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Comparative Evaluation of the Shear Bond Strength and Mode of Fracture of Different Core Materials - An in Vitro Study

Dr. Akshata Rudagi[1], Dr. Laxmikant Kamatagi[2], Dr. Prahlad Saraf[3], Dr. Rashmi[4], Dr. Sneha Vanaki[5], Dr. Pradip Chigdani[6]

[1]Post Graduate

[2]MDS, Professor

[3]MDS, Professor and Head

[4]MDS, Reader

[5]MDS, Reader

[6]MDS, Senior Lecturer

Abstract: ***Background: Core build up is one of the important steps in the success of root canal treatment. It serves to restore severely damaged teeth, and become an integral part of the tooth structure. Mastication is related to the shear phenomenon, and shear bond strength measures the bond between the restorative material and tooth. Hence, the present study aimed at evaluation of the shear bond strength of different core build up materials using universal testing machine and mode of fracture using Scanning Electron Microscope. Objectives: To compare and evaluate the shear bond strength of different core build up materials. Materials and methods: A total of 20 human molars were selected and were decoronated at the level of CEJ. They were randomly divided into 4 groups (n=5) and core build up was done with all groups. Group 1 MultiCore, Group 2 Rebuilda DC, Group 3 Type 9 GIC, Group 4 Miracle Mix. After core build up was done samples of all groups were loaded in the Universal Testing Machine to evaluate the shear bond strength. Later the samples were evaluated for mode of fracture using Scanning Electron Microscope. Results: MultiCore and Rebilda DC showed maximum shear bond strength and cohesive failures. Conclusion: MultiCore and Rebilda DC showed maximum shear bond strength and cohesive failures followed by GIC. Miracle mix showed least SBS and maximum adhesive failure.***

Keywords: Adhesive failure, Cohesive failure, Core Build up, Shear Bond Strength

1. Introduction

Core build-up is one of the most important steps to restore a severely damaged, fractured or extensively carious tooth. As the core becomes an integral part of the load bearing structure of the tooth, it should provide resistance and retention form for the coronal restoration and possess sufficient strength to resist occlusal forces.[1]Endodontically treated teeth are more susceptible to fracture in comparison to healthy teeth. Access cavity preparation leading to loss of coronal structure is a critical cause for the weakening of tooth structure and consequent tooth fracture.Thus, the material used for core build-up has both structural and functional roles.[2]The process of mastication is basically related to shearing phenomenon and the true nature of the adhesive strength of materials at the tooth and restoration interface is described by the shear bond strength (SBS). SBS test is the most common method to evaluate bond strength, as testing in shear mode is more clinically relevant and relatively simple, reproducible, and widely accepted test.[1] Mode of fracture determines the bond strength between teeth and restorative material.

Hence, the aim of this study was to determine shear bond strength and mode of fracture of different core materials using Universal Testing machine and SEM.

2. Materials and Methods

A total of 20 human molars were selected and were decoronated at the level of CEJ. They were randomly divided into 4 groups (n=5) and embedded in acrylic cylinders. Core build up was done with all groups according to the manufacturer's instructions.

The Following core materials were used for core build-up:

- Group 1 - MultiCore Flow (Ivoclar)
- Group 2 - Rebilda DC (VOCO)
- Group 3 - Type IX GIC (GC)
- Group 4 - Miracle Mix (Shofu)

Samples decoronated at level of CEJ

Core build up done

The shear bond strength was tested using an Universal Testing Machine UNITEST 10 at 1.0 mm/minutes. The fracture sites along the dentin core materials interface was evaluated by Scanning electron microscope (Ultra 55, field emission scanning electron microscope, Karl Zeiss) to determine whether the fracture was adhesive or cohesive in nature.

Statistical analysis was done using Kruskal Wallis Test followed by Mann Whitney Post hoc test was used to compare the mean Shear Bond Strength between different groups.

The level of significance [P-Value] was set at $P<0.05$.Statistical analysis was done on SPSS Version 22.0 Armonk, NY: IBM Corp.

3. Results

The test result showed the mean Shear Bond Strength for Group 1 was 17.512 ± 2.785, Group 2 was 17.196 ± 2.164, Group 3 was 1.982 ± 0.627 and Group 4 was 2.774 ± 1.129. The difference in the mean Shear Bond Strength between 4 groups was statistically significant at $P<0.001$.

