions in microgaps (10–6 μm) between the cavity wall and the restorative material. Good intraoral longevity of any restorative material is ensured by its minimal microleakage score.(8)

2-Materials and methods:

Materials: Materials used in the study are shown in table (1) and figure (1).

Materials	Description	Composition	Manufacturer	Lot number
Cention N ®	Alkasite bulk fill resin composite.	Powder approximately 57.6% (vol.) (calcium fluoro-silicate glass, barium glass, calcium-barium-aluminium fluoro-silicate glass, iso-fillers, ytterbium trifluoride), initiators and pigments Liquid: Dimethacrylates initiators, stabilizers, additives, and mint flavor.	Ivoclar Vivadent Schaan,Liechtenstein.	W44058
Tetric N Ceram®	Nano-hybrid resin composite.	Bis-GMA, Bis-EMA and UDMA. filler content of approximately 61% (vol.) (barium aluminium silicate glass, 17% Isofillers “, ytterbium fluoride and spherical mixed oxide)	Ivoclar Vivadent Schaan,Liechtenstein.	V35942
Fuji II LC	Light-Cured,	Polyacrylic acid (20-25%),	GC, Tokyo,	2302132

capsule ®	resin reinforced restorative material.	2-Hydroxyethyl methacrylate (30-35%), Proprietary ingredient (5-15%), 2,2,4-Trimethyl hexamethylene decarbonate (1-5%), Alumino-fluorosilicate glass (95-100%).	Japan	

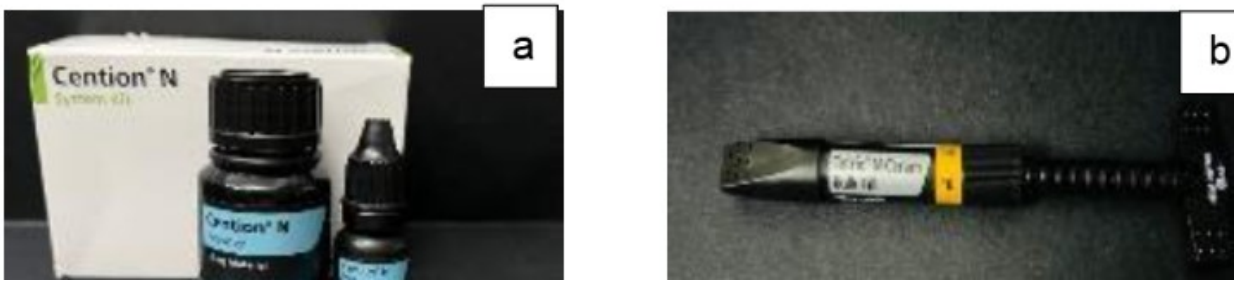

Figure (1): Materials used in this study, a) (Cention N) resin composite with alkaline fillers, b) (Tetric N ceram) nanohybrid resin composite, c) (Fuji II LC capsule) Resin modified glass ionomer.

All materials were manipulated according to their manufacturers' instructions:

Group I: Cention N (Ivoclar Vivadent Schaan, Liechtenstein), alkasite bulk fill resin composite was prepared manually. Two measuring spoons of powder and 2 drops of liquid were mixed on a mixing pad to a smooth consistency using a plastic spatula. Half the powder was blended with the liquid until fully wet, followed by mixing the remaining powder in limited amounts and a mixing time not exceeding one minute and light cured for 20 seconds, using a LED curing-light unit (Johnson-Promident. USA) at 1200mW /cm2. Group II: Tetric N ceram (Ivoclar Vivadent Schaan, Liechtenstein), the nano-hybrid resin composite was packed in bulk and cured for 20 seconds, using a LED curing-light unit (Johnson-Promident.USA) at 1200mW /cm2. Group III: Fuji II Light Cure Capsule (GC, Tokyo, Japan), resin-reinforced restorative material, was mixed in an amalgamator for 10 seconds. After mixing, the capsule was injected into the cavity using a gun applicator, and light cured for 20 sec using a LED curing-light unit (Johnson-Promident. USA) at 1200mW /cm2. Each specimen was prepared for evaluation Microleakage. -Methods 2.1 Teeth selection c 30 premolars teeth, extracted for orthodontic reasons, randomly selected. Each tooth was scaled to remove calculus and remaining tissue tags, followed by polishing with a pumice slurry. The teeth were stored in saline until restored (Fig.2).(1) 2.2 Cavity preparation Standardized Class V cavities (3mm mesiodistal width, 2mm inciso-cervical length, and 1.5mm depth) were prepared on the buccal teeth surfaces. The gingival margin was placed 1mm incisal to the cementoenamel junction. To standardize the cavity dimensions, a tofflemire metal band (window of 3

