Original Article

Evaluation of Effect of Dietary Solvents on Bond Strength of Compomer, Ormocer, Nanocomposite and Activa Bioactive Restorative Materials

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ABSTRACT

Objectives: The successful endodontic therapy is judged by ability of tooth to withstand masticatory forces. The present study focused on comparing the strength of restorative materials, i.e., compomer, ormocer, nanocomposite, and ACTIVA Bioactive after conditioning in dietary solvents.
Materials and Methods: This *in vitro* study consisted of 26 specimens of each restorative material Compomer (F2000 3M ESPE), Nanocomposite (Filtek Z350XT), Ormocer (Admira VOCO), and ACTIVA Bioactive (Pulpdent). The I-shear–punch test was conducted with the help of custom-designed shear–punch apparatus in Universal Testing Machine in different dietary solvents. Results were statistically analyzed using IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY) and using Tukey's test and one-way analysis of variance test at $P < 0.5$.
Results: Ormocer conditioned in heptanes had the highest mean shear–punch strength. ACTIVA Bioactive conditioned in distilled water showed the highest mean shear–punch strength. There was a significant difference in bond strength among all restorative materials ($P < 0.05$).
Conclusion: Ormocer conditioned in heptane had significantly higher shear strength. ACTIVA Bioactive conditioned in distilled water had significantly increased shear strength. The nanofilled composite was significantly stronger than the Ormocer, ACTIVA Bioactive, and Compomer – a polyacid-modified composite.

KEYWORDS: *Compomer, nanofilled, ormocer*

INTRODUCTION

The steps of endodontic therapy involve access opening and cleaning the canals using various instruments along with the use of irrigating solution such as sodium hypochlorite followed by obturation of prepared canals with obturating materials such as gutta percha. After root canal treatment, tooth is restored with various restorative materials such as amalgam, composite, or glass ionomer cement (GIC) depending on clinical condition.[1]

The invention of new restorative materials and techniques in the field of endodontics offers minimally invasive treatment and therefore leads to better esthetics and function.[1] The foremost aim of restorative dentistry is to provide restorative material with good strength, esthetics, and good seal between restorative material and tooth structure.[2] Numerous restorative materials are available in the endodontics. Conventional glass ionomers show poor fracture toughness, moderate wear resistance, and rough surface conditions. With the development of highly viscous GICs (Fuji IX) and composite-based restorative materials such as compomer, ormocer, and nanoceramics, the clinical use of conventional glass ionomer has been improved making

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it popular.[3] Manuja *et al*. found that nanoceramic and ormocer-based restorative materials had better bonding potential to dentin as compared to GIC and giomer.[3] Various composite materials are used even for bonding of orthodontic brackets such as flowable composite and nanofilled composites, which need good bond strength.

"Compomers" are newly introduced products in the market. It is one of the dental materials having combined advantages of composites and glass ionomers. Ormocers are new class of materials in the field of dentistry. These are also popular as "Ormosils" (organically modified silicates).[4] Nanofilled composites are new brand of composite resins manufactured with nanofiller technology and formulated with nanomer and nanocluster filler particles. Recently, new materials such as packable and nanofilled composites have entered in the market.[4]

ACTIVA Bioactive products are materials that show a specific biological response at the interface of the material, leading to the formation of a bond between the material and tissues.[5] These materials liberate calcium, phosphate, and fluoride and are more bioactive than glass ionomers and traditional resin-modified glass ionomer (RMGI). It has been observed that dietary solvents such as food-simulating liquids are used to simulate the oral conditions and to determine its effect on the performance of resin restorative materials.[6] The existing information on effect of dietary solvents on bond strength of various restorative materials such as compomer, ormocer, nanocomposite, and ACTIVA Bioactive restorative materials is very scarce. Hence, the present *in vitro* study was conducted to compare the strength of compomer, ormocer, nanocomposite, and ACTIVA Bioactive after conditioning in dietary solvents. The results of our study will help us to evaluate the effectiveness of various restorative resin materials in the oral condition.

