RESEARCH ARTICLE

Comparative Evaluation of Adhesive Bond Strength of Conventional GIC and Cention N to Enamel and Dentin of Primary Teeth: An *In Vitro* Study

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Abstract

Aim: The aim of this *in vitro* study was to evaluate and compare the adhesive bond strength of conventional glass ionomer cement (GIC) and Cention N to the primary enamel and dentin using an accelerated fatigue test.

Materials and methods: A total of 30 sound human primary molars were collected and were mounted on a metal cylindrical block using acrylic resin, embedding the root up to cemento-enamel junction (CEJ). Proximal box was prepared on both mesial and distal surfaces, one of the cavity was restored with GIC (Type 9) and the other proximal cavity with Cention N. A nonretentive cavity design was followed for both the materials so as to maintain the uniformity between the two specimens were then placed under a universal testing machine (Instron) and subjected to accelerated cyclic loads till a separation fracture occurs at the tooth-restoration interface. The number of endured cycles a particular restoration could withstand before getting fractured was registered.

Results: Cention N resisted significantly more number of endured cycles before separation from the cavity as compared to GIC ($p < 0.001$).

Conclusion: Within the limitations of the study, it can be concluded that newly developed material Cention N is preferred alternative over conventional GIC for the restoration of proximal cavities in primary molars.

Keywords: Bond strength, Cention N, Fatigue test, Glass ionomer cement.

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Introduction

Comprehensive oral health treatment plan comprises restorative care that considers numerous factors, including caries-risk assessment, durability of dental materials, biocompatibility, developmental status of the dentition, anticipated parental compliance, and patient's ability to cooperate with the treatment.[1] The traditional way of treating a carious tooth is by restoring it to appropriate restorative material to maintain the structural integrity of the crown structure with long-term durability.

There is an array of dental materials available for restorative treatment in children and adolescents. The conventional dental materials for restoring primary teeth are amalgam, GICs, compomers, giomers, and resin-based composite systems.[2–4] In the past, amalgam was considered as the "gold standard" against which all the new materials were compared for outcomes such as the effectiveness and durability of the restoration.[5] However, in the era of minimally invasive dentistry, the use of amalgam has declined over the past decade because of its potential toxicity, cavity design that demands cutting down of healthy tooth structure and esthetic issues.[6] GIC is still considered to be the restorative material of choice in primary dentition as it provides an adaptive seal with the cavity wall and leaches out fluoride from restorative margins that prevent recurrent caries.[7] Because of its poor mechanical properties, like low fracture strength and wear resistance, various modifications have been created in its composition.[8] But these changes have made GIC less basic and added to the number of application steps in many cases.

The arrival of new composite restorative materials, together with new generations of adhesives, has provided prodigious benefits in terms of esthetics and stridden toward minimally invasive dentistry. They may, however, be perceived as expensive, time-consuming and technique sensitive, hence less preferred in children with limited cooperative ability.[9,10] Cention N (Ivoclar Vivadent; Schaan, Liechtenstein) is a new basic restorative material that offers advantages over both amalgam and GICs. It is an "alkasite" restorative material used for bulk placement in retentive preparations, which can be used with or without an adhesive.[11] Alkasite attributes to a new category of filling material, which like compomer or ormocer materials, is essentially a subgroup of the composite material class. It is radiopaque and releases fluoride, calcium, and hydroxide ions.[11]

The clinical success and longevity of current restorative materials depend upon good adhesion with enamel and dentinal

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surface and its strength to resist various dislodging forces and occlusal load acting in the oral cavity. The most common laboratory tests conducted earlier for predicting the clinical performance of a restorative material are tensile and shear tests. However, with these static tests, the predictive power is questioned as the majority of dental restorations fail under cyclic occlusal loads over an extended period of time and maintenance of interfacial integrity is essential for a restoration to be durable.

With the above-mentioned concepts, an *in vitro* study was carried out to evaluate and compare the adhesive bond strength of conventional GIC and Cention N to the primary enamel and dentin using an accelerated fatigue test method by continuously increasing load.

Materials used in the study (Table 1).

Materials and Methods

Sample Selection

A total of 30 sound human primary molars, extracted as a result of exfoliation/over-retention, were collected from the outpatient Department of Pediatric & Preventive Dentistry. Inclusion criterion for the samples was the presence of at least one-third of the root structure so that the tooth could be embedded into the metal block.

