A Comparative Evaluation of Shear Bond Strength of a Self-Adhering Flowable Composite and a Bulk-Fill flowable Composite to Pulp capping materials including NEO MTA PLUS, Dycal, Biodentine and MTA: In Vitro study

Abstract

Aim: The aim of this study was to compare the shear bond strength of a self- adhering flowable composite(SAFC) and bulk-fill composite to NEO MTA Plus,Dycal,Biodentine and MTA.

Material and method: Eighty acrylic blocks with 2mm deep central holes that were 4 mm in diameter were prepared and divided into 2 groups (n=40 each) according to the composite used (Dyad flow or SDR).They were further divided into 4 sub-groups according to the pulp capping agent used. SBS was tested using a universal testing machine at a crosshead speed of 1 mm/min .Data were analysed using One way ANOVA test, Post Hoc Tuckey test and independent t- Test was used.

Result: The intergroup comparison of mean shear bond strength between SDR and Dyad flow was statistically significant (_<0.05) with higher strength in SDR as compared to Dyad flow when analysed using independent t test.

Conclusion: Among the 8 sub-groups, the combination of Neo MTA Plus and SDR exhibited the highest shear bond strength.

Keywords: Biodentine, Bulk-fill composite, Dyad flow, Mineral trioxide aggregate, NEO MTA Plus,SDR.

INTRODUCTION

Following traumatic injuries or restorative procedures, normal dental pulp exposure may occur inadvertently. In this situation, vital pulp therapy is performed by placing direct pulp capping biocompatible materials to maintain the health and vitality of dental pulp.(1,2,3,) Vital pulp therapy is indicated in those cases where there are signs or symptoms of reversible or even irreversible pulpitis, and no periapical lesions of endodontic origin are present.(4) The purpose of the treatment is to maintain healthy pulp by sealing the pulp tissue against bacterial infiltration and forming dentine bridge at the

exposed site.(5) Pulp-capped teeth have to be sealed by restorative materials like amalgam or resin composite. Bond between restorative materials and pulp capping agents is very important and in the lack of a proper seal, permeation of bacteria into pulp and failure of pulp capping procedure will occur.(3) Therefore, the ideal bonding between pulp capping agents and restorative materia Traditionally, calcium hydroxide was used for this purpose since it is antimicrobial, has an alkaline pH, and stimulates mineralization. Dycal, a calcium hydroxide material, contains sulfonamide, butylenes glycol disalicylate, calcium phosphate, calcium tungstate, and oxides of zinc, iron, and titanium.(2) However, recent studies have also confirmed that calcium hydroxide is extremely toxic to cells in tissue culture and that it has some tissue altering and dissolving effects that might be responsible for the variable and somewhat unpredictable results, such as reparative dentin bridges containing multiple tunnel defects and aseptic necrosis.(6,7) This led to a decline in its use as a pulp-capping agent.

Mineral trioxide was introduced in 1993 and since then it has become a gold standard for many endodontic procedures. (8) MTA is comprised of calcium oxide in the form of tricalcium silicate, dicalcium silicate, tricalcium aluminate, and bismuth oxide for radiopacity. (9) MTA is a biocompatible material and has excellent sealing ability. It is claimed to provide double seal due to its physical sealing ability as well as ability to induce cementogenesis that provide biological seal. MTA has the ability to seal in the presence of moisture. (10) Long setting times and difficult handling are the main disadvantages of MTA. (11)

Materials based on tricalcium silicate with a reduced setting time have thus been introduced.Biodentine is a calcium silicate cement with dentin like mechanical properties, consisting of water, calcium chloride (decreases the setting time)and a hydrosoluble polymer (water reducing agent), the powder part of which composed of tricalcium silicate (main component), dicalcium silicate (second main component), zirconium oxide (radiopacifier) and calcium carbonate (filler component).(12,13) Biodentine has exhibited better

sealing ability, higher compressive strength, shorter setting time, lower microleakage, better antimicrobial properties, less toxic effects, and better biocompatibility, bioactivity and biomineralization compared to MTA.(14) Biodentine may be the viable choice for conducting “preventive” endodontics.(15) Biodentine has shown positive effects on vital pulp cells for stimulating tertiary dentin formation, and early formation of reparative dentin.(16)

NeoMTA Plus was developed with similar properties to MTA. It contains tricalcium silicate, dicalcium silicate, tantalum oxide, calcium sulfate and silica. Tantalum oxide was used instead of bismuth oxide as a radiopacifier. (17) It is mixed with a water-based gel that produces good handling properties. The powder to gel mixing ratio can be varied and a thin consistency can be used as an orthograde sealer or a thick mixture of root end filling material. (18,19) NeoMTA Plus is easily manipulated and remains in place without being washed out (due to its unique gel properties) and does not stain the tooth. (20)