Materials and Methods

The present *in vitro* (prospective) study was conducted in the Department of Endodontics, Hi-Tech Dental College and Hospital, Bhubaneswar, Orissa, from June 2016 to April 2017. It comprised of 26 specimens of each restorative material such as Compomer (F2000 3M ESPE), Ormocer (Admira VOCO), Nanocomposite (Filtek Z350XT), and ACTIVA Bioactive (Pulpdent Corporation). The study protocol was approved by the Institutional Ethics Committee Letter No. HDC. Res-28/2016–2017.

Specimen preparation for I-shear–punch testing

Shear–punch specimens were made by placing the restorative material into the brass washers. The washers were placed over a glass slide on which Mylar Strips were attached. A second Mylar strip was placed over samples on which the second glass slab was placed over the top of the washers, and gentle finger pressure was applied to extrude the excess material. Light curing was performed using spectrum of 800 polymerization unit. Twenty-six specimens of each material were made (total sample 104) and stored in distilled water in airtight containers, at 37°C for 1 week. Light curing was done in the 400–500 nm visible light range with an output power up to 800 mW/cm^2.

At the end of conditioning period of another 1 week in the different dietary solvents, the specimens were washed, blotted dry, and subjected to shear–punch strength testing using custom-designed shear–punch apparatus with universal testing machine at a crosshead speed of 2.0 mm/min and the maximum load to make punch through the specimen was recorded. Color stability of each restorative material was evaluated at 1 day, 7 days, and 30 days.

The four different subgroups of the conditioning media such as heptane (37°C), 50% ethanol–water solution (37°C), 0.02 M citric acid (37°C), and distilled water (37°C) were used to assess the bond strength at different conditions.

Statistical analysis

Results thus obtained were subjected to statistical analysis using IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY) and using Tukey's test and one-way analysis of variance test at $P < 0.5$.

Results

There was a significant difference among all restorative materials ($P < 0.05$) [Table 1]. Nanofilled composites showed highest mean punch strength value than other composites, irrespective of various dietary solvents after 1 week conditioning in dietary solvents. Ormocer conditioned in heptanes significantly demonstrated the highest mean shear–punch strength, i.e., 898.20 N compared to specimens conditioned in the other three conditioning media. ACTIVA Bioactive conditioned in distilled water demonstrated significantly highest

Table 1: Intergroup comparison among the four groups

Composite (I)	Composite (J)	Mean difference	P
Nanocomposite	ACTIVA bioactive	386.112	0.0001
	Compomer	710.240	0.0001
	Ormocer	382.525	0.0001
ACTIVA bioactive	Compomer	301.126	0.0001
	Ormocer	−11.051	0.5
Compomer	Ormocer	−315.212	0.0001

*The mean difference is significant at the 0.05 level mean shear–punch strength, i.e., 988.00 N, compared to specimens conditioned in the other three conditioning media [Graph 1 and Table 2].

Regarding the effect of conditioning media for 1 week, nanofilled composite and compomer restorative materials showed no statistical significance difference ($P > 0.05$) in mean shear–punch strength values, but statistical significance difference ($P < 0.05$) was seen in ormocer and ACTIVA Bioactive restorative materials [Table 2]. Table 3 indicates various restorative materials used in the study with manufacturer details and composition. Table 4 indicates mean flexural strength and modulus of elasticity of restorative materials, and flexural strength was highest in nanocomposites followed by ormocer, compomer, and active bioactive. Elasticity modulus was highest in nanocomposites followed by ormocer, active bioactive, and compomer. Table 5 indicates color stability.