x 2mm) was held around each tooth by a tofflemire matrix retainer, and a permanent marker was used to mark the cavity outline, Fig. 2a, b, c. The cavities were prepared using a no 1 round bur (ELA Carbide Burs, Germany) mounted on a high-speed handpiece (COXO, China) with copious water cooling, Fig.2d. The bur was replaced by a new one after every 4 cavities. To standardize the cavity depth, a rubber stopper was mounted on the bur on pre-measured length of 1.5mm, and depth was confirmed using a periodontal probe), Fig. 2e. The prepared cavity was rinsed thoroughly with air/ water spray and dried. The teeth were randomly assigned to three groups of 10 teeth each according to the type of restorative materials used. The test materials were prepared and packed into cavities according to their manufacturers' instructions.(9)

Figure (2): Teeth and instruments used for their preparation: a) 30 randomly extracted premolars; b) Standardized Class V Cavity; c) Tofflemire metal band and retainer; d) Prepared Class V cavity using high speed handpiece; e) Depth measurement using a periodontal probe.

2.3 Thermocycling regime

All specimens were thermocycled in distilled water (500 cycles between 50C - 550C, with dwell time 25 seconds in each bath , and 5 seconds transfer time from one tank to the other) (Robota automates thermal cycle; BILGE, Turkey) as shown in Figure(3).(10)

Figure (3): Robota automates thermocycler; BILGE, Turkey

2.4 Preparation prior to sectioning

The specimens were immersed in 0.5% methylene blue dye solution for 24 hours at room temperature. Afterwards, the specimens were removed from the dye solution, rinsed under e Figure (2): Teeth and instruments used for their preparation: a) 30 randomly extracted premolars; b) Standardized Class V Cavity; c) Tofflemire metal band and retainer; d) Prepared Class V cavity using high speed handpiece; e) Depth measurement using a periodontal probe. running water to remove excess dye, then allowed to dry. The specimens were kept in specimen bottles containing distilled water until the time of sectioning, Figs 4a, 6b (1)

Figure (4): Teeth prepared for testing; a) The specimens immersed in 0.5% methylene blue dye solution, b) The teeth removed from the dye solution.

2.5 Sectioning of specimens:

Each tooth was mounted onto special holding and sectioned buccolingually through the center of restoration with the help of low-speed diamond disk under water coolant saw (Top Dent, Edenta Golden, Swiss) The specimens were rinsed under running water, and dried with tissue paper, Fig.5(10)

2.6 **Evaluation of microleakage**:

Each specimen was photographed using USB Digital microscope with a built-in camera), Fig.6 Technique; the images were taken with the following image acquisition system.

1) Digital camera (U500x Digital Microscope, Guangdong, China) with 3 Mega Pixels of resolution, placed vertically at 2.5 cm from the samples. The angle between the axis of the lens and the source of illumination is approximately 90o.
2) Illumination was achieved with 8 LED lamps (Adjustable by Control Wheel), with a color index close to 95 %. The images were taken at maximum resolution and connected with compatible personal computer using a fixed magnification of 40X.the image of the restoration was captured and transferred to a computer equipped with the image analysis software program (Image J 1.43U, National Institute of Health, USA), where the leakage was assessed. The degree of microleakage of both halves of the restored teeth was assessed at the gingival and the occlusal margin using a digital microscope under 40x magnification and the following scoring criteria(8):

   0: No dye penetration
   1: Dye penetration along with the interface to one third of the cavity depth
   2: Dye penetration along with the interface to two third of the cavity depth
   3: Dye penetration up to, and along the axial wall

