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Properties of different coronal restorations placed over MTA and Biodentine in direct pulp capping procedures - A review

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ABSTRACT:
Vital pulp therapy is a widely performed procedure following traumatic/mechanical or carious pulp exposure. It involves the placement of a biomaterial such as MTA or Biodentine over the exposed pulp for reparative dentinogenesis followed by coronal restoration to restore the form and function of the involved tooth structure. The choice of the restorative material is a significant factor for the prognosis of pulp therapy. the restorative material can also interact with the pulp capping agent and affect its properties. Thus this review aims to check the most compatible final restorative material with biomaterials like MTA and Biodentine. Methodology: PubMed, SCOPUS, Google Scholar databases were searched. Clinical studies and reviews were identified using electronic search. The parametersfocussed onwere the shear bond strength,Microleakage, time of restoration, surface characteristics and interface reactions between the biomaterials and final restorative materialsduring pulp capping procedures.Conclusion:Calcium silicate cements have a prolonged setting time due to which definitive restorative treatment should be delayed so as to achieve the desired properties of the biomaterial, although no ideal restorative material currently exists to facilitate single visit treatments, GIC restorations can be placed in single visit without significant loss of properties.

KEYWORDS: MTA, Biodentine, Permanent Restorative materials, Shear bond strength,Microleakage, timeOf restoration

I. INTRODUCTION:

Vital pulp therapy aims to maintain the coronal and radicular pulp in a viable healthy state. This is achieved by protecting the exposed pulpal tissue by means of a biomaterial. The management of these procedures involve placement of the biomaterials in the coronal portion of the root canal. Studies have shown that calcium hydroxide compounds were considered the gold standard for the same (1,2) but disadvantages such as extensive dentin formation leading to obliteration of the pulp chamber, its high solubility in oral fluids, a lack of adhesion and degradation following acid etching (3,4) and a lower rate of healing have limited their use and led to a shift to other calcium silicate based materials such as MTA and Biodentine.

MTA is hydrophilic in nature and sets by hydration,Its contact with blood, body fluids, and moisture is inevitable.But it complicates the same-visit application of the final adhesive restoration, which requires a relatively dry field. As a consequence, multiple appointments have to be scheduled, for setting reaction of MTA to complete.

Immediate placement of the final coronal restoration plays a very important role as it promotes a coronal seal and improves the prognosis of the treatment. Immediate coronal seal with a permanent restoration has been shown to lead to less microleakage and increased treatment success.

The success of these procedures depends on the final restorative material placed on the biomaterials and their interaction. Various factors need to be considered before placement of any restorative material on MTA and Biodentine, the type of material, correct time to restore, shear bond strength, microleakage, cavity adaptation, tensile strength, antimicrobial properties, interface and fracture patterns.

Resin composites and glass ionomer cements (GICs) due to their esthetic qualities have become very popular in restorative dentistry and are widely used as final restorations. These materials when placed over these pulp capping agents have to be compatible with the material and prevent the dislodgement of the unset MTA or Biodentine during the etching and rinsing procedure for resin composites or during placement of Glass ionomer cements.

Thus, this review was done to find the ideal final restorative material which is most

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compatible with novel biomaterials, MTA and Biodentine.

Aim- The aim of this review was to analyse the various final restorative materials (composite and GIC) placed following pulp capping with MTA/Biodentine.

II. MATERIALS AND METHODS:

- Search databases included-
- Pubmed
- Google scholar

- Keywords used to search-

MTA, Biodentine, Restorative materials, Shear bond strength,Microleakage, time to restore

- Inclusion criteria
- In vitro studies
- Studies comparing composite and GIC as final restorative materials after pulp capping with either MTA or Biodentine
- Full text
- From the year 2000

- Exclusion criteria
- Case reports/series
- Animal studies
- Human studies
- Studies not meeting the inclusion criteria

III. DISCUSSION:

1. SHEAR BOND STRENGTH

The bond between the restorative materials and the cavity liner is an important factor determining the prognosis of restorative treatments. Studies have shown that an estimated bond strength ranging from 17 MPa to 20 MPa may be required to resist contraction forces sufficiently to constitute gap-free restoration margins (1,2)

Nandini et al,2007 reported that placement of glass ionomer over MTA resulted in either of two mechanisms-the carboxyl ions of the polyacrylic acid interact with the calcium ions of MTA to form calcium salts or the silicate hydrate gel of the MTA could condense with the silicate hydrate gel of the GIC. A deposition of calcium salts at the interface of the 2 materials was seen and due to their similar ion composition , the shear bond strength was not affected by contact with partially set MTA.