Discussion

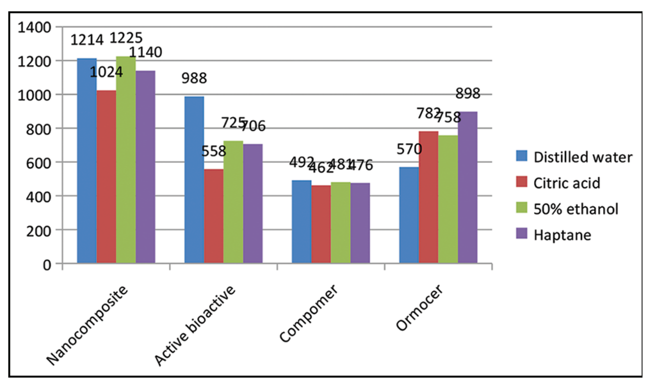
The foremost requirement in endodontics is the production of durable bond between biomaterials and tooth substrate. It is mandatory in terms of both mechanical and biological point of view. The chemical environment in oral cavity may have a substantial effect on *in vivo* degradation of composite resins.[7] The normal mastication process and parafunctional habits induce shear stresses in teeth. In the present study, we assessed the strength of different restorative materials and effect of dietary solvents on it. Inter group comparision of all restorative material was significant [Table 1]. Table II indicates mean value of shear punch strength of different composite in different dietary solvents. We observed highest shear strength for nanocompostes fallowed by ACTIVA, ormocer and least in compomer [Table II].

We observed that nanofilled composite showed better results of shear–punch test in all dietary solvents used in the study as compared to other composites, and because of the increased volume of the filler, the amount of water absorbed into the matrix is reduced. Kaur *et al* found that Nanocomposite revealed to have higher strength, thereby indicating its better application universally. Nanofilled composite was both bisphenol A-glycidyl methacrylate (BisGMA) and bisphenol A-ethoxylate dimethacrylate (BisEMA) based. BisEMA made it more resistant to the softening effect of ethanol–water solution. Nayak *et al*.[9] found that BisEMA-based composites were highly resistant to the degradation effect of food-simulating liquids including ethanol. BisEMA is hydrophobic as it does not contain any unreacted hydroxyl groups on the main polymer chain. The compomer and giomer materials were more affected by acids of low pH than the composite material.[10] Khan *et al*. showed that pH does not have any effect on nanofilled composites.[11]

Table 2: Shear-punch strength of different composites in different dietary solvents

Composite	Median	Mean±SD	P
Nanocomposite	Distilled water	1214.0±81.4	0.1
	Citric acid	1024.40±92.7	
	50% ethanol	1225.05±210.2	
	Heptane	1140.45±90.2	
ACTIVA bioactive	Distilled water	988.0±1.18	0.0001
	Citric acid	558.20±62.0	
	50% ethanol	725.45±146.1	
	Heptane	706.15±41.3	
Compomer	Distilled water	492.00±11.5	0.04
	Citric acid	462.75±13.1	
	50% ethanol	481.25±18.3	
	Heptane	476.50±7.6	
Ormocer	Distilled water	570.55±105.6	0.0001
	Citric acid	782.05±16.0	
	50% ethanol	758.00±23.3	
	Heptane	898.30±45.5	

One-way ANOVA test used $P>0.05$. SD=Standard deviation



Graph 1: Shear–punch strength of different composites in different dietary solvents

Table 3: Composite materials used for the study

Material	Type	Composition	Filler (%)	Manufacturer
Nanocomposite	Ceramic matrix	SiC, Al_2A_3, MgO	7.2	Filtek Z350XT, 3M ESPE, St.Paul, MN, USA
Active bioactiva	Composite	Ionic resins	4.2	Pulpdent Corporation, Watertown, USA
Compomer	Resin-modified GIC	Composite, GIC	6.2	F2000, 3M 3M ESPE, St.Paul, MN, USA
Ormocer	Organic-modified composite	BisGMA, urethane dimethacrylate, and triethylene glycol dimethacrylate	8	Ormocer (Admira VOCO), Cuxhaven, Germany