The bond strength between pulp capping material and the overlying restoration is vital for the treatment success. A well-bonded adhesive joint between the restoration and the pulp capping agent can evenly spread stresses over the entire region of the bond. (21)

An ambitious step ahead was achieved by introducing self-adhering flowable composite (SAFC), uniting the advantage of both adhesive and restorative material technologies in a single application procedure (eighth generation).(22,23)

Dyad Flow is a newly introduced, self adhering flowable composite. Incorporation of an all all-in-one bonding system into the composite eliminates the requirement for adhesive application, reducing chair time.(2)

Bulk-fill composites were reported to promote less polymerization shrinkage stress than conventional microhybrid composite during and after the light curing process.(24)

Surefil SDR (Dentsply, konstanz, Germany) is a light cured bulk-filled, fluoride- containing, radiopaque material capable of generating an intimate contact with cavity surfaces.(25) Bulk-fill

composites(BFCs) have been introduced to reduce the time taken for placement and also increase the fracture resistance to Endodontically treated teeth (ETT). These materials can be placed in bulk layers upto 4-5 mm due to its enhanced translucency and low polymerization shrinkage stress.(26,27)
Therefore, the aim of the study is to compare the shear bond strength(SBS) of a self-adhering flowable composite(Dyad Flow) and a bulk-fill flowable composite (SDR) to pulp capping materials including NEO MTA Plus, Dycal, Biodentine and MTA.

Materials and Methods

Eighty acrylic blocks were prepared (2 cm in height and 2 cm internal diameter). A hole was drilled in the center of each block (diameter 4mm and 2 mm in depth). These 80 blocks were divided into following groups:

- Group I: Dyad Flow(n=40)

Subgroup I-a (n=10): NEO MTA Plus +Dyad Flow

Subgroup I-b (n=10): Dycal + Dyad Flow

Subgroup I-c (n=10): Biodentine Dyad Flow

Subgroup I-d (n=10): MTA+Dyad Flow

- Group II: SDR (n=40)

Subgroup II-a (n=10): NEO MTA Plus + SDR

Subgroup II-b (n=10): Dycal SDR

Subgroup II-c (n=10):Biodentine+SDR

Subgroup II-d (n=10): MTA+SDR

MTA; Dycal; NEO MTA Plus; and Biodentine will be placed in their respective blocks after mixing according to the manufacturer's instructions.All 80 blocks would be coded and incubated at 100% humidity and 37^0 C for 72 hours.

After incubation, Dyad Flow will be dispensed directly over the capping agents in group I blocks in 2 increments of 1 mm each, through a dispensing tip, using a plastic cylinder(2mm height and 2mm diameter). Each increment was light cured for 15-20 seconds using the LED unit.
In group II blocks (n=40), Optibond all-in-one self-etch adhesive was applied in 2 increments, each of which was light cured for 20 seconds using the LED unit. SDR will be then placed over the capping agents using a plastic spatula and light cured for 20 seconds using the LED unit. All the specimens were incubated at 100% humidity and 37^0 C for 24 hours.
The specimens were mounted in a universal testing machine and subjected to a shearing force using knife-edge blade at a crosshead speed 1 mm/min. The load at failure was recorded in Newtons (N), and the bond strength was calculated in megapascals (Mpa) by dividing the load at failure by th adhesive surface area (mm^2).
All specimens were subjected to gold sputtering using a plasma sputtering coater, followed by bond failure mode evaluation under SEM. The mode of bond failure will be categorized as adhesive, cohesive, or mixed.

Results

Data were analysed using SPSS version 23.0 version. The level of significance for the present study was fixed at 5%. Descriptive and analytical statistics were done. The intergroup comparison was done using the One Way ANOVA and independent t test followed by post hoc Analysis. The Shapiro-Wilk test was used to investigate the distribution of the data and levene's test to explore the homogeneity of the variables.
Table 1 shows mean and standard deviations of shearbond strength comparison between the Dylan flow and SDR composite resins used with 4 pulp capping materials.