The adhesive system employed and the type of composite was also seen to effect the resultant shear bond strength to biomaterials. Studies by Atabek et al reported that total etch adhesive systems demonstrated higher SBS compared to self etching adhesives as the phosphoric acid produced microporosity which were deeper and more retentive on the underlying MTA.The acid etch procedures created a minimal loss of matrix around the crystalline structure resulting in a honeycomb etched pattern. However, Neelakantan et al found that 1 step self-etch adhesives showed higher SBS to MTA than 2 step self-etch adhesives and etch and rinse adhesives.

Biodentine was shown to exhibit higher SBS with composite using the 2 step self- etch adhesives compared to 1 step self-etch and etch and rinse adhesives according to Odabas et al.Cantekin et al, showed that the highest shear bond strength exists between Biodentine and methacrylate based composite,when compared to other restorative material like GIC or silorane based composite. While MTA exhibits highest bond strength with methacrylate-based composites when compared to silorane based material and GIC.

Mean Shear strength values in MPa

Study	Materials	COMPOSITE	
		MTA	BIODENTINE
Serin et al, 2018	Silorane based composite: FiltekSilorane System Adhesive, Self-etch, 3M ESPE, USA FiltekSilorane Low-shrinkage Posterior Restorative, 3M ESPE, USA	After 24 hrs Methacrylate based-- 10.5± 3.5 Silorane based-11.1± 4.7	-

	Methacrylate based composite: Clearfil SE Bond primer, Kuraray Medical Inc., Okayama, Japan Clearfil SE Bond Bond, Kuraray Medical Inc., Okayama, Japan Filtek Z250, 3M ESPE		
Cantekin et al,	Proroot MTA Septodont Biodentine Aelite all purpose body methacrylate based composite Filteksilorane composite	Methacrylate based- 8.9 ±5.7 Silorane based 7.4± 3.3	Methacrylate based 17.7± 6.2 Silorane based 8.0± 3.6
Tulumbaci et al,	MTA – proroot Septodont Biodentine Composite-Filtek™ Z250 Compomer -Dyract XP	Composite -18.69 (72 hrs) Compomer – 21 (72 hrs)	Composite-9.34 (72 hrs) Compomer-7.58 (72 hrs)
Ajami et al, 2013	Adper TM Single Bond, 3M ESPE Dental Products, St. Paul, USA composite resin (Filtek TM Z250, A2 shade, 3M ESPE Dental Products, St. Paul, USA	After 24 hrs 12.12 ± 2.31	
Altunsoy et al ,2015	Self adhesive flowable composite-Vertise Flow Kerr, Orange, CA X-tra base Voco GmbH, Cuxhaven, Germany, Futurabond DC VocoGmbH , Cuxhaven, Germany	Vertise flow- 2.01 ±0.6 XTRA base-2.17 ±0.9	Vertise flow-1.2 ±0.5 Xtra base-1.69 ±0.3

Study	Materials	GIC	
		MTA	BIODENTINE

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Cantekin et al,	Pro root MTA Septodont Biodentine GC fuji IX GIC	5.8 ±3.2	6.7± 2.6
Yesilyurt et al,	Ketac molar -3M ESPE Fuji IX – GC	Ketac molar – 8.85± 2.68 (45 mins) 9.16 ±2.96 (72hrs) Fuji IX- 9.34± 4.51 (45 mins) 9.96 ±3.84 (72 hrs)	-
Tulumbaci et al,	RMGIC- Photac-Fil Quick Aplicap	RMGIC- 2.54 (72 hrs)	RMGIC- 2.59(72 hrs)
Ajami et al,2013	RMGI Fuji II LC, CG Corp., Tokyo, Japan	After 24 hrs RMGIC-3.24± 0.58	

The studies included showed high variance in sample preparation and time of restoration which resulted in varying shear bond strengths. However,MTA was seen to exhibit sufficient SBS with GIC following 45 minutes of setting while for composite,restorations following a period of 24 hrs of MTA setting provided good results.

