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COMPARATIVE EVALUATION OF COMPRESSIVE STRENGTH OF FOUR RECENT CORE BUILDS UP MATERIALS: AN IN VITRO STUDY

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ABSTRACT

Context: Mechanical properties such as compressive strength of core build up materials play an important role in efficacy and longevity of the tooth and its restoration. Since majority of the masticatory forces in the posterior region are of compressive nature, the compressive strength of the restorative material should be high enough to resist fracture. **Aims:** To compare the compressive strength of four different core build up materials Paracore, Luxacore Z Dual, Fluorocore and Multicore. **Methods and Material:** A total of 40 specimens divided into four groups, 10 of each material were fabricated and subjected the universal testing machine to determine the compressive strength of each. Readings were recorded in each group and compared using one factor analysis of variance (ANOVA) after ascertaining normality by Shapiro-Wilk's test and homogeneity of variance between groups by Levene's test and the significance of mean difference between the groups was done by Bonferronis's post hoc test after adjusting for multiple contrasts. Analyses were performed on SPSS software (Windows version 17.0). The differences observed between the groups were statistically significant. **Results:** Group 1 namely Paracore showed the highest compressive strength than the rest of the groups. **Conclusions:** It was concluded that Paracore is the best suited material for core build up.

KEYWORDS: Compressive strength, Core build up, Composites.

INTRODUCTION

Dental treatment and techniques have evolved from "extracting the infected tooth" to "treating the infected tooth". Endodontic therapy has traversed a serpentine course so far. In the current scenario, a grossly decayed tooth having little or no crown structure is effectively used to support a restoration. It thereby restores function and aesthetics, also provides psychological comfort to the patient. Special techniques have to be considered when we need to restore such mutilated teeth in order to attain a good prognosis.[1] With advances in restoration of endodontically treated teeth, post and core system has emerged as an option to build up the lost tooth structure. The post is that part which engages the radicular dentin to achieve retention and the core replaces the coronal portion of the crown. This can be fabricated in metal as one piece –casted restoration or could be a separate post with a core buildup.[2]

Core build-up materials are those which are used to repair the damaged tooth structure before the crown preparation is done and stabilize the weakened parts of the tooth. So it can be stated that they are a key part of the preparation for an indirect restoration consisting of a restorative material.[3] Cores provide retention and resistance form for crowns and behave as transitional restorations before crown preparation.[4]

An ideal core build-up material must possess excellent mechanical properties in order to resist the stresses that may be produced during function, providing unbiased stress distributions of forces and decreasing the probability of tensile and compressive failures.[3] Strength is not the only criteria for selection of core material, but it is crucial. Stronger core materials better resist deformation and fracture, provide fair stress distributions, and reduce probability of tensile and compressive failure, leading to greater stability and higher probability of clinical success. If other variables are considered to be equal, the strongest core material is indicated.[5]

The strength of a material can be described by tensile strength, shear strength, flexural strength and compressive strength, each of which is a measure of stress required to fracture a material. In the oral environment shear failure is likely not to occur due to four reasons:

1) many brittle materials in restored tooth surfaces generally have rough curved surfaces
2) Presence of chamfers, bevels, or changes in curvature of a bonded tooth surface would make shear failure of a bonded material highly unlikely to occur
3) to produce shear failure, the applied force must be located immediately adjacent to the interface
4) tensile strength of brittle materials is usually well below their shear strength values, tensile failure is hence more likely to occur.[6]

Compressive strength is considered to be a crucial indicator of success because a high compressive strength is necessary to resist masticatory and para functional forces. According to Philips[6] compressive strength is the capacity of a material or structure to withstand axially directed pushing forces. It provides data of force versus deformation for the conditions of the test method.

Amalgam has been used traditionally as a build-up material for more than 150 years now. There are some advantages of dental amalgam as a restorative material such as amalgam being strong in bulk section, it not being technique sensitive and it being sealed by corrosion products .The compressive strength of dental amalgam as per literature is 380 − 540 MPa, which develops progressively after trituration. The well-known disadvantages of amalgam such as slow setting process, lack of adhesion to the tooth structure, weak in thin section, mercury content and color, are the reasons why alternative core build-up materials have been developed.[7]

Glass IonomerCements(GICs) for restorative dentistry were developed by the end of the 1960’s and were first described by Wilson and Kent in 197.[8] Many properties of glass-ionomer cements such as fluoride release, adhesion to tooth structure, ease of placement and biocompatibility made these materials attractive for their use in practice. The main problem in using glass-ionomer as a core material arose from low compressive (150 MPa) strength and the role of water in the setting reaction. In order to improve the physical properties of Glass Ionomer Cements, several modifications were done. One of the major developments in this direction was the addition of silver particles to Glass Ionomer Cement (Miracle Mix) which significantly increases its strength, however in vitro studies showed opposing results. [9] Glass Ionomer Cement with Resin adheres to both enamel and dentin encouraging clinicians to select such materials in core build up procedures.

