ORIGINAL RESEARCH PAPER
Volume - 10 | Issue - 02 | February - 2021 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

COMPARATIVE EVALUATION OF MICROTENSILE BOND STRENGTH OF NANOHYBRID AND ALKASITE COMPOSITE IN CLASS II CAVITIES WITH CERVICAL MARGIN ON CEMENTUM : AN IN VITRO STUDY.

Dental Science

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ABSTRACT

AIM: To evaluate the microtensile bond strength (µTBS) of nanohybrid and alkasite composite for different depths of Class II cavities with cervical margins in cementum. **MATERIALS AND METHODS:** Standardized conservative mesio - occlusal Class II cavities were prepared on forty four sound human maxillary premolars. The samples were randomly divided into two groups. Group I(n = 22) - Nanohybrid composite, Tetric N-Ceram and Group II(n = 22) - Alkasite composite, Cention N. They were further divided into two subgroups of (n = 11) samples each according to the different occluso-gingival heights: subgroup (A - 4 mm, B - 5 mm). The gingival margins for all the samples were located 1 mm below the cementoenamel junction. The restored samples were subjected to thermocycling (500 cycles) followed by µTBS testing. **RESULTS AND STATISTICAL ANALYSIS:** The scores were statistically analyzed using Independent t-test and multiple correlation matrix. Highest mean value of µTBS was seen in group II-B followed by group II-A, group I-B and group I-A. Cention N revealed superior microtensile bond strength values than Tetric N-Ceram at both 5 mm and 4 mm depths. Both Cention N and Tetric N-Ceram exhibited higher µTBS values at 5 mm depth when compared to their corresponding 4 mm depth. **CONCLUSION:** Cention N has higher microtensile bond strength than Tetric N-Ceram. There was an increase in the microtensile bond strength with proportional increase in the depth of the cavity.

KEYWORDS

Alkasite Material, Cention N, Microtensile Bond Strength, Nanohybrid Composite, Tetric N-Ceram, Thermocycling.

INTRODUCTION

Incremental insertion techniques of composites are recommended to reduce the undesirable effects of polymerization shrinkage by decreasing C-factor (ratio of bonded to unbonded surfaces)[1]. However, it is time consuming, cause incorporation of voids or contaminants between composite layers[2] and increased deformation of restored tooth[3]. To overcome these shortcomings, bulk fill composites have been introduced.

Dentists have long sought after a real alternative to Amalgam or Glass ionomer cements – a cost effective fluoride releasing product that is quick and easy to use without complicated equipment and that offers both strength and good esthetics. One such material is Cention N. Its an "alkasite" restorative. Alkasite refers to a new category of filling material, which like compomer or ormocer materials is essentially a subgroup of the composite material class. This new category utilizes an alkaline filler, capable of releasing acid-neutralizing ions. Cention N is a tooth coloured, basic filling material for direct restorations. It is self curing with optional additional light curing. Cention N is available in the tooth shade A2. It is radiopaque, and releases fluoride, calcium and hydroxide ions. As a dual cured material it can be used as a full volume (bulk) replacement material. Optional light curing is carried out with blue light in the wavelength range of approximately 400 – 500 nm.

Tetric N-Ceram Bulk Fill is a light cured, hybrid composite for direct restorations (Class I and II) in posterior teeth, for Class V restorations, extended fissure sealing in molars and premolars and for reconstructive build up. Tetric N-Ceram Bulk Fill can be applied in "bulk" increments of up to 4 mm without any adverse effect on the material's polymerisation behaviour or mechanical properties. It can be cured with conventional LED curing lights and also in just 10 seconds using a light source with > 800 mWcm^2 (Ivoclar Bluephase N).

Adhesion property of the newly introduced composite is evaluated by calculating microtensile bond strength and its value as compared to conventionally used Tetric N- Ceram bulk filled composite. Microtensile bond strength evaluation reduces the non uniform stress distribution on adhesive interface and has made possible the evaluation of several clinically relevant substrates and conditions. Adhesion is an important property of all restorative materials in which if it fails can affect the prognosis of the treatment procedure. Hence aim of the current study was to compare adhesiveness of newly marketed resin material Cention N Vs Conventionally used bulk fill composite Tetric N-Ceram.

