ORIGINAL ARTICLE

EVALUATION OF SIGNIFICANCE OF TIME IN PLACEMENT OF COMPOSITE OVER VARIOUS CALCIUM SILICATE BASED MATERIALS: AN IN-VITRO STUDY

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ABSTRACT:

Background: the present in vitro study has been undertaken to evaluate the significance of time in placement of composite over calcium silicate based materials i.e. MTA, Biodentine and TheraCal LC with and without bonding agent application. **Materials & Methods:** 105 plastic tubes were cut from plastic pipes for taking internal diameter of 4 mm. 30 blocks for each experimental group were made, i.e. MTA, Biodentine and TheraCal LC (4 X 5mm) in dimension. And similarly, 15 blocks for control groups (n=5 for MTA, Biodentine and TheraCal LC) were made of similar dimensions. These blocks were divided on the basis of timing of placement of composite (10 minutes, 1 day and 7 days) into experimental group (MTA, Biodentine and TheraCal LC) and control groups and marked accordingly. Each experimental group was subdivided depending on the use of bonding agent (Adper single bond 2, 3M ESPE), i.e. with and without bonding agent. The groups were divided into various subgroups. All the samples were viewed under scanning electron microscopy were gold plated using vacuum evaporator (JEOL JFC 1600, Japan). All the samples were then subjected to statistical analysis. The mean microhardness value of each specimen was calculated, and the values were expressed as the mean ± standard deviation. The microhardness measurements were performed with a Vickers microhardness tester. The data obtained was tabulated and subjected to statistical analysis. **Results:** Maximum amount of gap was shown by Biodentine 7 day subgroup without bonding agent (B5). MTA 10 minutes subgroup with and without bonding agent (A1, A2), Biodentine 10 minutes with bonding agent (B2), Biodentine 7 day with bonding agent (B6), TheraCal LC 10 minute and 1 day subgroup with and without bonding agent (C1, C2, C3, C4) showed no gap (0 µm) between the calcium silicate material and composite resin or bonding agent interface. In case of Vickers microhardness number, duncan's test parameters attains value from A (minimum microhardness number) to G (maximum microhardness number), with B, C, D, E, F having intermediate values in increasing order. **Conclusion:** The composite restoration can be placed immediately over the calcium silicate based materials if proper manufacturer's instructions are followed while manipulation of calcium silicate based materials.

Key words: Biodentin , Composite, Esthetic, MTA, TheraCal LC

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INTRODUCTION

The search for excellence in restorative dentistry is a never ending endeavour. As the demand for composite restorations have increased due to its improved properties and esthetic needs, bulk fill composites have been introduced, which can be filled into cavities upto 4-5mm per increment. So, calcium hydroxide liner has been used for pulp protection and repair over the years. Calcium hydroxide liner has poor compressive strength and therefore should always be covered with a glass ionomer or resin-modified glass ionomer liner before tooth is finally restored. Newer liner materials have been introduced in the market which includes calcium tri-silicate based materials i.e MTA, Biodentine and TheraCal LC to combat poor strength of calcium hydroxide. Calcium hydroxide was introduced to endodontics as a direct pulp-capping agent.[1] Mineral trioxide aggregate (MTA) has shown promising results due to its good sealing properties, bioactivity, and potential to stimulate cementogenesis. The main advantages of MTA are its biocompatibility and its osteogenic and regenerative potential. On the other hand it has disadvantages like longer setting time of 4 hours, difficult handling characteristics and moisture requirement for its setting. So, the research of new materials to overcome these

difficulties has been going on and recently some new calcium silicate based materials like Biodentine and TheraCal LC has been introduced. Biodentine is a new calcium silicate based restorative material which can be used for pulp protection, temporary closure, deep caries management, cervical filling, direct and indirect pulp capping and pulpotomy. TheraCal LC is light cured, resin modified calcium silicate filled liner which is used in direct and indirect pulp capping.[2] Hence, the present in vitro study has been undertaken to evaluate the significance of time in placement of composite over calcium silicate based materials i.e. MTA, Biodentine and TheraCal LC with and without bonding agent application.