Preparation of Samples

Selected primary molars were pumiced to remove the organic debris and stored in 0.1% thymol solution. Each tooth was mounted on a metal cylindrical block using acrylic resin, embedding the root up to CEJ. Later, the blocks were immersed in water to avoid the expansion of the resin.

Restorative Procedures

Proximal box extending into the dentin and without any retentive groove was prepared on both mesial and distal surfaces of thirty primary molars with a straight fissure diamond bur (Mani-SF 41) using a high speed airotor with water cooling. In each tooth, one of the proximal cavities (either mesial or distal) was filled with GIC and the other with Cention N and a similar pattern was followed for all the 30 teeth. Tofflemire matrix system was used to create an external wall so that the restorative materials could be packed and adapted along the cavity walls. Finishing and polishing of the restorations were completed using diamond finishing bur and soflet disc (Fig. 1). A computer generated random allocation sequence was followed while selecting a restorative material to fill the cavity, and a total of 60 restorations (GIC = 30 and Cention N = 30) were done. Retentive cavity design, as recommended by the manufacturer of Cention N, was not followed so as to maintain uniformity with GIC restorations.

Thermocycling and Fatigue Testing

Twenty-four hours following the restorative procedure, the samples were kept in distilled water at ambient temperature for 1 week and then thermocycled for 500 cycles at 5–55°C for 60 seconds. Samples were then placed under a universal testing machine (Instron) (Fig. 2), and a specific loading force (200 N) was exerted using a ball indenter with a diameter of 1/8th inch and was repeated till a separation fracture occurred at the tooth-restoration interface (Fig. 3). This experiment was replicated with accelerated cyclic loads (200–600 N) for both the restorative materials, and at each accelerated cyclic load, the number of endured cycles a particular restoration could withstand before getting fractured was registered. At each specific load and for each restorative material, six samples were used (Table 2).

Statistical Analysis

The mean values of fatigue strengths of the two materials at each loading force were calculated and compared using an independent *t*-test, and the level of significance was set at p-value < 0.05.

Results

Table 2 and Figure 4 depict the mean number of cycles needed to dislodge the restorations at every load point for both the restorative materials. Restorations with Cention N resisted more number of endured cycles at each loading force before getting dislodged from the cavity compared to GIC, which was highly significant ($p < 0.001$).

Discussion

While predicting the clinical performance of a restorative material, a mechanical test of fatigue failure/fracture is of paramount importance because most materials fail due to accumulated damage from cyclic loading in the oral cavity rather than a static loading event. Fatigue failure is the formation and propagation of cracks due to a repetitive or cyclic load. In contrast, fracture of other origin is caused by continuously increasing static load till the material gets fractured. Hence, the cyclic load that can yield fatigue fracture of the material is significantly less than the static load. Three distinct stages of fatigue failure are evident: crack nucleation; crack

Table 1: Materials used in the study

Materials	*Powder*	*Liquid*	*Manufactures*
GIC type 9[12]	Silica- 29% Alumina- 16% Aluminium fluoride- 5% Calcium fluoride- 34% Cryolite- 5% Aluminium phosphate- 9.9%	Polyacrylic acid- 35% Itaconic acid Maleic acid Tricarballylic acid Tartaric acid- 5–15% Water	GC gold label 9
Cention N[11]	Barium aluminium silicate glass Ytterbium trifluoride Isofiller Calcium barium aluminium Fluorosilicate	Urethane dimethacrylate (UDMA) Tricyclodecan dimethanol dimethacrylate (DCP) Tetramethyl-xylylen-diurethane dimethacrylate (Aromaticaliphatic UDMA) Polyethylene glycol dimethacrylate-PEG-400 DMA	Ivoclar vivadent