2. MODES OF FAILURE:

Failure by means of fracture occurs by 3 main types, Adhesive fracture occurs due toFailure between MTA/Biodentine materials and restorative materials,Cohesive fracture by failure within the MTA/Biodentine materials or restorative materials and Mixed fracture wherein both adhesive and cohesive failures occur.

In a study by Tambucci et al, it was shown that samples restored with composite resin,compomer and GIC following MTA or Biodentine pulp capping, majority of MTA samples were prone to adhesive fractures while most Biodentine samples showed cohesive fractures. It was observed that samples exhibiting high bond strength showed cohesive failure while samples with low bond strength showed adhesive failure.Camilleri et al showed that placement of GIC on partially set MTA resulted in a withdrawal of water from MTA into GIC and the materials drifting away from each ,this could result in adhesive fractures.On comparison of the failure modes seen in MTA bonded to 2 different types of composites- siloranebased , methacrylate based, mixed failures were seen in all restorations. Most cohesive failures were seen within GIC, while adhesive failures were seen associated to lower bond strength,Serin et al,2018. Study by Palma et al reported cohesive failures in all samples of MTA regardless of the restorative material while Biodentine samples showed differing patterns of fracture based on time of restoration, samples restored 12 minutes after setting of Biodentine exhibited cohesive failures while those restored 7 days later exhibited adhesive failures

3. TIME TO RESTORE-

Shift from the Calcium silicate materials to the novel biomaterials for treatment of immature necrotic teeth is seen currently.

During vital pulp therapy, these biomaterials have to be placed in the coronal portion of the root canal and the timing of placement of the final restoration will determine the outcome of the treatment. Various materials can be used as final restorative materials such as GIC or resin based composite materials. The perfect time to place these materials over MTA and Biodentine is essential to be known as they improve the Shear bond strength and the microhardness of the restoration. The placement time also affects the cohesive and the adhesive fracture patterns in the biomaterial-restoration interface.

Studies have shown that, MTA has a prolonged setting time of about 2hr 45min due to hydration and a second appointment would be required to allow for the completion of treatment whereas Biodentine(Septodont) has shown a faster setting time of just 12 mins.

A study by Palma et al,2018 has shown that MTA + GIC gives 1.14MPa bond strength. According to the American Association of

endodontics a layer of 2-3 mm of GIC must be placed over the biomaterial, this prevents the discolouration of the tooth which occurs due to MTA.

When MTA was tested with the resin-based composite (after 12 mins)= 1.13MPa strength was observed while after 7days with resin-based composite =3.06MPa strength was obtained

Biodentine with resin-based composite(after 12 mins) showed the highest strength of 4.44MPa and after 7days with resin-based composite-3.09MPa was obtained. Biodentine exhibits lesser discolouration as compared to MTA

The GIC specimens with MTA showed 50% fractures during handling and in MTA there was 100% cohesive fractures regardless of the timing of the restoration while Biodentine exhibited 50% cohesive fractures and adhesive fractures.

Another study by Tsujimoto et al,2013 compared correct time to restore MTA with composite with a bonding agent and without at time intervals of 10 mins, 1 day and 7 days found that with the use of a bonding agent there was no gap at the interface of MTA and composite for the 10 min,1 day or 7-day groups while without the bonding agent a gap was observed in the 10 min and the 7-day group of MTA and composite. The microhardness was reduced in the 1-day group irrespective of the presence or absence of the bonding agent.