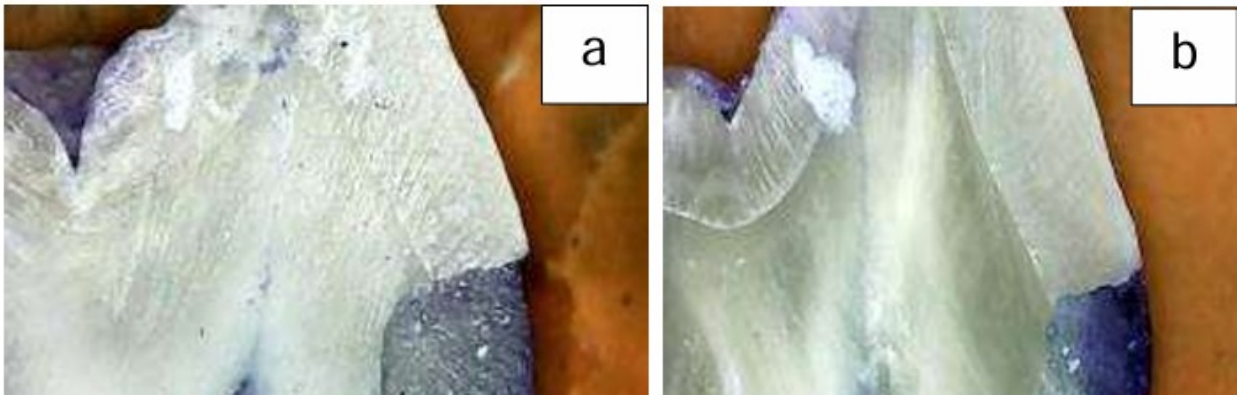

Figure (6): Digital microscopic images of three tested materials; a) Digital microscopic image of Cention N®; b) Digital microscopic image of Tertic N Ceram®; c) Digital microscopic image of Fuji LC®

3-**Results**:

A significant difference exists between three groups and their scores using chi square test at p <0.05. Gingivally, group (I) Cention N, about 10% had score 0 (no dye penetration, 10% had score 1 (dye penetration along with interface to one third of cavity depth), 30% had score -2 (dye penetration along with interface to two third of cavity depth) and 40% had score -3 (dye penetration up to and along the axial wall. For group (II) Tetric N Ceram, about 20% had dye penetration along with interface to one third of cavity depth, 30% had dye penetration along with interface to two third of cavity depth and 50% had dye penetration up to and along the axial wall, and. For group (III) Fuji II, about 70% had a score -3. (dye penetration up to and along the axial wall), While Score 1, 2 and 3 each took 10%. Occlusally, group(I) Cention N, about 30% had score -0 (no dye penetration), 60% had score -1 (dye penetration along with interface to one third of cavity depth), and) and 0nly 10 % had score -3 (dye penetration up to and along the axial wall). For group (II) Tetric N Ceram group, about 20% had dye penetration along with interface to one third of cavity depth, 30% had dye penetration along with interface to two third of cavity depth and 50% had dye penetration up to and along the axial wall. For group Fuji (GIII), about 20 % had score - 0 (no dye penetration), and 60% had a score -3. (dye penetration up to and along the axial wall), While both Score 1, 2 and took 10% each and. According to the total microleakage, statistical analysis showed significant differences between the three groups using Kruskal Walis at p <0.05. The high mean scores were recorded in Fuji II group (III), followed by Tetric N ceram group (II) while Cention N group (I) was the lowest one, (Table 2 and figures 7,8).

Table 2, Comparison between three groups for Microleakage

	scores	Cention N (GI)	Tetric N Ceram (GII)	Fuji II (GIII)	Chi squa
		N= (10)	N= (10)	N= (10)	
Gingival	Score-0	1(10%)	0 (0%)	1(10%)	
	Score-1	2(20%)	2 (20%)	1(10%)	
	Score-2	3 (30%)	3 (30%)	1(10%)	3.41
	Score-3	4(40%)	5(50%)	7(70%)	
mean		2.21	2.3	2.7	
Occlusal	Score-0	3(30%)	0 (0%)	2(20%)	
	Score-1	6(60%)	2 (20%)	1(10%)	
	Score-	0(0.0%)	3 (30%)	1(10%)	14.4

