Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/18430
DOI URL: http://dx.doi.org/10.21474/IJAR01/18430

RESEARCH ARTICLE

EVALUATION OF BOND STRENGTH OF NEWER BONDING AGENTS TO HUMAN DENTIN AFTER SIX MONTHS OF STORAGE; AN ANALYTIC STUDY

Anas Kallayil, Faseela Thenukutty, Kartik Salaria, Shweta Verma, Munish Goel and Aryman Dogra
Conservative Dentistry & Endodontics Himachal Pradesh India.

Manuscript Info

Manuscript History
Received: 15 January 2024
Final Accepted: 17 February 2024
Published: March 2024

Key words:-
Bonding Agents, Adhesive Dentistry, Composite Resin

Abstract

Introduction: Among various materials, composite resins have been developed in order to provide the best aesthetics to the anterior restorations as well as for posterior restorations. Resin-dentin bonds are more difficult to achieve than resin-enamel bonds, because dentin bonding relies on organic components.

Materials & Methodology: A total number of 44 extracted human mandibular premolars were collected. Occlusal enamel surface was removed using an airotor and diamond bur.The collected 44 teeth were divided in to four groups according to the bonding agents used. 1st sub group with five teeth that is submitted for microtensile testing within 24 hours and SEM analysis for failure mode, 2nd sub-group contains five teeth which is submitted to microtensile bond strength after six months of storage in normal saline and thereafter for SEM analysis for failure mode, and the 3rd sub-group with one teeth which is prepared for analyzing the bond interface using SEM

Results: Summarized data was presented using Tables. Data was normally distributed as tested using the Shaperio-Wilk W test (p-value was less than 0.05). Therefore, analysis was performed using the parametric tests i.e. Independent‘t’ test (for comparing two groups) and One way Anova test (for comparing more than two groups). Level of statistical significance was set at p-value less than 0.05.

Conclusion:The lowest bond strength values both at 24 hours and after 6 months in normal saline due to its solvent system (acetone, ethanol, water), which might not create a stable adhesive layer like other agents. Optimal filler load could also reduce bond strength by limiting resin availability. SEM analysis revealed that fewer resin tags, indicating incomplete penetration into dentinal tubules, resulting in weaker bonding and susceptibility to degradation. Adhesive failures indicating poor adhesion at the dentin interface, while mixed failures suggested inadequate bonding with the composite resin. This underscores the importance of refining bonding agent formulations and application techniques to ensure enduring adhesive bonds in restorative dentistry.

Corresponding Author:- Anas Kallayil
Address:- Conservative Dentistry & Endodontics Himachal Pradesh India.

Introduction:-

In dentistry various adhesive restorative materials are used for the restoration. Among various materials, composite resins have been developed in order to provide the best aesthetics[1]. One of the challenges in dentistry is bonding restorative materials to different substrates such as enamel and dentin[2]. Bonding to dental enamel is considered effective and usually presents high bond strength values. Resin-dentin bonds are more difficult to achieve than resin-enamel bonds, because dentin bonding relies on organic components[3].

The longevity of adhesive restoration based on the durability of the adhesive bond between resin and tooth structure. Cyclic masticatory function and saliva in oral environment may fatigue the integrity of resin-tooth bonds, thereby permitting micro- or nanoleakage. This decrease in bonding effectiveness with time might be explained by degradation of interface components by water storage. Water sorption can decrease the mechanical properties, swelling of interface and leaching effect of break-down products. This passive hydrolysis and leaching effect is the most important mode of degradation of resin-dentin bond over time[4]. Microtensile bond strength test (μTBS) has a greater discriminative capability than the traditional macro-shear bond test and considered as a versatile and standard bond strength testing method[5].

In the present study, evaluation of μTBS of newer 7th generation bonding was agent done. 7thgeneration bonding agents are self-etch adhesives. Parallel to the evaluation of bond strength, the scanning electron microscopy (SEM) has been used to evaluate the interfaces between different restorative materials and the dental substrates. In the case of adhesive systems applied to dentin, the SEM image allows to analyze the morphology of the hybrid layer obtained with different adhesive systems, as well as the resin tags.

Subjects and Methods:-

The present study comparatively evaluated newer bonding agents namely Kerr OptiBond All-in-One(OAO), Prevest DenPro Fusion Bond 7 (FB7), Ivoclar Vivadent Tetric N-Bond Universal (TNBU), and Medicept Dental Bond Plus SE(BPSE) for their μTBS to human dentin after 24 hours and six month storage. Also their bond surface analysis was carried out using SEM.

Materials and Methods:-

A total number of 44 extracted human mandibular premolars were collected. Occlusal enamel surface was removed using an airotor and diamond bur (figure 1a). The remainder of the enamel was removed using 400- grit silicon carbide abrasive paper (figure 1 b). The superficial dentin was exposed and finished with 1000-grit silicon carbide abrasive paper and a flat surface was obtained (figure 1 c).