MATERIALS AND METHODS

Freshly extracted 44 sound maxillary premolars, free of any developmental anomalies were selected and mounted in self cure acrylic resin. Standardized conservative mesio -occlusal Class II cavities were prepared on each tooth with buccolingual width of 4 mm and axial wall depth of 2 mm in dentin using no: 245 burs in a water cooled high speed turbine. The samples were randomly divided into two groups (n = 22) according to the type of restorative material used: Group I -Nanohybrid composite, Tetric N- Ceram and Group II - Alkasite composite, Cention N.

Occlusal enamel of Class II cavities were abraded with 600 grit Silicone Carbide paper to obtain different occluso - gingival heights (4 mm -subgroup A, 5 mm -subgroup B), keeping the gingival margins 1 mm below the cemento-enamel junction (CEJ) for all the samples, so as to have a standardized substrate for different occluso-gingival depths. In each subgroup, there would be eleven samples and Mylar strips fixed around each sample while restoring them. In Group I, the dentinal surfaces of the specimen's cavity were etched with 37% phosphoric acid for 15 seconds followed by cleaning with gentle water spray for 10 seconds. Tetric N bond Universal bonding agent(6th Generation) was applied to etch dentin surface according to manufacturer's instructions. The adhesive was cured for 20 seconds with a LED light curing unit. The cavities were restored with nano hybrid

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

composite, Tetric N-Ceram and polymerized for 40 seconds using LED. In Group II, after completion of the bonding protocol as in the first group, the specimen's cavities were filled with the alkasite composite, Cention N and light cured as in Group 1. Since manufacturer did not recommend any specific etchant, bonding agent or light curing unit, those recommended by Ivoclar for their other available composites were used in the study. On mixing a smooth homogeneous mix was obtained which could be placed with ease using a Teflon coated instrument and was not too sticky. LED curing unit used presented a broad spectrum activity, which allowed efficient activation of different photoinitiators. In addition, they displayed better depth of cure, marginal adaptation, and interfacial integrity.

The samples were stored in moist conditions for 24 hours at 37°C and then subjected to thermocycling of 500 cycles with the temperature varying from 5°C to 55°C, dwell time of 15 seconds and an interval time of 10 seconds each. After collecting the teeth samples they were stored in distilled water till the start of the study to keep the dentin hydrated. Moreover the depth of dentin was standardised to have sufficient exposed dentin for the study. Dentin surface polishing was done using 600 grit sand paper as mentioned in previous literatures to obtain a smooth polished surface[5]. To embed these samples in auto polymerising acrylic resins, custom made moulds were made, so that all the external walls should be straight without any irregularities. Acrylic resin was poured keeping voids to a minimum and then this set resin surface was polished, preventing surface irregularities since it will affect the stability of the samples when they are placed in Universal testing machine during testing (Fig 1).

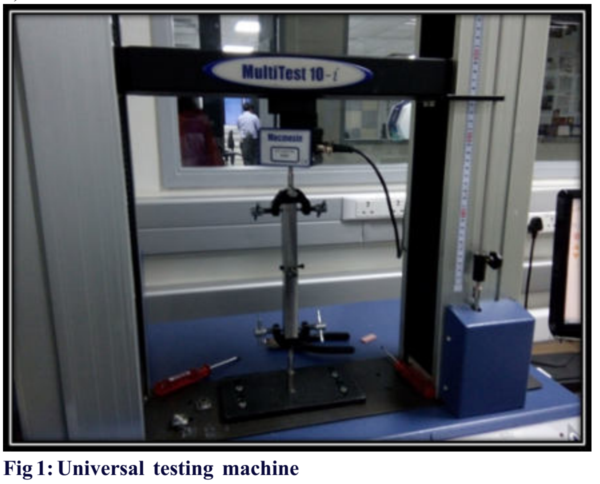

Fig 1: Universal testing machine

The restored specimens were serially sectioned creating approximately 1 mm thick slabs. Each slab was trimmed from cemental and dentinal sides to obtain dentin restoration interface that had a bonded surface area of approximately 0.9 mm^2. Two sticks were obtained from each restoration; therefore, twenty two specimens were evaluated in each subgroup. The microtensile bond strength was evaluated at a cross-head speed of 0.5 mm/min until debonding at the dentin adhesive interface occurred. The maximum force at which debonding occurred was measured. Microtensile bond strength was calculated in Mega pascals by dividing the maximum force by the cross-sectional area of the bonding surface for each specimen.