GIC=Glass ionomer cement, BisGMA=Bisphenol A-glycidyl methacrylate

We observed that ormocer showed lower punch test value than nanofilled composites in all the dietary solvents. This could be due to the presence of triethyleneglycol dimethacrylate which causes solvent susceptibility and plasticizing effect. This is in agreement with Kaur and Nandlal.[12] The strength of the ormocer material was significantly increased by conditioning in heptanes as compared to distilled water, 50% ethanol, and citric acid. The higher strength values may be due to the fact that heptane eliminates the leaching out of silica and combined metals in fillers. Cramer *et al.*[13] found that the strength of active bioactive resin was significantly higher in conditioning in distilled water. The higher strength value credited to the fact that they are water based or contain zones or phases of water and continuously release and recharge their ionic components.

Koç-Vural *et al*. evaluated the bond strength of aged resin-based nanocomposites repaired with the same and bulk-fill composites and found highest bond strength with bulk-fill repaired materials compared to Filtek Ultimate.[14] Jayasree conducted a study to compare the bond strength and microleakage of Compomer with Composite and Glass ionomer (conventional and light cured) and found that Compomer–Dyract had superior bond strength and least microleakage than glass ionomer and composite resins.[15] Korkut *et al*. compared the mechanical properties of four different RMGI cements (RMGICs) as follows: Photac Fil Quick Aplicap (3M ESPE, Minnesota, ABD), GC Fuji II GP (GC Corporation, Tokyo, Japan), Riva Light Cure (SDI, Illinois, ABD), and ACTIVA Bioactive (Pulpdent Corporation, Watertown, USA) and found better mechanical and physical properties with ACTIVA Bioactive Restorative material than conventional RMGICs.[16]

Omidi *et al*. compared the microleakage of Class II (box only) cavity restorations with ACTIVA Bioactive Restorative Glass, RMGI, and composite in primary molars and observed that microleakage of ACTIVA Bioactive Restorative material was comparable to microleakage of composites in the absence or presence of etching and bonding.[17]

Condò *et al*. conducted a study to investigate the morphological and structural characteristics of giomers over a Compomer (Dyract Extra by Dentsply, Caulk, Germany), GI cement (Ketac fil plus by 3M ESPE, London, Canada), and a composite resin and found that giomers had similar behavior to the other restorative materials investigated.[18] Shathi *et al*. compared the marginal microleakage of ormocer restorative material with that of giomer and concluded that ormocer restorative material had lesser microleakage than that of giomer.[19]

Thekiya *et al*. assessed the shear bond strength of ormocer-bonded orthodontic brackets with self-etching primer and conventional adhesive system and found that Ormocer may be utilized as a substitute to generally used BisGMA-based adhesives.[20] Magdy *et al*. evaluated surface roughness of different resin-based composites and observed that bulk-fill and nanohybrid resin composites exhibit smoothest surfaces compared with nanoceramic and microhybrid resin composites after polishing.[21] Kumar *et al*. in their review article suggested that silorane restorative material may enhance the strength of the tooth after restoration.[22]

We found higher flexural strength and elastic modulus with nanocomposites over other materials [Table 4]. Rodrigues Junior *et al*. concluded from an *in vitro* study that filler content significantly interfered in the flexural strength and modulus of elasticity of the composites tested.[23]

Table 6 for color stability indicates no changes in color after 1 day, 7 days, and 30 days. Malekipour *et al*. stated that blood does not have significant role in changing the color stability of resin restoration.[24] Kumar *et al*. found that color changes were maximum with Coca-Cola immersion but there were negligible changes with distilled water after 24 and 48 h.[25]

Table 4: Flexural strength and modulus of elasticity among the restorative materials

Restorative material	Flexural strength	Modulus of elasticity (GPa)	Filler weight (%)
Nanocomposite	166.77±15.26 A	6.30±0.96	72
Active bioactiva	118.43±18.68 C	5.66±1.49	42
Compomer	126.38±11.67 C	5.18±0.73	62
Ormocer	143.65±13.86 B	6.82±0.69	80