The collected teeth were divided in to 4 groups according to the bonding agents used (Table 1). Each main group contains 11 teeth. After the bonding procedures all 4 main groups again divided to 3 sub-groups i.e. 1st sub group with 5 teeth that is submitted for microtensile testing within 24 hours and SEM analysis for failure mode, 2nd sub-group contains 5 teeth which is submitted to microtensile bond strength after 6 months of storage in normal saline and thereafter for SEM analysis for failure mode, and the 3rd sub-group with 1 tooth which is prepared for analyzing the bond interface using SEM (Table 2).

Table 1:- Adhesives used in this study.

Material	Composition	Manufacturer
Group 1 OAO	Glycerol phosphate dimethacrylate, mono- and di-functional methacrylate monomers, Water, Acetone, Ethanol, Camphoroquinone, Three nano-sized fillers, Sodium hexaflourosilicate, Yterbium flouride	Kerr
Group 2 FB7	Hema phosphate, Urethane dimethacrylate, Triethylene glycol dimethacrylate, Bisphenol a diglycidyl methacrylate, 2-hydroxy ethyl methacrylate, Adhesive acidic monomer, Curing initiators, Stabilizer and nano colloidal silica in: · Teritery butanol · Ethanol · Water base	PREVEST DenPro

Group 3 TNBU	2-hydroxy ethyl methacrylate, Bis-GMA, HEMA, UDMA,Ethanol, 1,10-decandiol dimethacrylate, Methacrylate phosphoric acid ester, Camphorquinone, 2-dimethaylaminoethyl methacrylate	Ivoclar Vivadent
Group 4 BPSE	Optimal filler load(15%), Uncured methacrylate resin, 0.4 micron barium glass, Acetone/Ethanol/ Water solvent	Medicept Dental

Table 2:- Group according to bonding agent used (n=11).

Sub-groups		
a n=5	b n=5	c n=1
Submitted to µTBS within 24 hour and then thereafter for SEM analysis	Submitted µTBSafter 6 months and then thereafter for SEM analysis	Prepared for bond interface analysis using SEM

The dentin surfaces in the respective four groups were subjected to bonding procedures as recommended by manufacturer. It is described in Table 3.

Table 3:- Bonding procedure.

Group 1 (n=11)	OAO was applied in self-etch mode; the adhesive was applied to the dentin with a micro brush and scrubbed for 20 seconds and then a second layer was applied with a brushing motion for 20 seconds, followed by gentle air drying for 5 seconds and light curing for 10 seconds.
Group 2 (n=11)	FB7 was applied in self-etch mode; the adhesive was applied to the dentin with a micro brush and scrubbed for 20 seconds and then a second layer was applied with a brushing motion for 20 seconds, followed by gentle air drying for 5 s and light curing for 20-30seconds.
Group 3 (n=11)	TNBU was applied in self-etch mode; the adhesive was applied to the dentin with a micro brush and scrubbed for 20 seconds, followed by gentle air drying for 5 secondsand light curing for 10 seconds.
Group 4 (n=11)	BPSE was applied in self-etch mode; the adhesive was applied to the dentin with a micro brush and scrubbed for 20 seconds and then a second layer was applied with a brushing motion for 20 seconds, followed by gentle air drying for 5 seconds and light curing for 10 seconds.

After the adhesive systems applied and cured, the surface of all prepared specimens were built up using three layers of GC Solare X (GC INDIA DENTAL), each layer was light cured for 40 seconds and composite resin to a height of 6 mm (figure 2).

The specimen sectioned in to 2 for µTBS. The roots of 20 specimens which are subjected to µTBS testing were mounted in self-cured acrylic resin (figure 3) according to the group. Samples which are subjected to bond interface analysis didn't mount with acrylic resin. 5 specimens from each adhesive group then stored for 24 hours at 37℃ in normal saline and the other 5 specimens were then stored for 6 months at 37℃ in normal saline. The saline was changed every week, and specimens were used within 6 months.

5 specimens from each group were submitted to µTBS test after 24 hours, and the other 5 specimens from each group were tested after 6 months of storage in normal saline at 37° C.

The specimens were fitted to the micro tensile-testing device for analysing (figure 4). This device had two stainless steel grips, which had a surface area of 8×10 mm and sliding shafts that prevent torsion movements during the tests. These shafts had a fixation screw that prevented the specimen from moving. From above a drill chuck used to hold the specimen. Drill chuck has three stainless steel grips, which hold the composite portion of the specimen tightly. The specimens were stressed at a crosshead speed of 0.5 mm/min until failure in a universal testing machine (H50K, Tinius Olsen India Pvt. Ltd., Noida, India) (figure 5) using a cell load of 50 N. The µTBS was expressed in MPa and derived by dividing the imposed force (N) at the time of fracture by the bond area (mm2). The values were obtained and subjected to statistical analysis.

The fractured surfaces of all specimens were observed by using scanning electron microscope (Nova Nano SEM-450 JFEI Company of USA (S.E.A) PTE LTD.) (figure 6). The failures wereclassified as adhesive (failure between adhesive and dentin), cohesive in adhesive (failure inside the adhesive), interfacial (adhesive and cohesive in adhesive), cohesive in dentin (failure inside the dentin), cohesive in composite resin (failure in composite resin), or mixed (two or more types of failure).