RESULTS

Results obtained by means of universal testing machine for all 11 samples in each subgroup are given below (Table 1).

Table 1: Microtensile bond strength of samples in Mpa

Group I-A 4mm (Tetric N-Ceram)	Group I-B 5mm (Tetric N-Ceram)	Group II-A 4mm (Cention N)	Group II-B 5mm (Cention N)
35	36	39	43
36	37	40	45
34	38	43	44
37	32	38	46
32	39	42	48
33	37	44	47
34	39	46	45
35	38	45	44
36	34	43	46
33	38	42	45
38	35	39	44

Statistical analysis

Statistical analysis was done using Independent t-test and multiple correlation matrix.

Table 2: Independent t test for Groups I-A & I-B

Hypothesis Test: Independent Groups (t-test, pooled variance)		
4mm Group I-A (TETRIC N CERAM)	5mm Group I-B (TETRIC N CERAM)	
34.82	36.64	mean
1.83	2.2	std. dev.
11	11	n

Where,	
20	df
-1.818	difference
4.109	pooled variance
2.027	pooled std. dev.
0.864	standard error of difference
0	hypothesized difference
-2.104	t
0.0483	p-value (two-tailed)

Graph 1: Mean and standard deviation of Groups I-A & I-B

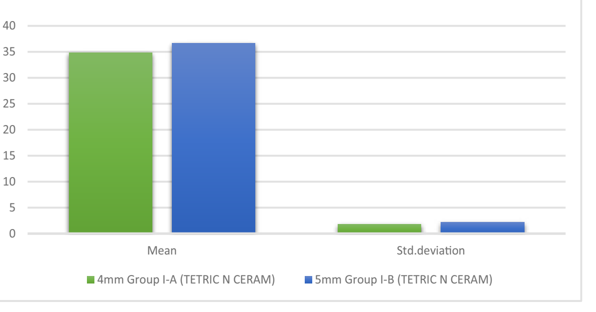

Table 3: Independent t test for Groups II-A & II-B

Hypothesis Test: Independent Groups (t-test, pooled variance)		
4mm Group II-A (CENTION N)	5mm Group II-B (CENTION N)	
41.91	45.18	mean
2.63	1.47	std. dev.
11	11	n

Where,	
20	df
-3.273	difference
4.527	pooled variance
2.128	pooled std. dev.
0.907	standard error of difference
0	hypothesized difference
-3.607	t
.0018	p-value (two-tailed)

Graph 2: Mean and standard deviation of Groups II-A & II-B

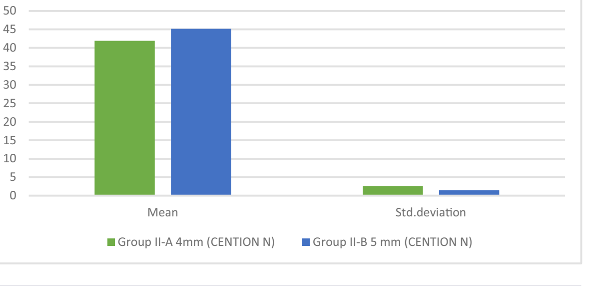

Table 4: Independent t test for Groups I-A & II-A

Hypothesis Test: Independent Groups (t-test, pooled variance)		
4mm Group I-A (TETRIC N CERAM)	Group II-A 4mm (CENTION N)	
34.82	41.91	mean
1.83	2.63	std. dev.
11	11	n

Where,	
20	df
-7.091	difference
5.127	pooled variance
2.264	pooled std. dev.
0.966	standard error of difference
0	hypothesized difference
-7.344	t
4.26E-07	p-value (two-tailed)