MTA Angelus has a similar setting time as that of Biodentine, 15 mins, hence the type of MTA used also matters before placement of final restorative material

A study by Alena Schmidt et al, used MTA Angelus and various materials like Ionoseal(light curing composite), Vertise flow(self-curing composite), and Grandio flow(nanohybrid composite- pre-treated with Futura bond NR before placement on MTA) and all of them showed a better bond strength when placed after 2 days. Ionoseal and Vertise Flow showed a better bond with Biodentine of 5.13+/- 0.79MPa and 6.25+/-1.15MPa respectively, but Grandio Flow showed a better bond with MTA after 15 mins as well as after 2 days of 6.75+/-0.35MPa. Also, Biodentine exhibited more cohesive fractures but mostly they were of mixed type.

MTA exhibits more adhesive fractures when used with GIC as both of them set by hydration reactions and this causes an interface gap between the materials

Various studies have been done to check the use of conventional GIC and RMGIC and to check the bond of the final restorative material

A study by Ballal et al,2008 – showed that GIC can be layered over partially set MTA i.e after 45 mins, (shown similar to a study by Nandini et al), and can be used to finish the placement of final restorative material in a single visit. A moist cotton pellet was placed over MTA and a temporary filling was placed, then after 45 mins Type 2 GIC was placed after removing the temporary restoration and it was seen that when placed at 45 mins or after 4 days there were so craze lines but when GIC was placed after 4 hours many craze lines appeared and there was an interfacial gap observed at all the 3 times of 45ins, 4 hours and 4 days

Studies by Patil et al, 2015 and Ashraf et al, 2013 also showed similar results wherein they compared conventional GIC and RMGIC and saw that cohesive fractures were observed when RMGIC is placed over MTA as RMGIC contracts similar to that of resin-based composites and also interfacial gaps were observed when GIC was placed at any different time period. Patil et al, 2015 showed that the bond strength was better with conventional GIC than RMGIC and concluded that GIC can be placed over freshly mixed MTA but the effect decreases over time

Also, studies showed that self-etch adhesives are better than etch and rinse as etching and rinsing may wash out the unset MTA

Placement of final restorative material over Biodentine has not been explored much to our knowledge but the studies have shown that since Biodentine sets faster, it can be used when a single sitting procedure has to be done to place the final coronal restoration

4. MICROLEAKAGE-

The biomaterial and the final restoration placed over it should provide a good sealing ability and marginal adaptation- to prevent internal gaps and microleakage, which would lead to a failure of the procedure. The common restorative materials used are composites and GIC.

A study done to check the microleakage and internal gaps when composite is placed over MTA and Biodentine showed that MTA with composite showed 0.00+/- 0.00 and 6.08+/- 1.82 µm per unit while Biodentine with composite showed 0.00+/- 0.00 and 4.00+/- 1.39 µm per unit.

Another study showed that different time periods of placing the restoration also affects the strength and microleakage when placed on Biodentine, they compared between 3,15 min, 1 hour, 24, 48 hrs, 7 days and showed that when composite is placed after 24 hr of curing

Biodentine it showed the least microleakage and internal gaps and the best shear bond strength.

A study by Meraji et al, 2017 compared microleakage and bond strength between Biodentine and GIC and Biodentine and composites, they showed that the Biodentine and glass ionomer interface showed wide open space, and glass particles from the glass ionomer adhered to the surface of Biodentine. Also, elemental migration of aluminium, barium, fluorine, and ytterbium from the overlying composite resin was seen in Biodentine. They also found that the surface of Biodentine was altered when etched and that it showed the weakest bond and greater microleakage.

IV. RESULTS:

The type of restoration was seen to affect the properties of MTA and Biodentine. The shear bond strength was greatly affected by the time of restoration. While the type of failure and extent of microleakage resulted from the bonding between the biomaterial and the restorative material. The studies included exhibited varying values for properties assessed which can be attributed to differences in study designs. MTA showed favourable properties with GIC following 45 minutes of setting while delayed composite restorations after 24 hrs was preferred over Biomaterials to achieve desired properties.

V. CONCLUSION:

The above studies have shown that there is no perfect or ideal restorative material which has a proper seal and adaptability over MTA and Biodentine. A two-visit approach is ideal for better physical properties, but GIC can be used over both MTA and Biodentine after 45 mins and has showngood physical properties. In resin-based composites the self-etch adhesives have shown most promise. The quest to find an ideal restorative material satisfying all the ideal physical properties is still on.

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