One tooth per group was sectioned perpendicular to the bonding surface using micromotor and handpiece (figure 7a & 7b). The bond interfaces were polished with 400-, 1000 grit silicon carbide abrasive papers and wetted with water using manual pressure (figure 8a & 8b). The specimens were then immersed in a hydrochloric acid solution (6 M HCl) for 2 min and then washed with normal saline. Shortly thereafter, the samples were deproteinized in a 1% sodium hypochlorite solution (NaOCl) for 10 min and washed in normal saline. The specimens were dried at room temperature for 7 days. The beams were gold-sputter coated (figure 9) and observed using scanning electronic microscope (figure 10). The bond interfaces of all the specimens were observed at 1.500× magnification. Representative images of each group were recorded and used to qualitatively describe the topography of the dentin/ adhesive interface.

Results and Observation:-

Summarized data was presented using Tables. Data was normally distributed as tested using the Shaperio-Wilk W test (p-value was less than 0.05). Therefore, analysis was performed using the parametric tests i.e. Independent‘t’ test (for comparing two groups) and One way Anova test (for comparing more than two groups). Level of statistical significance was set at p-value less than 0.05.

Table 4:- Comparison of mean microtensile bond strength values (MPa) for all 4 groups at 24 hours and after 6 months of storage in normal saline.

	Immediate (Tested after 24 hours)				**Delayed** (Tested after 6 months of storage)			
Sample No.	**Group 1**OAO	**Group 2**FB7	**Group 3**TNBU	**Group 4**BPSE	**Group 1** OAO	**Group 2**FB7	**Group 3**TNBU	**Group 4**BPSE
1	33.5	32.4	36.9	28.8	31.6	29.1	33.4	25.1
2	35.7	32.1	38.6	29.2	33.9	30.5	34.1	29.5
3	36.8	30.2	34.4	29.4	32.3	27	31.1	25.7
4	37.4	31.6	32.7	32.1	34.2	28.1	30.6	28.4
5	36.4	30.7	30.7	31.3	35.1	27.5	29.5	27.6
MEAN (MPa)	35.96	31.4	34.66	30.16	33.42	28.44	31.74	27.26
SD	1.507647	0.930054	3.167491	1.450172	1.434225	1.392121	1.939845	1.839293

As depicted in Table 4; microtensile bond strength analysis after 24 hours showed that **Group 1** (OAO) has the highest bond strength with a mean value of 35.96 MPa followed by **Group 3**(TNBU) with a mean value of 34.66 MPa and **Group 2** (FB7)with a mean value of 31.4 MPa. Least microtensile bond strength was shown by **Group 4** (BPSE) with a mean value of 30.16 MPa. Hence; the order of mean values of microtensile bond strength for different groups is **Group 1>Group 3>Group 2>Group 4**.

After 6 months of storage in normal saline; all the bonding agents showed a decrease in microtensile bond strength values. After 6 months of storage; the highest microtensile bond strength was shown by **Group 1** (OAO) with a

mean value of 33.42 MPa followed by **Group 3** (TNBU) with a mean value of 31.74 MPa and **Group 2** (FB7) with a mean value of 28.44 MPa. Least microtensile bond strength showed by **Group 4**(BPSE) with a mean value of 27.26 MPa. Hence; the order of mean values of microtensile bond strength after 6 months of storage in normal saline is **Group 1>Group 3>Group 2>Group 4.**

Table 5:- Intra-group comparison of mean microtensile bond strength values (MPa) obtained at 24 hours and 6 months of storage using paired 't' test. (a paired 't' Test, * Significance of relationship at $p < 0.05$).

	IMMEDIATE (24 hours)		**DELAYED (6 months)**		**T value**	**P value**
Groups	MEAN (MPa)	SD	MEAN (MPa)	SD		
Group 1 OAO	35.96	1.51	33.42	1.43	4.365	***.012****
Group 2 FB7	31.40	0.93	28.44	1.39	8.595	***.008****
Group 3 TNBU	34.66	3.17	31.74	1.94	5.080	***.007****
Group 4 BPSE	30.16	1.45	27.26	1.84	3.625	***.022****

As depicted in Table 5; for all the groups, microtensile bond strength values at 6 months were found to be significantly lower ($p < 0.05$) as compared to values at 24 hour testing.

Table 6:- Inter-group comparison of mean microtensile bond strength values (MPa) at 24 hours and 6 months using ONE WAY ANOVA test. (a ONE WAY ANOVA Test, * Significance of relationship at $p < 0.05$).

	IMMEDIATE (24 hours)		**DELAYED (6 months)**	
Groups	MEAN (MPa)	SD	MEAN (MPa)	SD
Group 1 OAO	35.96	1.51	33.42	1.43
Group 2 FB7	31.40	0.93	28.44	1.39
Group 3 TNBU	34.66	3.17	31.74	1.94
Group 4 BPSE	30.16	1.45	27.26	1.84
P VALUE	**0.001***		**0.001***	
POST HOC	G1> G2, G4 G3> G4		G1> G2, G4 G3> G2, G4	

A two-factor (2 × 2) Analysis of Variance was conducted to evaluate the influence of type of bonding agent used and duration of treatment on microtensile bond strength (μTBS)values (dependent variable) after 24 h and six months of storageamongst 4 groups**.** The two independent variables in this study are, type of bonding agent used and duration of treatment (Immediate: 24 hours and delayed: 6 months). The means and standard deviations as a function of the two factors are presented in Table 6.