Graph 3: Mean and standard deviation of Groups I -A & II-A

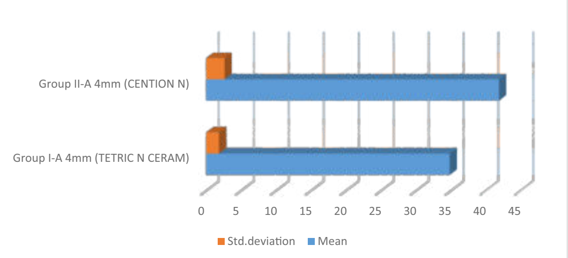

Table 5: Independent t test for Groups I-B & II-B

Hypothesis Test: Independent Groups (t-test, pooled variance)		
Group I-B 5mm (TETRIC N CERAM)	Group II-B 5 mm (CENTION N)	
36.64	45.18	mean
2.20	1.47	std. dev.
11	11	n

Where,	
20	df
-8.545	difference
3.509	pooled variance
1.873	pooled std. dev.
0.799	standard error of difference
0	hypothesized difference
-10.698	t
0.000	p-value (two-tailed)

Graph 4: Mean and standard deviation of Groups I-B & II -B

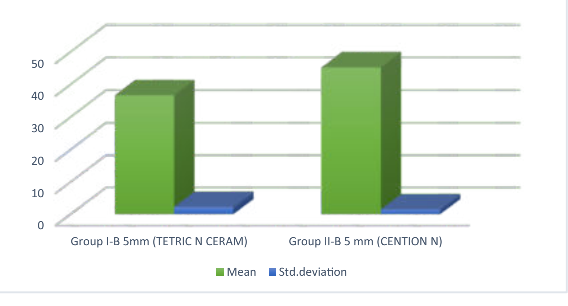

Table 6: Correlation Matrix of Groups I-A, I-B, II-A and II-B.

	4mm Group I-A (TETRIC N CERAM)	*5mm Group I-B (TETRIC N CERAM)*	*Group II-A 4mm (CENTION N)*	*Group II-B 5 mm (CENTION N)*
4mm Group I-A (TETRIC N CERAM)	1.000			
5mm Group I-B (TETRIC N CERAM)	-.760	1.000		
Group II-A 4mm (CENTION N)	-.565	.651	1.000	
Group II-B 5 mm (CENTION N)	-.431	.022	.160	1.000

where,	
11	sample size
± .602	critical value .05 (two-tail)
± .735	critical value .01 (two-tail)

Graph 5: Correlation Matrix of Groups I-A, I-B, II-A and II-B

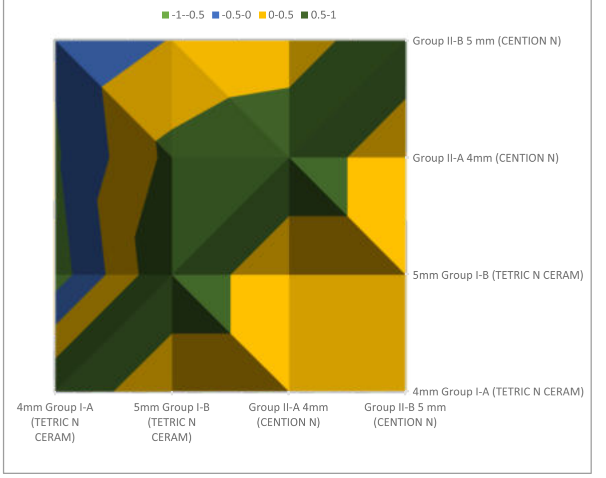

Table 2 shows mean and standard deviation of microtensile bond strength values of Tetric N-Ceram at different depths (4mm and 5mm). A sample of 11 teeth were considered for each group and first group is having 4mm depth and second group having 5 mm depth. Independent sample t test was applied to examine the microtensile bond strength. With regard to Tetric N-Ceram (4mm) the mean value obtained is 34.82 ± 1.83 MPa and the mean value for Tetric N Ceram (5mm) is 36.64 ± 2.2 MPa. The standard error difference is 0.864 which is found low in the group.