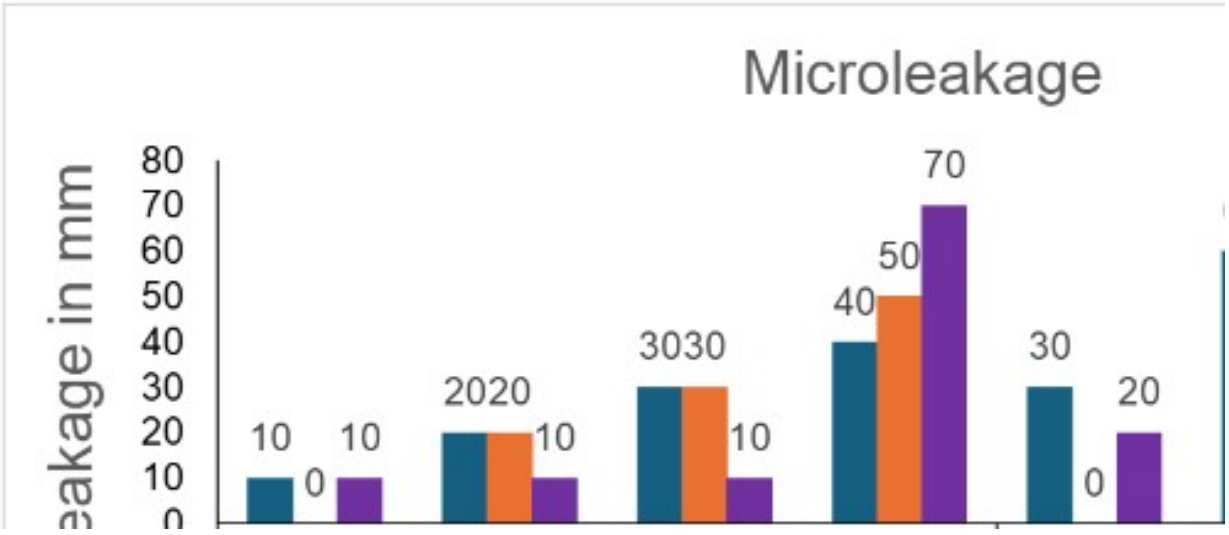

Figure (7): Microleakage scores of three tested groups in gingival and occlusal areas.

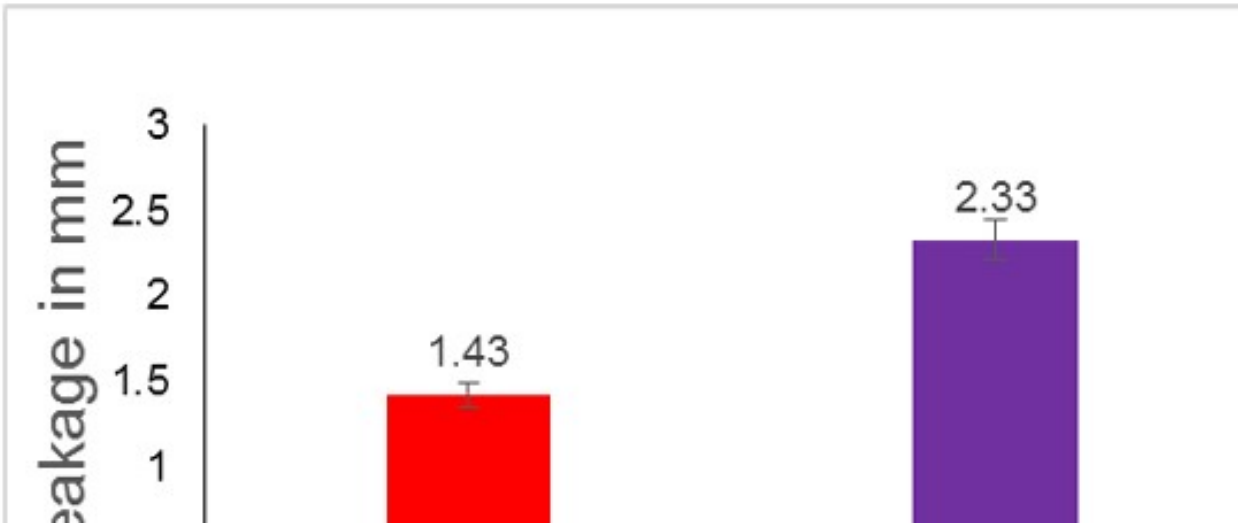

Figure (8): Mean microleakage scores of three tested groups.