As depicted in Table 6; inter group comparison of µTBS values (MPa) at 24 hours and 6 months was performed using POST HOC analysis. It was found that:

At 24 hours:
Group 1 (OAO) showed significantly higher µTBS values as compared to **Group 2** (FB7) and **Group 4** (BPSE), (p value 0.001). However, when compared with **Group 3** (TNBU) the results were statistically non- significant. Also, **Group 3**(TNBU) had significantly higher µTBS values when compared with **Group 4** (BPSE), (p value 0.001).

At 6 months of storage:
Group 1 (OAO) had significantly higher µTBS values in comparison with **Group 2** (FB7) and **Group 4** (BPSE), (p value 0.001). However, when compared with **Group 3** (TNBU) the results were statistically non- significant. Also, **Group 3**(TNBU) was significantly better than **Group 2** (FB7) and **Group 4** (BPSE), (p value 0.001). Amongst all bonding agents used in the study, **Group 4** (BPSE) had the least mean values for µTBS.

Analysis of type of failure in bonding agent
Fractured surfaces were observed under SEM (50 µm and 1500 × Magnification); to analyse the type of fracture in bonding agent after 24 hours as well as 6 months of storage in normal saline. Types of fractures found were Adhesive, Cohesive in Adhesive, Interfacial, Cohesive in Dentin, Cohesive in Composite Resin and Mixed.

Table 7:- Distribution of type of failures seen in fractured surfaces under SEM for all four groups.

		Adhesive		**Cohesive in Adhesive**		**Interfacial**		**Cohesive in Dentin**		**Cohesive in Composite Resin**		**Mixed**	
		N	%	N	%	N	%	N	%	N	%	N	%
24 HOUR	**GROUP 1** OAO	0	0	1	20	0	0	1	20	1	20	2	40
	GROUP 2 FB7	1	20	1	20	1	20	1	20	0	0	1	20
	GROUP 3 TNBU	0	0	1	20	0	0	2	40	0	0	2	40
	GROUP 4 BPSE	2	40	1	20	1	20	0	0	0	0	1	20
6 MONTHS	**GROUP 1** OAO	1	20	0	0	1	20	1	20	0	0	2	40
	GROUP 2 FB7	1	20	1	20	0	0	1	20	0	0	2	40

	GROUP 3 TNBU	1	20	0	0	0	0	2	40	0	0	2	40
	GROUP 4 BPSE	1	20	2	40	1	20	0	0	0	0	1	20

As depicted in Table 7;
For **Group 1** (OAO) most common mode of failures was **mixed**at both 24 hours i.e. 40 % (Figure 11) and at 6 months of storage i.e. 40 % (Figure 12). For **Group 2** (FB7) showed equal distribution of **adhesive, cohesive in adhesive, interfacial, cohesive in dentin** and **mixed** failure modes i.e. 20 % for each at 24 hour storage. The failures were predominantly **mixed** i.e. 40% at 6 months of storage (Figure 13). For **Group 3** (TNBU) most failures were **cohesive in dentin** i.e. 40% (Figure 14) and **mixed** i.e. 40% (Figure 15) at both 24 hours and as well as 6 months of storage. For **Group 4** (BPSE) most failures were in **adhesive** i.e. 40% (Figure 16) at 24 hour storage. However, the failures were predominantly **cohesive in adhesive** i.e. 40% (Figure 17) at 6 months of storage. (A- Adhesive, CR- Composite Resin, D- Dentin)

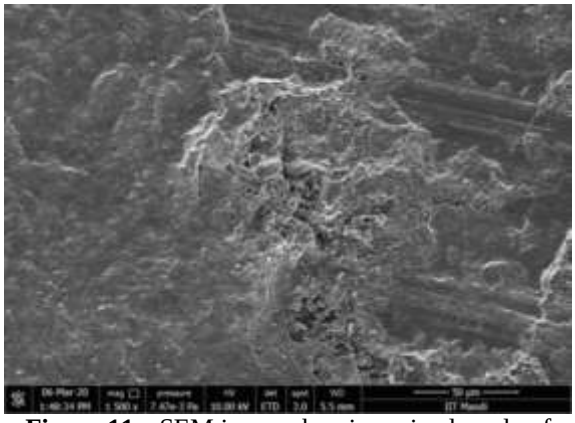

Figure 11:- SEM image showing mixed mode of failure at 24 hour.