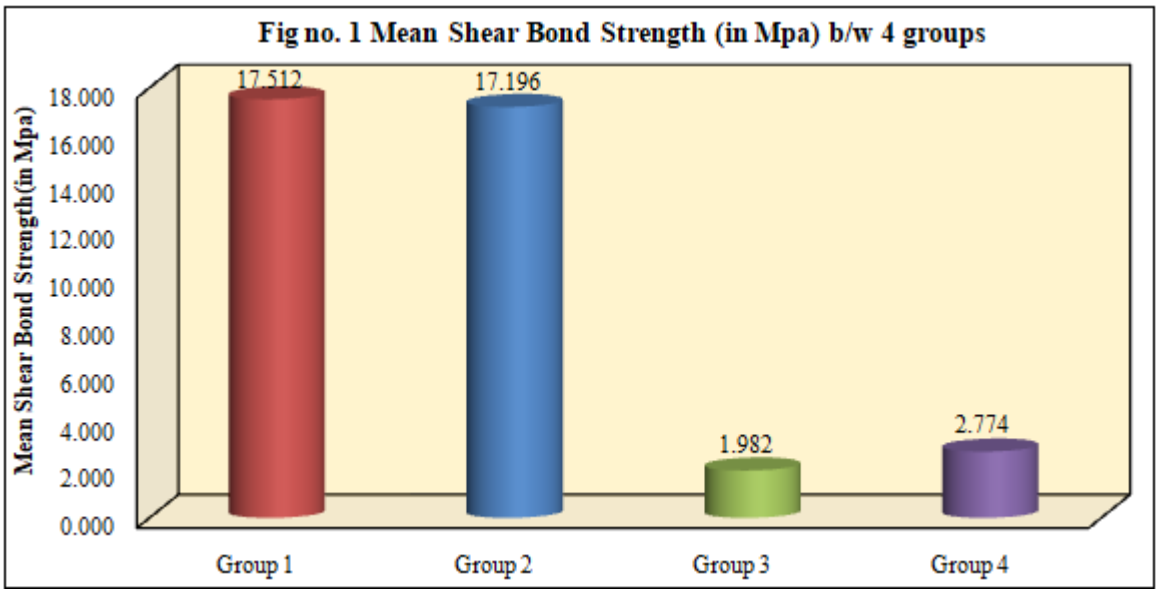
Multiple comparison of mean differences between groups showed that both Group 1 showed significantly higher mean Shear Bond Strength as compared to Group 3 & Group 4 at $P<0.001$.This was then followed next with Group 2 showing significantly higher mean Shear Bond Strength as compared to Group 3 & Group 4 at $P<0.001$. However, Group 1 showed a relatively higher mean shear bond strength as compared to Group 2 and similarly, Group 4 showed a relatively higher mean shear bond strength as compared to Group 3, there was no significant difference between Group 1 &Group 2 [P=0.92] and between Group 3 & Group 4 [P=0.25].

Table 1

Comparison of mean Shear Bond Strength (in Mpa) b/w 4 groups using Kruskal Wallis Test

Groups	N	Mean	SD	Min	Max	P-Value
Group 1	5	17.512	2.785	14.81	21.58	<0.001*
Group 2	5	17.196	2.164	14.54	19.96	
Group 3	5	1.982	0.627	1.25	2.67	
Group 4	5	2.774	1.129	1.13	3.89	

* - Statistically Significant



Graph 1

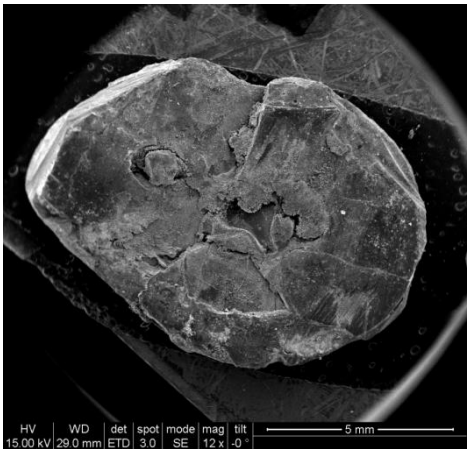
The following three types of fracture were found to occur:

Adhesive failure: when the fracture mode occurs or present at the junction of core and tooth surface.

Cohesive failure: when the fracture mode within the core material.