4-**Discussion**:

The ultimate goal of dental restorative material is to restore biological, functional and esthetic properties of the healthy tooth structure. (11) For many years, many dental restorative materials including amalgam, composite and GIC have been utilized in restoration procedures. Resin composites have become more and more popular over the last decade because of patients' increasing esthetic demands. (12) The present study was conducted to compare and evaluate microleakage of Cention-N with nanohybrid composite and GIC restorative materials. Prevention of microleakage is a crucial requirement for improving the prognosis through increased restorative durability. This is accomplished by ensuring that the restorative material is well adhered to the tooth structure. (13). In the present study, non-carious minimal Class V restorations were selected, because of their easy preparation and restoration, thus decreasing technique-sensitivity and operator related variability.(14) Due to the differences in coefficient of thermal expansion between the restorative material and teeth, thermal changes could be utmost important features for effective marginal seal. With an attempt to the intraoral temperature changes and stresses occurring at the tooth-restoration interface, all the samples were subjected to a thermocycling procedure. (15) Among the various methods used to detect microleakage, dye penetration with methylene blue has proven to be a time-tested method. Methylene blue was used in the present study due to the low molecular weight of the dye known to be smaller than bacteria, useful to detect leakage in places where bacteria cannot penetrate.(16) In the present study, Cention-N revealed the lowest microleakage values compared with nanohybrid resin composites and GIC. The result of this study is also similar to that of the study conducted by Sujith et al.2020(8), who investigated the mechanical and microleakage properties of Cention N, glass ionomer cement (GIC) and composite restorative materials. They recorded the lowest microleakage and higher mechanical properties for Cention-N compared with GIC and hybrid composites. These results might be explained by the high polymer network density and degree of polymerization of Cention-N over the complete depth of the restoration, due to the use of cross-linking methacrylate monomers in combination with a stable, efficient self-cure initiator. It also contains special fillers (Isofiller) which act as a shrinkage stress reliever reducing the shrinkage force, associated low volumetric shrinkage and least microleakage. Hybrid resin composite demonstrates higher microleakage

compared to Cention-N, since composite reveals polymerization shrinkage with volumetric contractions ranging between 2.6 and 4.8%.(17) Shenoi et al,2021(18) tested microleakage in Class V cavities when restored with flowable composite and Cention-N restorative material. Cention-N showed significantly lesser leakage and better adaptation than flowable composite. According to the findings of Nahar et al,2021(19), Cention N has shown least microleakage followed by Equia Forte, Ceram X and GIC.. Aakriti et al,2020(20) tested Microleakage in teeth restored with Conventional GIC and two recent restorative materials; EQUIA Forteand Cention N using Stereomicroscope. They also proved the least microleakage for Cention N, being better than the Equia Forte and Conventional GIC. Similar to the present study, Dennis et al,2021(21) declared the lowest microleakage at the occlusal margin and gingival margin for Cention N using adhesive system and highest microleakage at the RMGIC. Sahu et al,2018(22) compared microleakage of dental amalgam, bulk-fill composite, and Cention-N restorative material for class I cavities. They observed promising results with Cention-N and least microleakage with amalgam compared to composite. In contrast to the results of this study , Venugopal et al,2021(23) tested microleakage in Class V cavity restored with nanohybrid flowable composite, (RMGI) and Cention N. They proved significantly less microleakage for RMGIC compared to the other restorative materials used in their study, since RMGIC bond chemically to enamel and dentin, and by hybridization. Cention-N is a subgroup of resin composite materials available in powder and liquid forms. The powder contain alkaline ions (fluoride and calcium), and its liquid part has four different dimethacrylates (urethane dimethacrylate, tricyclodecandimethanol dimethacrylate, aliphatic UDMA, and polyethylene glycol), as well as an initiator which helps in the formation of cross link during polymerization and polymer density which, in turn, improves its mechanical properties.(14) From the present study, found that Cention-N is an esthetically acceptable restoration which requires lesser chair-side time for restoration.

Conclusions:

Within the limitations of this in vitro study, the following was concluded:

1- Cention-N is a new restorative material having promising properties.
2- None of the three materials are free from microleakage.
3- The highest scores in microleakage were recorded for Fuji II group (III), followed by Tetric N ceram group (II) while Cention N group (I) was the lowest.

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