MATERIALS AND METHOD

One hundred and five plastic tubes were cut from plastic pipes of internal diameter of 4 mm. Thirty blocks for each experimental group were made, i.e. MTA, Biodentine and TheraCal LC (4 X 5mm) in dimension. And similarly, fifteen blocks for control groups (n=5 for MTA, Biodentine and TheraCal LC) were made of similar dimensions. These blocks were divided on the basis of timing of placement of composite (10 minutes, 1 day and 7 days) into experimental group (MTA, Biodentine and TheraCal LC) and control groups and marked accordingly. Each experimental group was subdivided depending on the use of bonding agent (Adper single bond 2, 3M ESPE), i.e. with and without bonding agent. The groups were divided as shown in **Table 1**.

For control group, MTA, Biodentine, TheraCal LC blocks were added to plastic tubes after mixing for 1 minute, and moist cotton pellets was placed on it. 2mm hydraulic temporary cement (MD Temp, MetaBiomed) was placed on top of the blocks, and these were maintained in the container for 21 days at 37 ˚Celsius and relative humidity of 100%.

For subgroup A1, B1 and C1 (10 minute subgroups without bonding agent): Ten minutes after MTA, Biodentine, TheraCal LC block formation, 2mm of flowable composite resin (Filtek Z350 XT, 3M ESPE) was added on the top of blocks and light cured for 60 seconds with light emitting diode curing light source.

For subgroup A2, B2 and C2 (10 minute subgroups with bonding agent):

Ten minutes after MTA, Biodentine, TheraCal LC mixing, bonding agent was applied (Adper single bond 2, 3M ESPE) and cured for 10 seconds. Then, 2mm of flowable composite resin (Filtek Z350 XT, 3M ESPE) was added on the top of blocks and light cured for 60 seconds with light emitting diode curing light source. Tubes were maintained for 21 days at 37 degree celsius at a relative humidity of 100 %.

For subgroups A3, B3 and C3 (1 day subgroups without bonding agent):

After MTA, Biodentine, TheraCal LC block formation, a moist cotton pellet were placed on the blocks and hydraulic temporary cement were placed at a 2mm thickness on the blocks, and the blocks were maintained at 37 degree Celsius and 100% relative humidity. One day after the filling, hydraulic temporary cement and a moist cotton pellets with small fragments of hydraulic temporary cement were removed and the blocks surfaces were air blown. 2mm of flowable composite resin (Filtek Z350 XT, 3M ESPE) was added on the top of blocks and light cured for 60 seconds with light emitting diode curing light source.

For subgroups A4, B4 and C4 (1 day subgroups with bonding agent):

After MTA, Biodentine, TheraCal LC block formation, a moist cotton pellet were placed on the blocks and hydraulic temporary cement were placed at a 2mm thickness on the blocks, and the blocks were maintained at 37 degree Celsius and 100% relative humidity. One day after the filling, hydraulic temporary cement and a moist cotton pellets with small fragments of hydraulic temporary cement were removed and the blocks surfaces were air blown. Then, bonding agent was applied (Adper single bond 2, 3M ESPE) and cured for 10 seconds. 2mm of flowable composite resin (Filtek Z350 XT, 3M ESPE) was added on the top of blocks and light cured for 60 seconds with light emitting diode curing light source. Tubes were maintained for 21 days at 37 degree celsius at a relative humidity of 100 %.

For subgroups A5, B5 and C6 (7 days subgroups without bonding agent):

After MTA, Biodentine, TheraCal LC block formation, a moist cotton pellet were placed on the blocks and hydraulic temporary cement were placed at a 2mm thickness on the blocks, and the blocks were maintained at 37 degree Celsius and 100% relative humidity. Seve days after the filling, hydraulic temporary cement and moist cotton pellets with small fragments of hydraulic temporary cement were removed and the blocks surfaces were air blown. 2mm of flowable composite resin (Filtek Z350 XT, 3M ESPE) was added on the top of blocks and light cured for 60 seconds with light emitting diode curing light source.