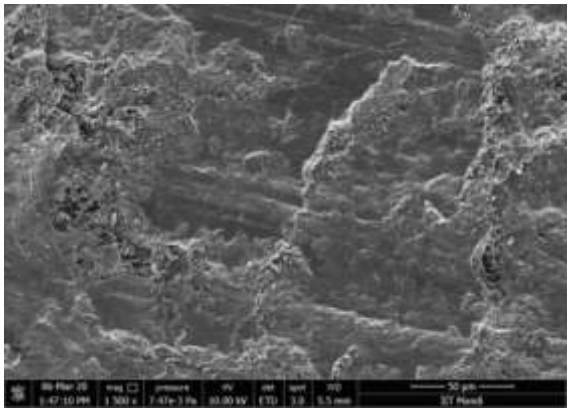

Figure 12:- SEM image showing mixed mode of failure at 6 months of storage.

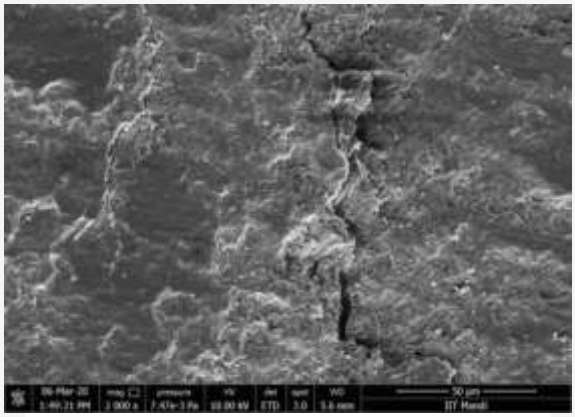

Figure 13:- SEM image showing mixed mode of failure after 6 months of storage.

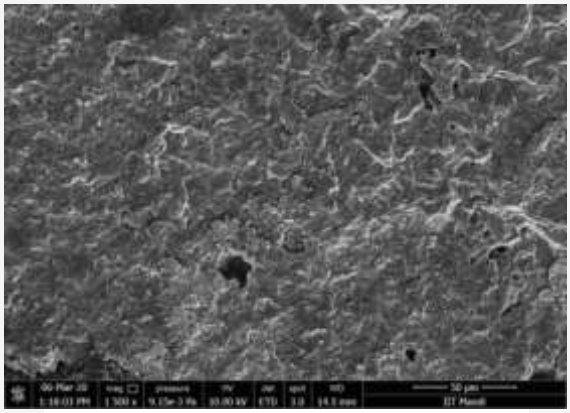

Figure 14:- SEM image showing cohesive in adhesive mode of failure.

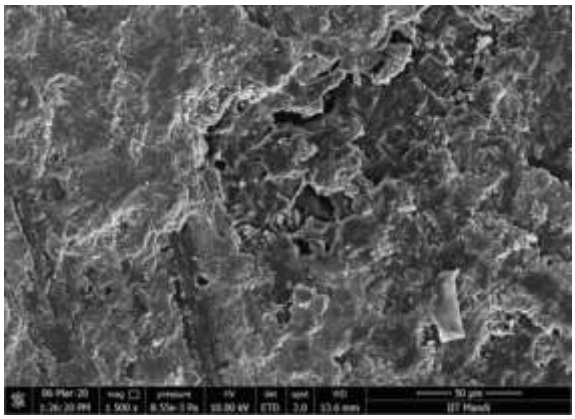

Figure 15:- SEM image showing mixed mode of failure.

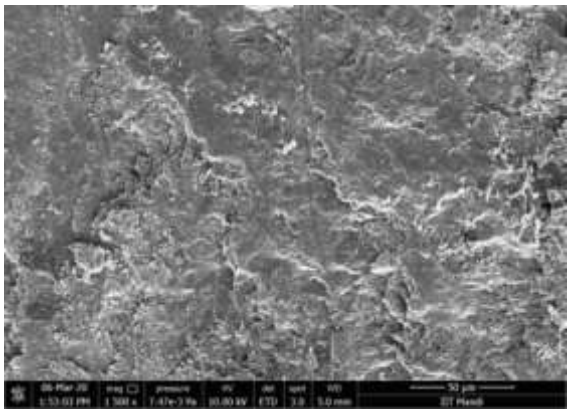

Figure 16:- SEM image showing adhesive mode of failure.

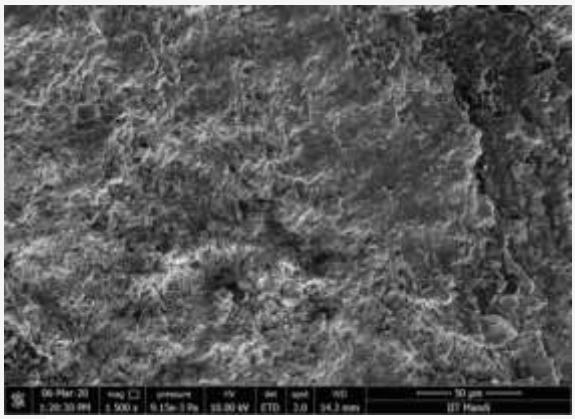

Figure 17:- SEM image showing cohesive in adhesive mode of failure.

The failure mode; cohesive in composite resin was absent in all the samples at 24 hours and 6 months storage except for **Group 1** (OAO) which showed this failure mode in 20% specimens at 24 hours testing.