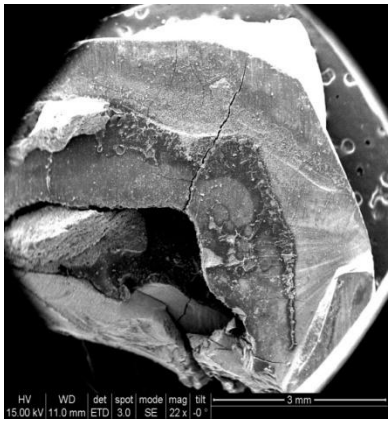
Mixed failure: when the fracture mode is at both the material and at the junction of core and tooth surface.

In samples of MultiCore, Rebilda DC & Type 9 GIC90% of samples showed cohesive failures whereas 20 % of samples showed adhesive and cohesive fractures. Less than 10% of the samples showed adhesive fractures. Miracle Mix showed maximum adhesive failure.



SEM Image of Sample Showing Adhesive and Cohesive Failure

SEM Image of Sample Showing Adhesive Failure



SEM Image of Sample Showing Cohesive Failure

Chart showing Mode of Fracture:

Type of failure	Multicore	Rebilda DC	Type IX GIC	Miracle Mix
Sample number	Group 1	Group 2	Group 3	Group 4
1	C	A+C	C	C
2	C	A+C	C	C
3	C	C	C	C
4	C	A	A	C
5	A	A	A+C	C
6	C	C	C	A
7	A+C	C	A	C
8	C	C	C	A
9	C	A	A	A
10	C	C	A	C
11	A	C	A	A
12	C	C	C	A+C
13	C	C	A	A
14	A+C	A	A	C
15	A+C	C	A+C	A
16	A	A	C	C
17	C	C	A	C
18	C	A+C	A	C
19	A	A	A	C
20	C	C	A	C

A- Adhesive Failure
C- Cohesive failure
A+C- Adhesive + Cohesive failure

4. Discussion

In endodontics, core materials are used to rehabilitate the endodontically treated mutilated tooth, to act as a post endodontic restoration and receive a full coverage restoration.As the core build up restorations are thicker restorations, the chemical curing capability is considered an added advantage. On light curing, however, the intensity of the light is greatest at the surface and generally decreases as it penetrates deeper within the material.

The mean shear bond strength of MultiCore Flow and Rebilda DC showed the highest values with 17. 51MPaand 17.19 MPa respectively. The highest mean SBS of Multicore &Rebilda DC can be attributed to the presence of nanofillersflourides and silicone dioxide (approximate 5 wt%) in adhesive used. They also have the added advantage of being esthetic materials.

This was followed by Type 9 GIC and Miracle Mix showed the least SBS. Type IX GIC are characterized by having smaller glass particles and higher powder: Liquid ratio. This is said to give them higher strength, greater wear resistance, and flexural strength as compared to Miracle Mix, since they bind chemically to the tooth structure.

The SBS of Miracle Mix is lowest, because the cement is brittle and fractures easily. They have inferior mechanical properties like low fracture toughness, tensile strength, and brittleness as compared to Fuji type IX glass ionomers.

When specimens were observed under Scanning Electron Microscope adhesive, cohesive and mixed types of failures were observed.

90 % of samples with MultiCore Flow and Rebilda DC showed Cohesive failures, 20% of samples showed mixed failures and less than 10% showed adhesive failures. This can be attributed due to higher adhesive bond between tooth/restoration interface due to bonding agent. Cohesive failures are preferable than adhesive failures since repair of restoration is easier, and more importantly tooth/restoration bond remains intact decreasing microleakage and sensitivity till the repair is done.

Type IX GIC also showed similar bond failures as MultiCore Flow and Rebilda Dc. The chemical adhesion of GIC has since long considered a major advantage of this cement.

Miracle Mix showed maximum adhesive failure. It is a mixture of silver alloy particles and GIC particles, to improve strength of conventional GIC. It lacks good adhesion mostly due to the fact that GIC particles in the cement act like a foreign material and hence forming inadequate bond to the tooth, and hence fails at tooth/restoration interface.

A deep understanding of the nature of materials can enable the practitioner to choose the appropriate core materials according to the clinical situation, ultimately leading to optimal restorations and higher success.

5. Conclusion

Within the limitations of this in vitro study, the following conclusions were drawn:

1) MultiCore and Rebilda DC showed maximum shear bond strength.
2) The shear bond strength of type 9 GIC showed less shear bond strength than multicore and rebilda but higher than miracle mix.
3) Miracle Mix showed least shear bond strength among all groups.
4) Multicore and Rebilda should be used as a core build up material in situations where there is significant loss of tooth structure, as well as in anterior esthetic zone.

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