INTERGROUP COMPARISON BETWEEN DYAD FLOW AND SDR

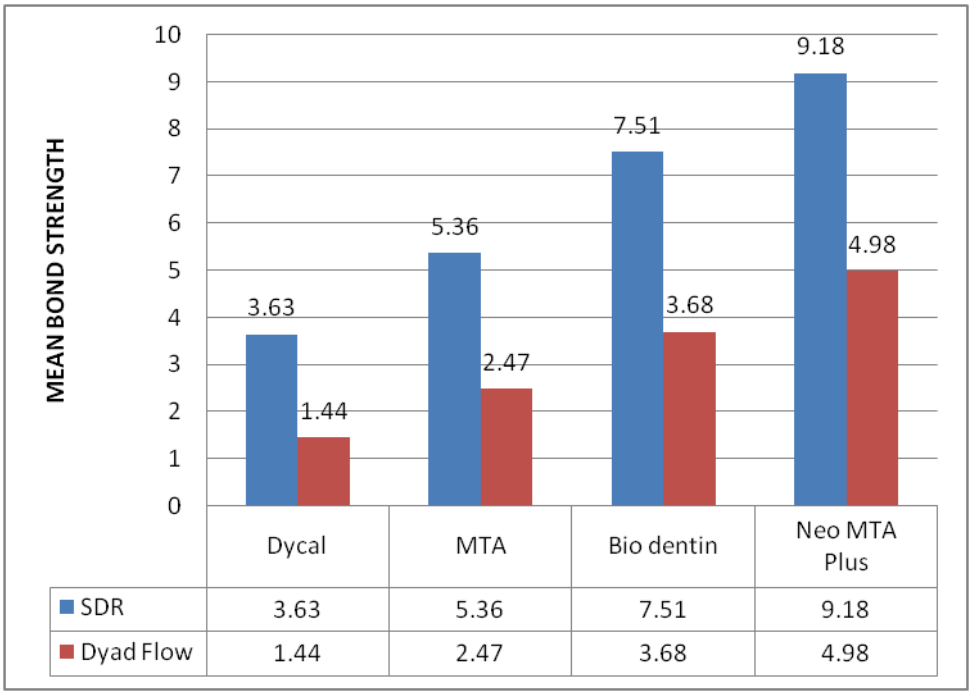
In the SDR Group the mean shear bond strength of Dycal was 3.63±1.29, in the MTA was 5.36±1.58, in the Biodentin was 7.51±1.72 and in the MTA plus was 9.18±1.27. In the Dyad Flow the mean shear bond strength of Dycal was 1.44±01, in the MTA was 2.47±1.17, in the Biodentin was 3.68±1.27 and in the MTA plus was 4.98±1.36.The intergroup comparison of

mean shear bond strength between SDR and Dyad Flow was statistically significant with higher strength in SDR as compared to Dyad Flow when analyzed using Independent t test

Table 1. INTERGROUP COMPARISON BETWEEN DYAD FLOW AND SDR

	SDR		Dyad Flow		
	Mean	Std. Deviation	Mean	Std. Deviation	P value
Dycal	3.63	1.29	1.44	1.01	0.001 (Sig)
MTA	5.36	1.58	2.47	1.17	0.001 (Sig)
Bio dentin	7.51	1.72	3.68	1.27	0.001 (Sig)
Neo MTA Plus	9.18	1.27	4.98	1.36	0.001 (Sig)

Fig. 1. Graphical presentation showing mean bond strength



DISCUSSION

Many tests are performed to measure the bond strength and clinical performance of composite resin, including shear, tensile, micro- shear and micro-tensile tests. In this study we used shear bond shear bond strength as a reliable and practical method.(28)

In restorative treatments involving a pulp exposure, since clinical findings and histological events do not often coincide, prediction of severity and type of the pulpal damage is almost impossible. The clinician, however, should make every effort to protect the vitality by elimination of caries and using biocompatible materials to provide strong barrier against bacterial microleakage.(29)

Dyad flow is one of a number of innovative resin based materials defined as self adhering resin composites. The etching, priming, bonding steps normally required to bond a resin composite to dentin and enamel are eliminated.(30)(31)(32) Dyad flow bonds to the tooth via micromechanical etching, facilitate by its low pH and chemical interactions between the phosphate groups in the monomer and the calcium ions in the tooth.(2)
Bulk-fill composite promotes less polymerisation shrinkage stress. The increased translucency of these resins are due to their incorporation of more photoinitiator reagents that allows for deeper photopolymerization and permits insertion of the material into thick 4 -5 mm increments, with uniform polymerization and degree of conversion.(33)(34)
Smart dentin replacement(SDR) is a type of bulk-fill composite. The SDR's stress relieving flowability and enhanced translucency that promotes light transmittance and better polymerization kinetic up to 4mm could be an additional factor for exhibiting lower cuspal deflection.(26)(35)