Bond Interface Analysis using SEM (50 µm, 1500× Magnification)

When examining the bond interface using SEM, a thinner hybrid layer and fewer resin tags were noted in the all groups. **Group 1**(OAO) (Figure 18) illustrated a uniform hybrid layer and formation of resin tags. The junction between the adhesive and dentin appeared tight and continuous. **Group 2** (FB7) (Figure 19) illustrated a thinner and non-uniform hybrid layer and formation of less resin tags. The junction between the adhesive and dentin appeared irregular and non-continuous. **Group 3** (TNBU) (Figure 20) illustrated a thinner and irregular hybrid layer and formation of fewer resin tags. The junction between the adhesive and dentin appeared irregular. **Group 4** (BPSE) (Figure 21)illustrated a thinner and irregular hybrid layer and break in the continuity of hybrid layer. Group 4 formed fewer resin tags. The junction between the adhesive and dentin appeared irregular.

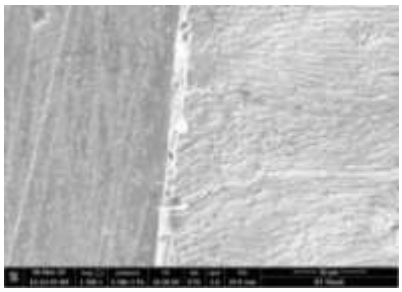

Figure 18:-

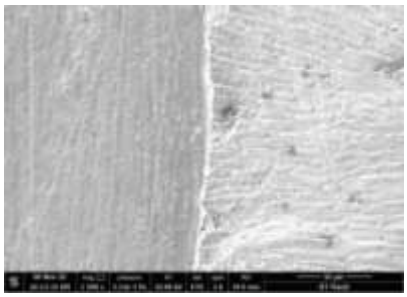

Figure 19:-

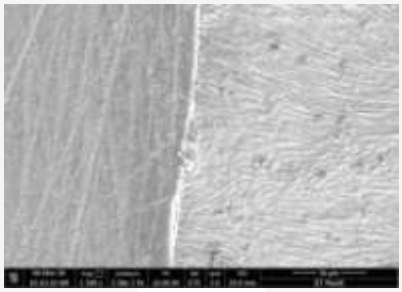

Figure 20:-

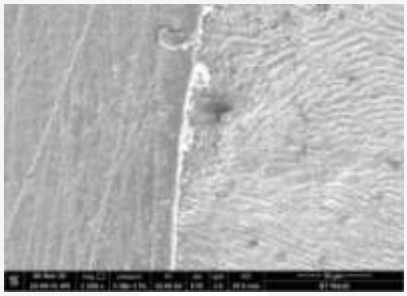

Figure 21:-

Discussion:-

In this study, OAO showed highest bond strength after 24 hour and 6 months of storage in normal saline. It's because OAO includes the ternary solvent system, which is comprised of three solvents- water, acetone and ethanol providing superior bonding as a result of more effective enamel etching[6].Adhesive material contains ethanol as a solvent, which favors its use in the wet bonding technique. A homogeneous adhesive layer maintains a uniform composition as solvents are removed during air drying. This reduces the chance for phase separation and bubble (void) formation known to occur in other brands. Monomer GPDM (glycerol phosphate dimethacrylate) adhesive coupled with ternary solvent system provides excellent adhesion to dentin[7]. Itcontains water as a solvent to promote wetting of the substrate and improve the homogeneity of the liquid. Hydrophilic monomers enhance the wettability and infiltration of the hydrophobic resin monomers into the demineralized dentin matrix[8].It is possible that the ternary solvent system provides enhanced self-life stability and effective bond strength.

The presence of acetone seems to help residual solvent and excess water removal following air-drying. Solvents and excess water need to be removed prior to or during monomer polymerization to obtain a pore free adhesive layer. Despite the presence of HEMA or hydrophilic groups in the final copolymer, reversible water uptake is inhibited by adequate crosslinking of the adhesive. Solvents are used to dissolve polar and non-polar components[9].

The high content of GDMA-P in OAO may render this solution a great capacity to demineralize the surface; this effect, however, could make it more difficult for the bonding resin to completely infiltrate the irregularities created on the dentin. Non-infiltrated areas may allow water to access the polymer thus enhancing the degradation of the bonding assembly during storage[10].

OAO has most failures were mixed at 24 hours and at 6 months of storage. In total 80% of were mixed failures. In terms of failure mode,higher bond strengths did correlate with greater mixed fractures or cohesive plus adhesive failure modes[11]. SEM images of the dentin- adhesive interface formed by OAO adhesive system illustrated a uniform hybrid layer and excellent penetration into dentinal tubules, forming resin tags. The junction between the adhesive and dentin appeared tight and continuous. This also contributed to the high bond strength.

FB7 has a pH of 1-2 and comes under intermediately strong self-etch. Such low pH self- etching adhesives have often been documented with rather low bond strength values, especially to dentine due to their initial high acidity that causes deep demineralization[12].At dentin, "strong self-etching" dissolves nearly all smear layer, but does not

remove the dissolved calcium phosphates. These embedded calcium phosphates seem to have low hydrolytic stability, with non-stable chemical interaction with the exposed collagen, thereby weakening the interfacial integrity, especially in a long-term[13].