As per the independent sample t test, the t test value is -2.104 and the p value obtained is 0.0483 (p value lower than the level of significance of 5%); the result is showing significance. This implies there is significant difference in the microtensile bond strength between the two sub groups having different depths. Since it statistically proved significant, an attempt is further made to examine the group which is favourable to the microtensile bond strength. 5mm group of Tetric N-Ceram is having higher microtensile bond strength when compared with 4 mm, based on the mean value.

Similarly, there was statistically significant difference among all the groups compared and the highest mean value of microtensile bond strength was seen in Cention N (5mm) followed by Cention N (4mm), Tetric N-Ceram (5mm) and Tetric N-Ceram (4mm).

Cention N (5mm) : 45.18 ± 1.47 MPa
Cention N (4mm) : 41.91 ± 2.63 MPa
Tetric N Ceram (5mm) : 36.64 ± 2.20 MPa
Tetric N Ceram (4mm) : 34.82 ± 1.83 MPa

Further an attempt was made to examine the relationship between the materials. From the study it is clear that there is high negative correlation between Group I-B (Tetric N-Ceram 5mm) with Group I-A (Tetric N-Ceram 4mm). The correlation is -0.760.

Similarly there is moderate correlation between Group II-A (Cention N 4mm) and Group I-B (Tetric N-Ceram 5mm). The correlation is 0.651. All other relations are found not significant.

DISCUSSION

The current study compared the adhesion to dentin of the newly introduced Alkasite material called Cention N versus the conventionally used Tetric N Ceram bulk fill composite. Cention N obtained the highest mean value of 45.18 which was found to be statistically significant when compared to Tetric N –Ceram whose mean value was 36.64. Also the 5mm subgroup showed significantly higher bond strength values than 4mm subgroup in both the groups. This can be attributed to increase in the bonding surface area and retention, with increase in depth of the cavity. To conduct the study maxillary premolars were taken as sample tooth because of the better availability of the intact tooth following orthodontic extraction and also due to the sufficient bonding area availability when compared to lower premolars. Current study considers bonding to only dentin which has a heterogeneous surface. It consists of dentinal tubules containing odontoblastic processes with approximately 30% volume of organic matter and lower surface energy. All this makes bonding to dentin a more complicated procedure[4].

Since the process of mastication is one of indentation, basically related to shearing and tensile phenomenon, the microtensile bond strength is one of the main factors which depicts the true nature of adhesive strength of materials at the interface and is thus considered as an important parameter of any restorative material. The quality and efficacy of bonding of these adhesive materials is reflected in their mode of failure[5]. Failures within the dentin or restoration was considered as cohesive. Those in tooth-restoration interface was considered adhesive and where both these failures are present was considered as mixed. The number of cohesive failures within the dentinal substrates increases with increasing bond strengths and in the present study Cention N had the highest number of cohesive failure in dentin among the study materials.

While testing, the upper grip was fixed at the junction between dentin surface and restorative material in such a way that force is not applied on the dentin but on the restorative material. When the experiment started the monitor showed the progressively increasing force being applied on the specimen, till it reaches the breaking point, where the material detaches from the dentin surface. In the majority of cases the restorative material fully detached from the dentin surface (adhesive failure). In few samples some restorative material was left behind showing that the fracture may have occurred within the restorative material also (mixed failure). Rare incidence of detachment of the dentin layer carrying restorative material en mass was also observed (cohesive failure).

The essence of the microtensile test is the division of resin bonded teeth in to slabs between 0.5 and 1.0 mm thickness that are then trimmed in such a manner that tensile force will be concentrated on the bonded interface during testing. Among the many advantages of the technique are that each tooth produces multiple specimens. Further, there is no need for a matrix to limit the bonded surface area, since the area is determined by the dimensions of the trimmed specimens. It is more labour intensive than conventional testing, but holds great potential for providing insight into the strength of adhesion of restorative materials to clinically relevant sites and substrates[6]. Microtensile bond testing was originally designed to permit evaluation of bond strengths between adhesive materials and small regions of dental tissue (eg, occlusal vs middle vs cervical third of enamel, normal vs adjacent caries affected dentin, occlusal vs gingival walls of Class V wedge shaped lesions)[7,8,9]. This technique is ideal for evaluating the long term durability of resin - hard tissue bonds and offers versatility that cannot be achieved by conventional methods.