In the present study significant differences were found between the bond strength of the SDR and Dyad flow groups. According to the results, the shear bond strength of the SDR group was higher than the Dyad flow group. Dyad flow, a self adhering composite, did not require any adhesive application. However, in the SDR group, we used the OptiBond all-in-one self etch adhesive.(2) **Vichi et al** reported that dyad flow showed lower bond strength to dentin and enamel, but superior marginal sealing,ability in comparison with all-in-one adhesive systems.(36) A contributing factor to the low bond strength of self-adhesive flowable composites may be lack of compression force/pressure during placement, which is crucial to prevent open spaces on the interfaces, thereby affecting the longevity of the resin.(2)

The manufacturer of OptiBond claims that it contains 15% barium glass filler(0.04μ) that not only reinforces the hybrid layer but also penetrates well into dentinal tubules and forms a structural bonding,which is not seen in unfilled or nanofilled composite resins. This filler increases the bond strength to a tooth surfaces and prevent microleakage.(37)

Among the 4 capping agents used in our study, NEO MTA Plus and Dycal showed the highest (9.18 ± 1.27) and lowest (3.63 ± 1.29) SBS respectively.
NEO MTA Plus is a calcium silicate based cement. NEO MTA Plus has fine particle size,which can increase cement penetration into dentinal tubules resulting in improved bond strength and may speed up the hydration process.(38),(39) Dycal is a Calcium Hydroxide based material. The lower shear bond strength of Dycal can be explained by its tendency to release fewer calcium ions than calcium silicate - based material. Calcium ions are necessary for differentiation and mineralization of pulp cells.(40)
In the present study Biodentine showed higher SBS than MTA. Smaller and uniform components might have a role in better interlocking of Biodentine. Smaller particle size of biodentine affects the penetration of cement into dentinal tubules in tag like structure leading to a micromechanical anchor.(41),(42) Furthermore, presence of calcium chloride increases its resistance to displacement, thereby increasing its bond strength.(2) Also Biodentine induces tertiary dentin formation and has a shorter setting time when compared to MTA. (11) Tulumbaci et al reported that MTA bonded better to compomer and composite than Biodentine.(43) However Cantekin and Avci showed that Biodentine displayed a higher SBS to methacrylate based composites.(44)
MTA is composed of calcium oxide in the form of tricalcium silicate, dicalcium silicate, tricalcium illuminate, and bismuth oxide as the radio opacifying agent.(45)(46)(47) Disadvantages of MTA are that it is highly soluble,causes discolouration and has a prolonged setting time.(48)(49)
NEO MTA Plus is a novel calcium silicate based cement. It has tantalum oxide as an radiopacifying agent instead of bismuth oxide. It imparts good handling properties and does not stain the tooth. In several studies it has been mentioned that bismuth oxide causes tooth discoloration.(50)(51)(52)(53)(54) The calcium and hydroxyl ions release

was greater and more prolonged, which is essential for induction and formation of mineralised tissue. Additionally it shows the potential to form calcium phosphate layer.(55)(56) NEO MTA Plus stimulates tissue repair and may be bioactive.(57)(58) In some studies this material has shown biocompatibility with human dental pulp stem cells.(59)It can also be used for root canal treatment of primary successors molars without successors based on radiographic evidence.(60)
NEO MTA Plus has several advantages in terms of handling, setting time, resistance to washout, and improved formulation.(59)(61)
After the SBS analysis of the specimens, the failure modes were evaluated under SEM and recorded as adhesive(2 flat surfaces,failure at the capping agent-composite interface), cohesive (failure within the capping agent or composite), or mixed (combination of adhesive and cohesive)(2)
The dominant failure mode was cohesive. The tendency towards cohesive fracture might be attributed towards to the uneven distribution of stresses within the bonded materials, resulting in early failure before the bonded surface affected.(14) Consequently it can be said that the pulp capping materials may be present a higher SBS to composites when cohesive failure is absent.

Conclusions

Within the limitations of this study,it was observed that both self-adhering composite and bulk fill flowable composite showed the highest SBS with NEO MTA Plus, followed by biodentine,MTA, and Dycal. The bulk-fill flowable composite bonded better than self adhering flowable composite in comparisons using the same pulp capping agent.
Thus it can be concluded that Neo MTA Plus might be favoured as a pulp capping agent due to its higher SBS. Between two types of composites, bulk fill flowable composite might be preferred over self adhering flowable composite use over the pulp capping agents.

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