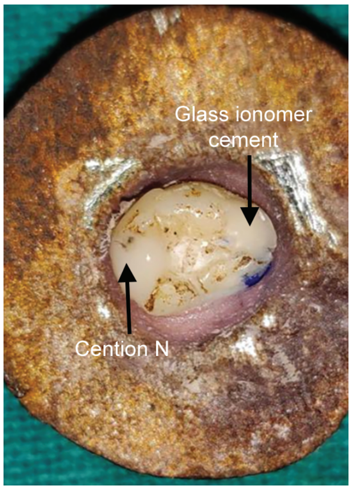

Fig. 1: Restoration of proximal cavities with Cention N and GIC

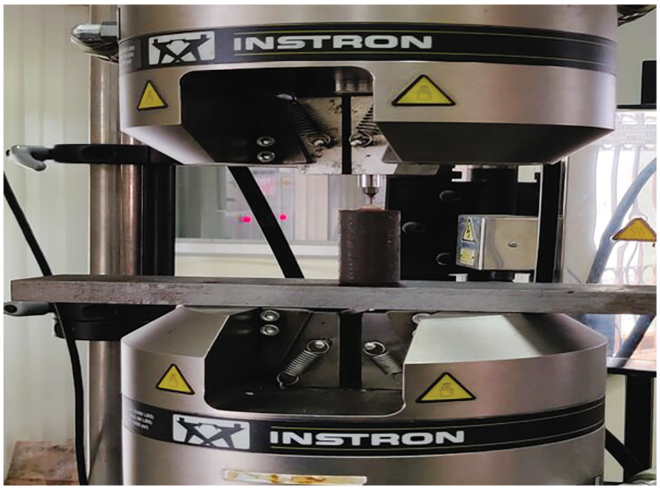

Fig. 2: Universal testing machine used for the experiment

Fig. 3: Separation fracture at the tooth restoration interface

propagation, and fracture (Fig. 5). Although crack nucleation is still not well-understood, this event generally occurs in regions of stress concentration, such as scratches or grain boundaries on the surface, or internal voids. In most restorations and prosthetic appliances, fractures develop in a similar fashion, and the induced tensile stress and the presence of an aqueous environment further reduce the number of cycles to cause dynamic fatigue failure.[12]

The present experiment closely reproduces the physiologic human mastication, where masticatory force varies with individuals depending upon the craniofacial morphology, age, gender, periodontal support of the teeth, and presence or absence of oral habits.[13] Also, at individual level, masticatory force differs with the type of food and position of the teeth.[13] More importantly, the same food may be chewed more number of times by a single individual than others before being swallowed. Therefore, repeated cyclic loading with a varying force identical to a masticatory force of different individuals is an important consideration for assessing the longevity of restoration in an oral environment. The load protocol in the present study covers the physiological masticatory forces (maximum occlusal bite force) in children ranging from 200–600 N.[14,15] Thus, the results can be analyzed using a probabilistic model, giving the survival probability of restorations.

Restorations under the cyclic loads experience tensile stresses at the interface to cause debonding.[16] In the present study, Cention N displayed significantly more resistance to cyclic loads prior to its separation at each loading force applied compared to GIC ($p < 0.001$). As the loading force was increased from 200–600 N, a substantial decrease in the number of resisted endured cycles was observed for both the materials (Fig. 4). The result can be extrapolated to clinical conditions where it can be perceived that Cention N is superior to conventional GIC for the restorations of primary molars, however, it cannot withstand a high level of masticatory force for a prolonged period of time. A smaller particle size (0.1–7 micron) of inorganic filler in Cention N compared to conventional restorative GIC (15–50 micron)[11] resulting in deeper penetration of the material into the dentinal tubules and uniform cement adaptability along the bonded interface might have resulted in higher bond strength of the experimental material, thereby revealing a higher fatigue strength.[17–20] Besides the low volumetric shrinkage observed in Cention N as claimed by the manufacturer, which acts as a shrinkage stress reliever, organic/inorganic ratio and the monomer composition of the material could also be attributed to exhibiting higher fatigue strength over GIC.[11]

The result of the present experiment can be co-related with the result of studies carried out on the microleakage where Cention N exhibited the least microleakage in comparison to GIC[21–23] and on flexural strength where Cention N displayed less flexural strength than composite but higher than silver amalgam and GIC.[24] Additionally, like GIC cement, Cention N also can prevent demineralization of the adjacent enamel due to the presence of its alkaline filler particles, which during acid attack, release hydroxide ions to regulate pH value.

Mechanical properties of Cention N, as reported by various authors, are significantly high compared to conventional GIC and can be comparable with nanocomposites and amalgam.[25,26] In a similar fashion, Cention N in the present study also displayed better adhesive bond strength to cavity walls of nonretentive form than GIC, still not sufficient enough to withstand a higher range of fatigue force for a longer duration. Therefore, a retentive cavity design or application of dentin-enamel adhesive, as suggested by the manufacturer, is recommended.