To avoid cohesive failures of dentin during bond testing, it is necessary to improve stress distributions during testing. This can be accomplished by the single plane lap-shear system, or by the microtensile bond testing method used in this study. Both methods tend to lower the variance associated with testing to 10% to 25%, instead of the more common 30% to 50% variance seen in conventional testing. Both methods have been used to evaluate regional differences in the strength of dentin or resin-dentin bonds, although this is more easily accomplished with the microtensile method. Regional differences in resin-dentin bond strength have been reported, indicating that these differences are greater than tooth-to-tooth variations[10]. In some parts of the world, it is difficult to obtain extracted teeth, especially intact premolars and third molars. This method permits multiple specimens to be prepared from each tooth. Thus, there is a trade-off between the extra labor involved in using this method, and the extra data that can be obtained per tooth. Using this method often results in higher apparent bond strengths at failure than are found using large specimens[11]. Since the introduction of the technique, numerous modifications have been made so that investigators can select the modification that best suits their testing needs[12]. In 1991, the International Organisation for Standardisation (ISO) published guidelines for adhesion to tooth structure, both tensile and shear tests were described as ideal testing methods[13]. Alternative methods of testing bond strength have also been developed including quantitative margin analysis, extrusion test, and the fracture toughness test. All these methods are significantly more time consuming and technically demanding than the micro tensile test, and none has yet demonstrated an improved association with clinical findings[14]. Hence in the present study, micro tensile bond testing was considered for testing adhesion.

Ferracane stated that insufficient polymerisation may lead to a decrease in the physical/mechanical and biological properties of resin composites[15]. Cention N is a dual cured cement and hence the unreachable areas inside the chemically set cement can be approached by the curing light which improves the mechanical property. The lower translucency may be related to the used alkaline fillers that induce a higher filler/ resin refractive index mismatch[16]. Mithra Hegde postulated that minimum bond strength of 17- 20 MPa is needed to resist contraction forces of resin composite materials for enamel and dentin. Cention N used in the present study had higher bond strength of 45.18 MPa which satisfies the minimum criteria for adhesion of composite resins. Total etch technique is being used by newer Cention N which seems to have better bonding than self etching adhesives, where later is inferior because of their semi permeability, incorporation of smear layer, shorter resin tag formation, residual acidity and hydrolytic instability.

Cention N was supplied in powder and liquid form, and needed mixing of the components as per manufacturer's instructions. Thus the manipulation is more time consuming when compared to Tetric N-Ceram, when used with etchants and bonding agents. But if this material is to be placed in cavities with retentive undercuts it is claimed that there is no need for applying etchant and bonding agent which will make it less technique sensitive like glass ionomer cement and amalgam. But since the standard protocol for measurement of microtensile bond strength advocates placement of material on flat dentin surface, there is no retentive element involved and etching and bonding becomes essential. There was no fear of bulk placement because this material had inherent self curing property as per manufacturer.

Since the main highlight of the new material was its less technique sensitivity, fluoride release, ease of use in geriatric and pediatric patients and the manufacturer's claim that it may be a replacement of age old practice of using amalgam and glass ionomer in conservative Class 1 and Class 2 restorations, in this study an attempt was made to compare Cention N and conventionally used Tetric N-Ceram in terms of microtensile bond strength as the primary criteria. Though there is no clear correlation between in vitro and in vivo retention, it can be assumed that if a restorative material exhibits lower bond strength under ideal laboratory test conditions, it is very likely that it may not be retained successfully in the oral environment and thus additional need for retention be thought of when applying clinically. Being an in vitro study, the intra oral conditions cannot be exactly simulated. Further research need to be done for thorough analysis of all important parameters of Cention N and to make full use of the material.

CONCLUSION

Among the two different bulk fill composites, Cention N demonstrated higher μTBS than Tetric N-Ceram. Both Alkasite composite Cention N and Nanohybrid composite Tetric N-Ceram exhibited higher values at 5mm depth when compared to their corresponding 4mm depth. There was an increase in microtensile bond strength with increase in the depth of the cavity. In vivo studies needs to be done to correlate the findings of present study to routine clinical situations.

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