Table 1: Showing distribution of samples into various subgroups.

Parameters	Group A: MTA (n=30)	Group B: Biodentine (n=30)	Group C: TheraCal LC (n=30)
Blocks subjected to composite restoration after 10 minutes without using bonding agent.	A1	B1	C1
Blocks subjected to composite restoration after 10 minutes using bonding agent.	A2	B2	C2
Blocks subjected to composite restoration after 1day without using bonding agent.	A3	B3	C3
Blocks subjected to composite restoration after 1day using bonding agent.	A4	B4	C4
Blocks subjected to composite restoration after 7 days without using bonding agent.	A5	B5	C5
Blocks subjected to composite restoration after 7 days using bonding agent.	A6	B6	C6

For subgroups A6, B6 and C6 (7 days subgroups with bonding agent):

After MTA, Biodentine, TheraCal LC block formation, a moist cotton pellet were placed on the blocks and hydraulic temporary cement were placed at a 2mm thickness on the blocks, and the blocks were maintained at 37 degree Celsius and 100% relative humidity. 7 day after the filling, hydraulic temporary cement and a moist cotton pellets with small fragments of hydraulic temporary cement were removed and the blocks surfaces were air blown. Then, bonding agent was applied (Adper single bond 2, 3M ESPE) and cured for 10 seconds. 2mm of flowable composite resin (Filtek Z350 XT, 3M ESPE) was added on the top of blocks and light cured for 60 seconds with light emitting diode curing light source. Tubes were maintained for 21 days at 37 degree celsius at a relative humidity of 100 %.

After 21 days MTA, Biodentine, TheraCal LC mixing, all samples were removed from tubes, embedded in epoxy resin and were maintained in container for 1 week at room temperature. Thereafter, they were cut longitudinally into two halves. Longitudinally planes were then grounded with silicon carbide papers and were finally polished with diamond abrasive discs.

- Scanning electron microscopy was performed on all samples which were sectioned longitudinally
- The microhardness was measured using Vickers microhardness tester.

All the samples were viewed under scanning electron microscopy were gold plated using vacuum evaporator (JEOL JFC 1600, Japan). All the samples were then subjected to statistical analysis. The microhardness measurements were performed with a Vickers microhardness tester. The mean microhardness value of each specimen was calculated, and the values were expressed as the mean ± standard deviation. The data obtained was tabulated and subjected to statistical analysis. The result of this study thus obtained were subjected to the statistical analysis using Duncan multiple test and one way ANOVA for calculating difference in gap between composite and MTA, Biodentine, TheraCal LC or bonding agent. One way ANOVA was also applied for average microhardness values of all the samples. All statistical tests were performed at a significant level of 'p' value $\leq$ 05. The result of this analysis was tabulated and plotted as graph.

RESULTS

Biodentine 7 day subgroup without bonding agent (B5) showed maximum amount of gap having mean gap of 7.0226µm. MTA 10 minutes subgroup with and without bonding agent (A1, A2), Biodentine 10 minutes with bonding agent (B2), Biodentine 7 day with bonding agent (B6), TheraCal LC 10 minute and 1 day subgroup with and without bonding agent