Test used, Tukey's test $P<0.05$

Table 5: Color stability of restorative materials

Restorative material	Mean +_standard deviation			*P*
	ΔE1 (1 day)	ΔE (7 day)	ΔE (30 day)	
Nanocomposite	1.76+_1.05	2.1+_1.7	2.58+_1.03	0.05
Active Bioactiva	2.12+_1.02	2.08+_1.04	2.03+_1.02	0.96
Compomer	1.85+_1.12	1.78+_1.07	1.69+_1.05	0.98
Ormocer	2.12+_1.04	2.06_1.08	2.03+_1.01	0.88

$P>0.05$, test used: ANOVA

Table 6: Color stability of restorative materials

Restorative material	Mean±SD			*P*
	ΔE1 (1 day)	ΔE (7 days)	ΔE (30 days)	
Nanocomposite	1.76±1.05	2.1±1.7	2.58±1.03	0.05
Active bioactiva	2.12±1.02	2.08±1.04	2.03±1.02	0.96
Compomer	1.85±1.12	1.78±1.07	1.69±1.05	0.98
Ormocer	2.12±1.04	2.06±1.08	2.03±1.01	0.88

$P>0.05$, test used: ANOVA. SD=Standard deviation

We found that nanofilled composite was significantly stronger than the Ormocer and ACTIVA Bioactive. Compomer had least bond strength. The data of the present study help to identify the effect of dietary solvent on bond strength of various restorative materials; hence, care can be taken in the material selection and restoration for long-term success of restoration.

The limitation of the study is that the assessment and evaluation of the strength of resin composite restorative materials should preferably be carried out at comparatively longer evaluation time periods in various dietary solvents. Further *in vivo* study is required to evaluate the dietary solvent on bond strength of various restorative materials on larger sample size.

Conclusion

It was found that the bond strength of the materials evaluated was not significantly influenced by dietary solvents except ormocer and ACTIVA Bioactive composites. For the ormocer composite, conditioning in heptane significantly increased shear strength. Shear strength was significantly increased for ACTIVA Bioactive after conditioning in distilled water. The nanofilled composite was significantly stronger than the Ormocer and ACTIVA Bioactive, which, in turn, was significantly stronger than the Compomer – a polyacid-modified composite.

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Conflicts of interest

There are no conflicts of interest.