Conclusion

Based on the results of this *in vitro* study, a conclusion can be drawn that Cention N is a preferred material of choice over conventional

Table 2: Comparison of the mean values of number of endured cycles sustained by GIC and Cention N at each loading force using independent *t*-test

Load (N)	*Groups*	*Mean ± SD*	*Standard error*	*(95% confidence interval)*	*Mean difference*	*p-value*
200	GIC (*n* = 6)	34,333.33 ± 6,713.17	2,740.64	27,288.29 41,378.37	–59,666.67	0.0000
	Cention N (*n* = 6)	94,000 ± 10,954.45	4,472.14	82,504.01 105,496		
300	GIC (*n* = 6)	4,500 ± 547.72	223.61	3,925.2 5,074.8	–15,000	0.0000
	Cention N (*n* = 6)	19,500 ± 5,357.24	2,187.08	13,877.92 25,122.08		
400	GIC (*n* = 6)	541.67 ± 190.81	77.91	341.40 741.93	–5,125	0.0000
	Cention N (*n* = 6)	5,666.66 ± 816.50	333.33	4,809.81 6,523.53		
500	GIC (*n* = 6)	11.33 ± 2.94	1.20	8.24 14.42	–58.66,667	0.0000
	Cention N (*n* = 6)	70 ± 17.89	7.30	51.23 88.77		
600	GIC (*n* = 6)	7.83 ± 1.33	0.54	6.44 9.23	–33.83,333	0.0090
	Cention N (*n* = 6)	41.66 ± 25.63	10.46	14.77 68.57		

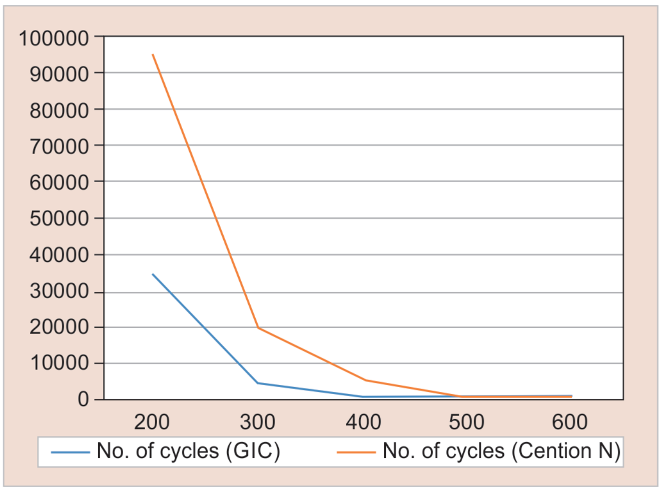

Fig. 4: Graph showing mean number of cycles resisted by GIC and Cention N at different load point prior to their separation.

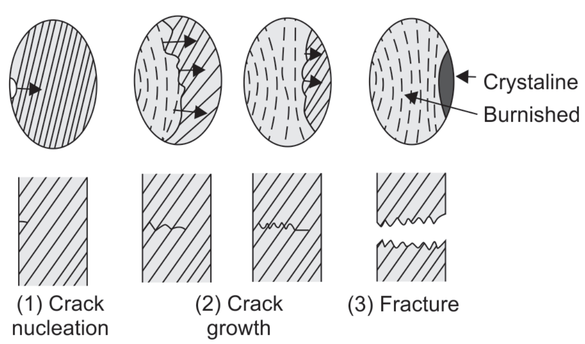

Fig. 5: Stages of fatigue failure

GIC for the restoration of nonretentive proximal cavities in primary molars. However, as the adhesive strength was not sufficient enough to withstand the cyclic loads higher than masticatory forces for a prolonged period, a proper retentive form in the cavity design, as suggested by the manufacturer, is recommended. Also, to confirm the findings of this *in vitro* study, multicentric *in vivo* studies need to be carried out.

Limitations

Although a retentive cavity design (application of bonding agent) is recommended by the manufacturer of Cention N, it was not followed in the present study. With the preparation of a retentive cavity design, Cention N is expected to sustain a higher number of the endured cycles under accelerating load. The present study was conducted in a dry testing environment. Therefore, further *in vitro* studies need to be conducted to evaluate the fatigue strength of Cention N and GIC under an aqueous environment to simulate the oral cavity.

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