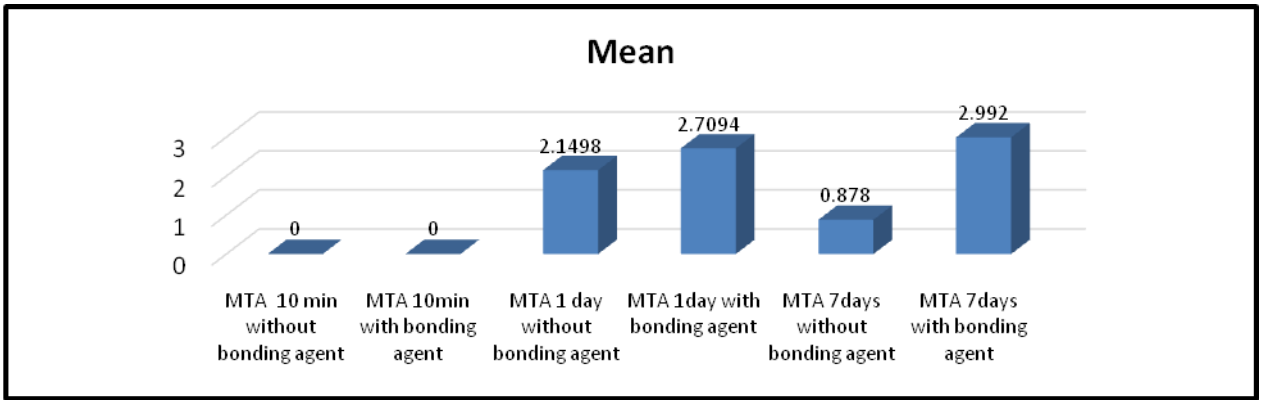
(C1, C2, C3, C4) showed no gap (0 µm) between the calcium silicate material and composite resin or bonding agent interface. MTA 1 day and 7 day with bonding agent (A4, A6) have D value in Duncan's test with mean gap of 2.9920µm. This is followed by MTA 1 day without bonding agent (A3), TheraCal LC 7 day without bonding agent (C5) which have C value in duncan's test with mean value of gap equals to 2.1224 and MTA 7 day subgroup without bonding agent (A5), Biodentine 10 minutes subgroup without bonding agent (B1) and 1 day subgroups with and without bonding agent (B2, B3) having B value in duncan's test with the mean gap of 1.0213µm.

In case of Vickers microhardness number, duncan's test parameters attains value from A (minimum microhardness number) to G (maximum microhardness number), with B, C, D, E, F having intermediate values in increasing order. TheraCal LC 7 days subgroups with and without bonding agent (C5, C6) have maximum Vickers hardness number while having G value in duncan's test with mean hardness value of 145.772 and 148.2240. MTA and Biodentine 1 day subgroups with bonding agent (A4, B4) have the minimum hardness number while having value 'A' in Duncan's test with mean hardness value of 64.3076 and 69.9720. TheraCal LC 1day without bonding agent (C3) had duncan's test value of 'F' having mean hardness number of 121.9880. MTA 10 minutes subgroup without bonding agent (A1), TheraCal LC 10 minutes subgroups with and without bonding agent (C1, C2) had duncan's test value of 'E' with mean hardness number of 111.3280, 114.0180 and 116.9000 respectively. Biodentine 10 minutes subgroups with and without bonding agent (B1, B2), TheraCal LC 1 day subgroup with bonding agent (C4) and MTA 10 minute subgroup with bonding agent (A2) had the duncan's test value of 'D' with mean hardness number of 100.7280, 101.3600, 101.6640 and 102.3880 respectively. MTA 7days subgroup with bonding agent (A6) had duncan's test value of 'C' with mean hardness number of 91.6236. MTA 1 day subgroup without bonding agent (A3), Biodentine 7 days subgroup with bonding agent (B6), Biodentine 1 day subgroup without bonding agent (B3), Biodentine 7days subgroup without bonding agent (B5) and MTA 7days subgroup without bonding agent (A5) had the duncan's test value of 'B' with mean hardness number 77.3800, 78.0480, 79.5660, 80.6160 and 82.1140 respectively.