References

1. Krämer N, Frankenberger R. Compomers in restorative therapy of children: A literature review. Int J Paediatr Dent 2007;17:2-9.
2. Shaik MS, Pattanaik S, Pattanaik S, Pathuri S, Sivakumar A. Shear bond strength of different adhesive materials used for bonding orthodontic brackets: A comparative *in vitro* study. Orthod J Nepal 2015;5:22-6.
3. Manuja N, Pandit IK, Srivastava N, Gugnani N, Nagpal R. Comparative evaluation of shear bond strength of various esthetic restorative materials to dentin: An *in vitro* study. J Indian Soc Pedod Prev Dent 2011;29:7-13.
4. Hickel RA, Folwaczny M. Various forms of glass ionomers and compomers. Oper Dent 2011;6:177-90.
5. Hamouda I, Elkader H, Badawi M. Microleakage of nanofilled composite resin restorative material. J Biomater Nanobiotechnol 2011;2:329-34.
6. Fares H. The effect of dietary materials on shear punch strength and surface texture of a nanofill and a microhybrid composite: A one year study. Life Sci J 2013;10:2070-9.
7. Pradeep S, Shanthraj R, Kiran HJ, Shivalinga BM. Comparative evaluation of the shear bond strength and debonding properties of a conventional composite and flowable composites used for orthodontic bracket bonding. World J Dent 2013;4:6-16.
8. Kaur H, Singh H, Vinod KS, Singh B, Arora R, Chatopaddhya S. Shear punch strength evaluation of nanocomposite and compomer, post-conditioning in dietarysolvents - An *in-vitro* study. J Oral Biol Craniofac Res 2014;4:30-4.
9. Nayak RS, Valecha S, Pasha A, Mamatha J, Khanna B, Shafiuddin B. A comparison of shear bond strength of new nanofilled composite and nano-ionomer restorative materials with traditional adhesive material for orthodontic bracket bonding: An *in vitro* study. J Int Oral Health 2015;7:70-6.
10. Mohamed-Tahir MA, Tan HY, Woo AA, Yap AU. Effects of pH on the microhardness of resin-based restorative materials. Oper Dent 2005;30:661-6.
11. Khan AA, Askari H, Waqar Z, Hanif S, Noori S, Imtiaz F. Influence of salivary pH on the sorption rate of nano-filled composite resin. Int J Med Dent Sci 2015;4:540-6.
12. Kaur H, Nandlal B. Effect of dietary solvents on the strength of nanocomposite, compomer, glass ionomer cement: An *in vitro* study. J Conserv Dent 2013;16:527-31.
13. Cramer NB, Stansbury JW, Bowman CN. Recent advances and developments in composite dental restorative materials. J Dent Res 2011;90:402-16.
14. Koç-Vural U, Kerimova L, Baltacioglu İH, Kiremitçi A. Bond strength of dental nanocomposites repaired with a bulkfill composite. J Clin Exp Dent 2017;9:e437-42.
15. Jayasree S. Compomer – dyract- A comparison of its bond strength and microleakage with composite resin and glass ionomer – An *in vitro* study. IOSR J Dent Med Sci 2017;16:32-42.
16. Korkut E, Gezgin O, Tulumbacı F, Özer H, Şener Y. Comparative evaluation of mechanical properties of a bioactive resin modified glass ionomer cement. EÜ Dişhek Fak Derg 2017;38:170-5.
17. Omidi BR, NaeinI FF, Dehghan H, Tamiz P, Savadroodbari MM, Jabbarian R. Microleakage of an enhanced resin-modified glass ionomer restorative material in primary molars. J Dent (Tehran) 2018;15:205-13.
18. Condò R, Cerroni L, Pasquantonio G, Mancini M, Pecora A, Convertino A, *et al.* A deep morphological characterization and comparison of different dental restorative materials. Biomed Res Int 2017;2017:7346317.
19. Shathi IJ, Hossain M, Gafur A, Rana S, Alam S. A comparative study of microleakage between giomer and ormocer restoration in class I cavity of first permanent premolar teeth *in vivo*. Bangabandhu Sheikh Mujib Med Univ J 2017;10:1-5.
20. Thekiya AH, Aileni KR, Rachala MR, Reddy SD, Devi KS, Khan MY. An evaluation of shear bond strength of admira (Ormocer) as an alternative material for bonding orthodontic brackets: An *in vitro* study. J Int Soc Prev Community Dent 2018;8:56-61.
21. Magdy NM, Kola MZ, Alqahtani HH, Alqahtani MD, Alghmlas AS. Evaluation of surface roughness of different direct resin-based composites. J Int Soc Prev Community Dent 2017;7:104-9.
22. Kumar T, Bhargava K, Sanap A, Aggarwal S. Advances in reinforced restorations: A review. Int J Dent Health Concerns 2015;1:1-5.
23. Rodrigues Junior SA, Zanchi CH, Carvalho RV, Demarco FF. Flexural strength and modulus of elasticity of different types of resin-based composites. Braz Oral Res 2007;21:16-21.
24. Malekipour MR, Shirani F, Taromi Z, Shahnazari S. Comparison of color stability of two resin composites in blood area. Dent Hypotheses 2017;8:65-9.
25. Kumar MS, Ajay R, Miskeen Sahib SA, Chittrarasu M, Navarasu M, Ragavendran N, *et al.* Color stability assessment of two different composite resins with variable immersion time using various beverages: An *in vitro* study. J Pharm Bioallied Sci 2017;9:S161-5.