SEM images of the dentin-adhesive interfaces formed by FB7adhesive system illustrated a thinner and non-uniform hybrid layer and formation of less resin tags. The junction between the adhesive and dentin appeared irregular and non-continuous.

Presence 10-Methacryloyloxydecyl dihydrogen phosphate-MDP in the TNBU adhesive had a significant effect on the microtensile bond strengths. The presence of methacrylate-modified poly alkenoic acid copolymer of the functional monomer is considered another factor that might positively influence the adhesive performance of these adhesives. This functional monomer forms a stable nano-layer together with a deposition of salts of MDP calcium at the adhesive interface, increasing the mechanical strength, and protecting against hydrolysis. Thus, it is known that this nano-layer interacts with the substrate, resulting in ”nanolayering” a process driven by the deposition of 10-MDP-Ca salts with low solubility[14].

Each nano-layer consists of two sub layers of parallel-oriented 10-MDP monomers, with opposite directionality. The 10- MDP methacrylate group is directed inwards, enabling mutual co-polymerization between the two opposed monomers. Its functional phosphate group is directed outwards, capturing calcium released from dentin due to the etching effect of 10-MDP. In this way, adjacent nano-layers are coupled[14]. When an MDP-containing universal adhesive was added to dentin with different degrees of relative humidity or even given saliva contamination, no significant change occurs in the bond strength[20]. This insensitivity to relative humidity and saliva contamination, no significant change occurs in the bond strength[14,15].

Higher hydrophilicity and lower degree of conversion were expected to render polymers with greater water sorption as observed in this work when comparing BisGMA to BisEMA-based polymers. BisGMAtends to suffer more degradation with decrease in mechanical properties in long term due to the higher water sorption[16].

TNBU has most failures were cohesive in dentin (40%) and mixed (40%) at 24 hour and at 6 months of storage. In total 80% failures were cohesive in dentin and mixed. SEM images of the dentin-adhesive interfaces formed by TNBUillustrated an irregular hybrid layer and forming fewer resin tags. The junction between the adhesive and dentin appeared irregular.

BPSE showed the least microtensile bond strength at 24 hours and after storage of 6 months in normal saline. BPSE contains uncured metacrylate resins in its composition. Water sorption and dissolution of the incompletely polymerized resin containing amphiphillicmonomers may result in deterioration of the one-step self-etch adhesive. In addition, the higher acidity and hydrophilicity of the acidic monomers increase the risk of hydrolytic action[4].

BPSE most failures were adhesive (40%) in 24 hour storage. Adhesive failures indicates low bond strength[17]. The failures were predominantly cohesive in adhesive (40%) at 6 months of storage. SEM images of the dentin-adhesive interfaces formed by BPSE adhesive system illustrated an irregular hybrid layer and forming fewer resin tags. The junction between the adhesive and dentin appeared irregular.

Figure Legends

Figure 1a, 1b & 1c: (1a) occlusal enamel removal using airotor and diamond bur. (1b & 1c) Polishing and removing remainder of enamel using 400 & 1000 grit abrasive paper

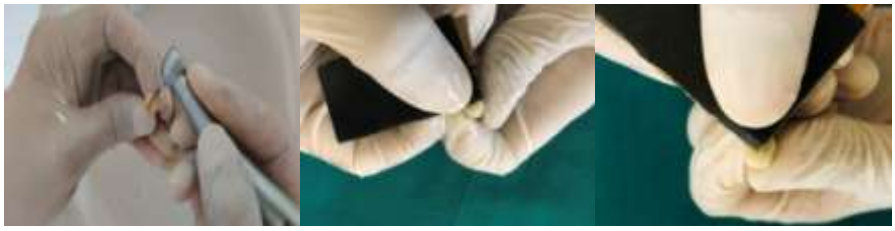

Figure 2:- Specimens after Build-Up with GC SOLARE X Composite.

Figure 3:- Specimen after Mounting.

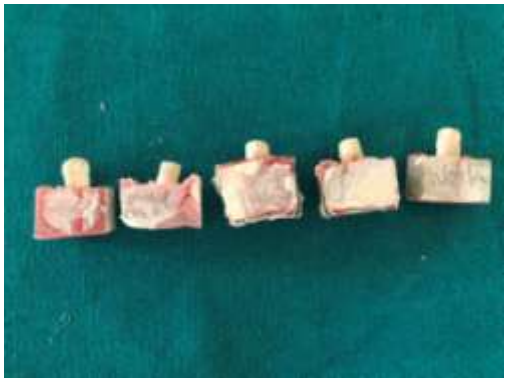

Figure 4:- Specimen loaded in UTM Machine for Microtensile Bond Strength Testing.

Figure 5:- UTM Machine for Microtensile Bond Strength Analysis- H50K, Tinius Olsen India Pvt. Ltd.

Figure 6:- SEM Analysis of the Fractured Surfaces.

Figure 7a & 7b:- (7a) Sectioning the Teeth for Bond Interface Analysis using Straight Handpiece and Diamond Disc. (7b) Specimen for Bond Interface Analysis after Sectioning.