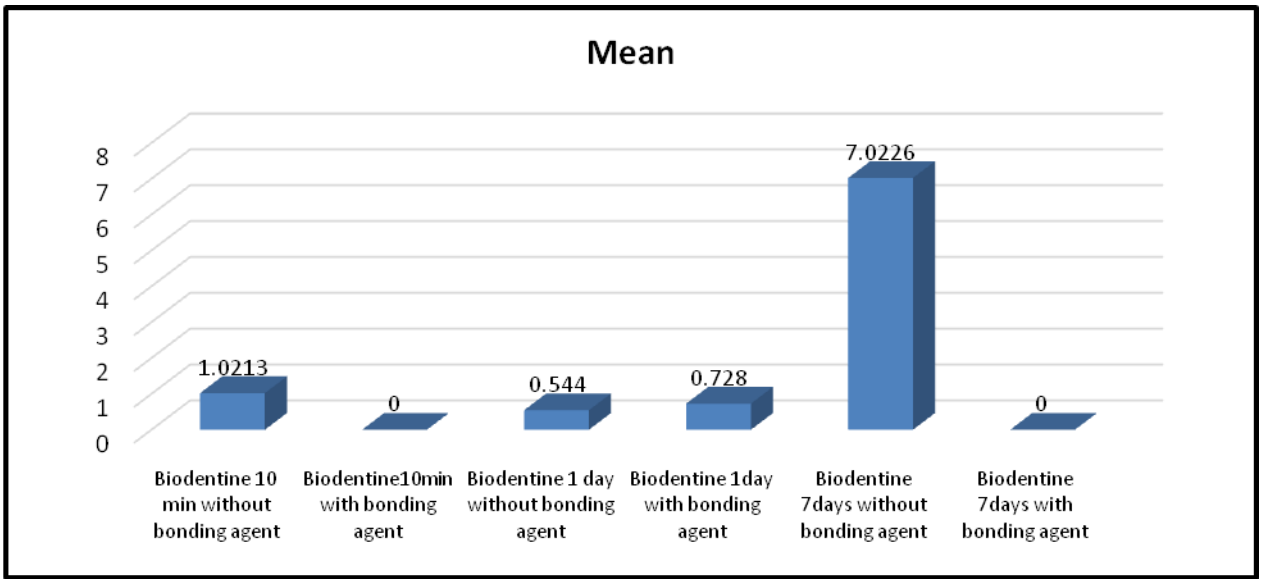
Table 2: Gap (in µm) between composite and MTA, Biodentine, TheraCal LC/ bonding agent

	10 minutes without bonding agent	10 minutes with bonding agent	1 Day without bonding agent	1 Day with bonding agent	7 days without bonding agent	7 days with bonding agent
Subgroups	A1	A2	A3	A4	A5	A6
MTA (GroupA) (gap in µm)	0	0	1.035	2.8458	.789	3.759
	0	0	2.8458	2.6432	.810	2.562
	0	0	2.1689	2.901	.635	2.102
	0	0	1.9726	2.536	1.236	3.620
	0	0	1.924	2.521	.920	2.918
Subgroups	B1	B2	B3	B4	B5	B6
Biodentine (Group B) (gap in µm)	1.257	0	.41	.719	7.582	0
	.8505	0	.49	.746	6.352	0
	1.123	0	.67	.823	7.243	0
	.8728	0	.80	.639	7.002	0
	1.003	0	.35	.713	6.934	0
Subgroups	C1	C2	C3	C4	C5	C6
TheraCal LC (Group C) (gap in µm)	0	0	0	0	2.5602	1.567
	0	0	0	0	1.868	3.75
	0	0	0	0	2.234	2.283
	0	0	0	0	1.928	3.120
	0	0	0	0	2.012	1.869

Graph 1: Difference in gaps between MTA (with/ without bonding agent and Composite at different time interval)



Graph 2: Difference in gaps between Biodentine (with/ without bonding agent and Composite at different time interval)



Graph 3: Difference in gaps between TheraCal LC (with/ without bonding agent and Composite at different time interval)

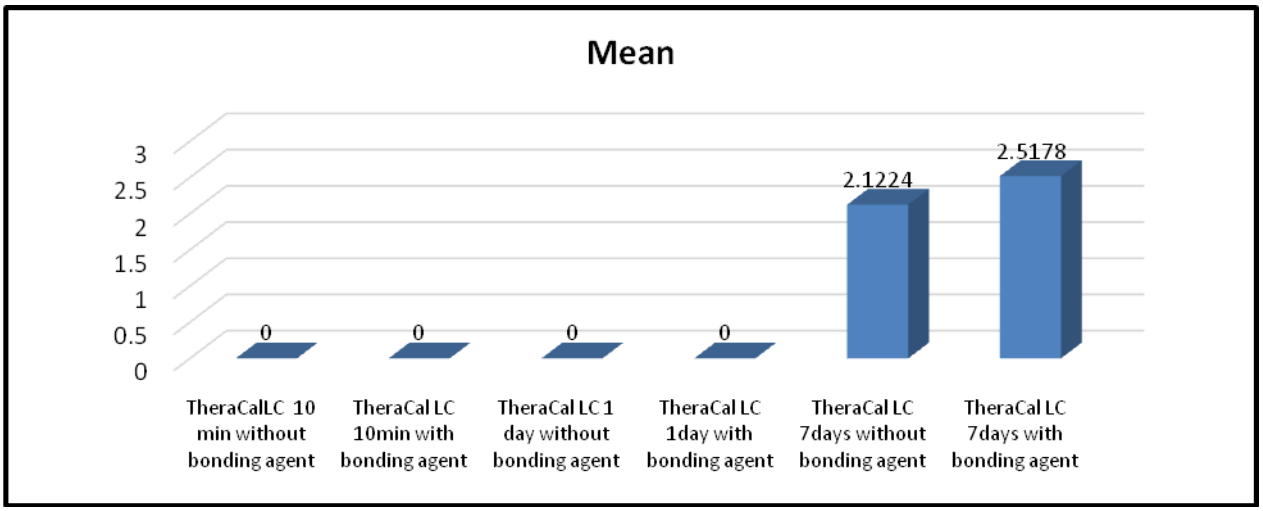


Figure 1: Sample (MTA block) showing absence of gap in subgroup 1A

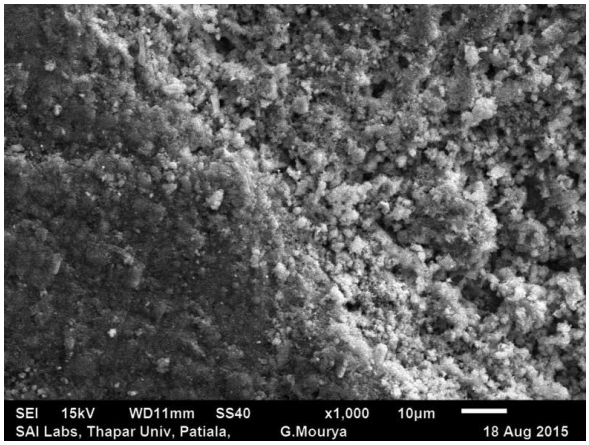


Figure 2: Sample (Biodentine block) showing gap in subgroup B1

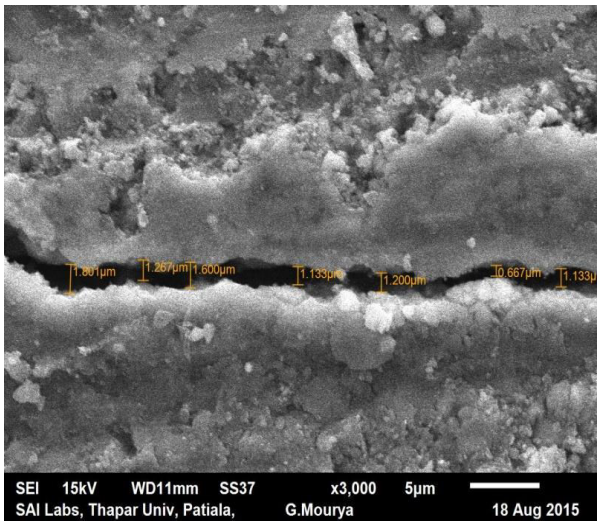
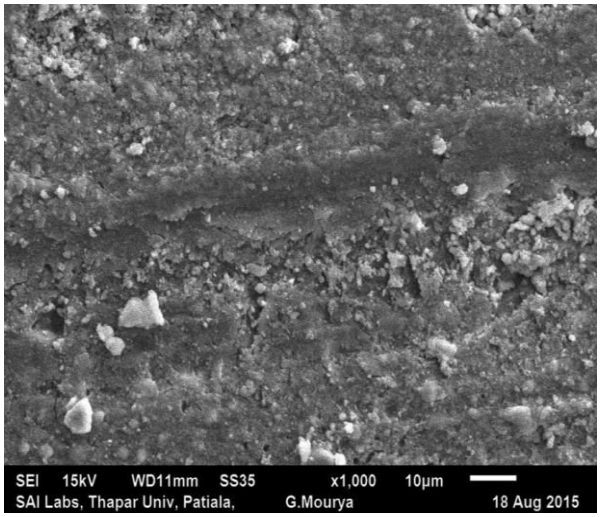