Figure 8a & 8b:- (8a) Polishing the Bond Interface using 400 & (8b) 1000 Grit Abrasive Paper.

Figure 9:- Specimen Coated with Gold Sputter for Bond Interface Analysis.

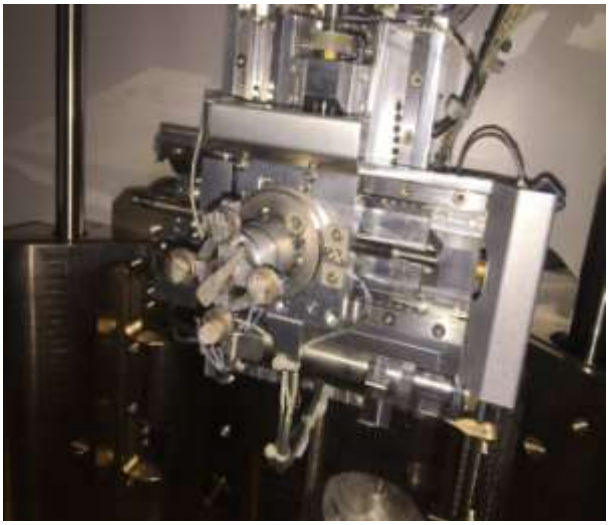

Figure 10:- SEM Analysis of the Bond Interface.

Bibilography:-

1. KumariRV, Siddaraju K, NagarajH and PoluriRK, Evaluation of Shear Bond Strength of Newer Bonding Systems on Superficial and Deep Dentin, J Int Oral Health. 2015, 7(9);31–35.
2. Manfroi FB,Marcondes ML, Somacal DC, Borges GA, Junior LH and Sophr AM, Bond strength of a novel one bottle multi-mode adhesive to human dentin after six months of storage, Open Dent J, 2016, 10; 268-277.
3. Zeidan LC, Reis AF, Cassoni A, Rodridues JA, Effect of six month storage on microtensile bond strength of new elective etching adhesive system on dentin in self-etching or etch-and-rinse approach, Saudi Dent J, 2016; 1-6.
4. Kamel MM, ElsayedHY, Abdalla AI, Darrag AM,The effect of water storage on micro-shear bond strength of contemporary composite resins using different dentin adhesive systems, Tanta Dent J, 2014; 1-9.
5. Sano H, Chowdhury AFMA, Saikaewb P, Matsumoto M, Hoshika S, Yamauti M, The microtensile bond strength test: Its historical background and application to bond testing, Jpn Dent Sci Rev 2020, 56; 24–31.
6. Kerr, Bonding Agents/ OptiBond All-in-One, Technical Bulletin.
7. Dantas DCRE, Ribeiro AIAM, Lima LHMA, Lima MG, Guenes GMT, Braz AKS, Braz R, Influence of Water Storage Time on the Bond Strength of Etch-and-Rinse and Self-Etching Adhesive Systems, Braz Dent J, 2008, 19(3); 219-222.
8. Kameyama A, Haruyama A, Abo H, et al. Infuence of solvent evaporation on ultimate tensile strength of contemporary dental adhesives, ApplAdhes Sci, 2019, 7(4); 1-11.
9. Koliniotou-Koumpia E, Kouros P, Koumpia E, Antoniades MH, Shear bond strength of a ”solvent-free” adhesive versus contemporary adhesive systems, Braz J Oral Sci, 2014, 13(1); 64-69.
10. Leal FB, Madruga FC, Prochnow EP, et al. Effect of acidic monomer concentration on the dentin bond stability of self-etch adhesives, Int J Adhes Adhes, 2011, 31; 571-574.
11. McLean DE, Meyers EJ, Guillory VL, Vandewalle KS,Enamel Bond Strength of New Universal Adhesive Bonding Agents, Oper Dent, 2015, 40 (4); 410–417.
12. Nair M, Paul J, Kumar S, Chakravarthy Y, Krishna V, and Shivaprasad,Comparative evaluation of the bonding efficacy of sixth and seventh generation bonding agents: An In-Vitrostudy, J Conserv Dent, 2014, 17; 27-30.
13. Giannini M, Makishi P, Ayres APA, Vermelho PM, et al. Self-Etch Adhesive Systems: A Literature Review, Braz Dent J, 2015, 26(1); 3-10.
14. Siqueira FSF, Cardenas AM, Ocampo JB, Hass V, et al. Bonding Performance of Universal Adhesives to Eroded Dentin, J Adhes Dent, 2018, 20; 121-132.
15. Amsler F, Peutzfeldt A, Flury S, Long-term bond strength of self- etch adhesives to normal and artificially eroded dentin; effect of relative humidity and saliva contamination. J Adhes Dent 2017, 19; 169-176.
16. Salgado NRGF, Gajewski V, Ornaghi BP,et al. Influence of the base and diluent monomer on network characteristics and mechanical properties of neat resin and composite materials, Odontology, 2015,103; 160-168.
17. Cebe M, Adigüzell M, Cebe F, Tekin M, Comparative evaluation of micro-tensile bond strength of one-step self-etching adhesive systems, J Res Dent, 2014, 2(3); 130-135.