Figure 3: Sample (TheraCal LC block) showing absence of gap in subgroup C1



DISCUSSION

In today's modern world scenario, restoration forms an indispensable part of rehabilitation part of dentistry. A proper treatment in conservative dentistry includes removing the diseased or injured part of the tooth cavity and restoring it with an appropriate tooth filling material which simulates the natural tooth anatomy and restore its function. For this, various restorative materials have been introduced into dentistry which include traditional materials like amalgam, glass ionomer, direct filling gold and cast metal alloy. All these materials have certain benefits as well as some drawbacks which had made the researcher to work continuously in the direction of developing newer and better restorative material.[3]

In the present study, significance of time of placement of composite over calcium silicate based materials i.e. MTA, Biodentine and TheraCal LC with and without bonding agent application was evaluated. The timing of placing the composite restoration on calcium silicate based materials and also the type of bond between these materials and composites have been a point of debate. Masaki Tsujimoto et al. (2013)[4] in 2013 undertook a study to determine the ideal time for placement of composite over MTA. The goal of this study was to compare the proper timing of composite placement over MTA, Biodentine and TheraCal LC by viewing the gap formation between the composite and calcium tri-silicate based material and bonding agent. In this study, Filtek Z350 XT, a nanofilled composite is used over the pulp capping materials i.e. MTA, Biodentine and TheraCal LC. Due to low filler loading, flowable composites have greater elasticity and flexibility. As a result of these properties, flowable composites show better adaptation to the cavity walls and can compensate for polymerization shrinkage of resin composite restorative materials.[5] **Nanotechnology** allowed the development of a composite with the strength and wear of a hybrid plus excellent polish retention and optical properties which has been incorporated in Filtek Z350 XT flowable composite. In addition the resin system of Filtek Z350 XT Flowable has been improved reduce shrinkage by almost 20% providing a lower shrinkage.[6] In this study, Adper Single Bond 2 Adhesive was used which is a total etch, visible-light activated dental bonding agent incorporating 10 percent by weight of 5nm diameter silica filler. As with the original Adper Single Bond Adhesive, Adper Single Bond 2 adhesive is indicated for direct light-cured restorative material as well as for the treatment of cervical sensitivity.

Adper Single Bond 2 adhesive contains the same components as the original Adper Single Bond adhesive: BisGMA, HEMA, dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids. Adper Single Bond 2 Adhesive is indicated for direct light-cured composite/compomer restorations, root surface desensitization, porcelain/composite repair, Porcelain veneers, crown & bridge, inlay/onlay, bonding amalgam.[7-10] In the present study, intergroup and intragroup comparison was done between a subgroup of one material and all other subgroups by using Duncan's test for both SEM and Vickers microhardness. The level of probability was set at 'p' value less than 0.05 which indicates statistically significant difference, while, 'p' value greater than 0.05 indicated no statistically significant difference in the results.

The results of this study favour the placement of composite over calcium silicate based materials almost immediately i.e. after setting of 10 minutes. But, since not much study have been conducted on TheraCal LC regarding long term behaviour of material in terms of strength and endurance. Hence, keeping in view the limitations of study, advanced research in direction of In vivo study is needed

CONCLUSION

From the above results, it can be concluded that composite restoration can be placed immediately over the calcium silicate based materials if proper manufacturer's instructions are followed while manipulation of calcium silicate based materials. In case of all three calcium silicate based materials, composite restoration can be done over all of them immediately after their setting i.e. after 10 minutes. However, if these materials are mixed as per manufacturer's instruction, composite material could be placed over these materials without affecting their hardness.

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