Composite resins are clinically proven dental restorative materials that were developed in the beginning of 1960’s. Composite resins were used because of their appearance, convenience of a single visit core placement and preparation, avoiding mercury controversy and strong dentin bond strengths (11−28 MPa). Compared to glass ionomers, composites proved to be superior in respect to their mechanical properties. Composite resins also had some pitfalls such as high technique sensitiveness, difficulties in distinguishing tooth from core during preparation and dentine bond rupture by polymerization contraction.[7]

Improvements in composites and the development in dentin bonding systems have lead to the development of more conservative techniques, which allow increased opportunities to preserve the badly broken down teeth. Recently core build up materials such as flow composite materials have been introduced. There are, however concerns that the mechanical properties of these materials, which incorporate less filler content, could be reduced to allow flowability since fillers have been reported to improve the mechanical properties of bis-GMA-based dental resin . This suggests that flowable materials with less filler content might be mechanically weaker than their more filled counterparts.[3]

The present in – vitro study is being undertaken to evaluate the compressive strength of four different direct core build up materials:

- Para Core (ColteneWhaledent , USA)
- Luxacore Z Dual (DMG –Dental Milestones Guaranteed , Germany)
- Fluorocore (Dentsply Caulk ,USA)
- Multi Core (IvoclarVivadent)

Para Core is a fiber reinforced, dual cure, and radiopaque core build up material. It exhibits a stackable, non slumpy consistency and is formulated to cut similar to dentin, allowing the bur to move smoothly between natural tooth structure and the material without creating troughs and grooves. It incorporates glass particles that impart high strength. Using Parabond adhesive along with Paracore provides excellent retention to enamel and dentin providing lasting restoration. Parabond is a composite cured self-conditioning adhesive.[9]

Luxacore Z Dual can be automatically mixed and dispensed with intraoral tips, has ideal flow properties allowing tooth substance, and posts to be totally surrounded, while avoiding gaps or air pockets , and is available in different shades. It has thorough and even distribution of nanoparticles throughout the resin matrix, resulting the virtual elimination of particle agglomeration. With the addition of Zirconium Oxide, the compressive strength and dentin like cutting characteristics of radiopaque Luxacore have been enhanced. It cuts and trims like dentin and is not too hard as many other core or general restorative composites tend to be.[10]

Fluoro Core composite build up material consists of two components, base plus catalyst which when mixed form dual cured highly filled resin core build up material.

Multi Core composite is a dual curing core build up material consisting of two components –base and catalyst and comes in four shades which provide an optimum foundation for the reconstruction of vital and non-vital teeth with part or most of the clinical crown missing.

These materials are being readily used in the modern day dentistry due to their desired properties which are required for maintaining the longevity of the teeth.

METHODOLOGY

A total of 100 specimens were made -25 of each material namely Paracore, Luxacore, Fluorocore, Muliticore for measuring compressive strength. The experimental variables of specimen size, shape, testing configuration, fabrication procedure, temperature, humidity, storage time, storage temperature, strain rate, and set time were all standardized in this study. All specimens were treated identically throughout this study, which is based on American Dental Association (ADA) Specification No. 27.

Preparation of Specimens

The specimen dimensions for each property were selected according to International Standards Organization (ISO) 4049 (ISO, 1992). Compressive strength was measured from cylindrical specimens, 4 × 6 mm. A two part stainless steel mold was used to prepare the specimens. The mold was placed on a glass slab and a mylar matrix will be placed under the mold to obtain flat surface. Composite resins were applied in the mold in 2 mm layers to fill the mold. For the last layer a mylar matrix was placed over the layer. Light curing was done with light curing unit for 40 seconds per layer. In order to have maximum curing, each specimen was post-cured 10 minutes after preparation for 60 seconds at all directions. Specimens were stored in distilled water at 37 ± 1°C prior to testing.

In Group I, there were 25 samples of Paracore, in Group II, there were 25 samples of Luxacore, in Group III, there were 25 samples of Fluorocore and in Group IV there were 25 samples of Multicore.

Measurement of properties

All tests were carried out on an Instron universal testing machine. A Universal testing machine, also known as the material testing machine or materials test frame, is used to test the compressive strength of materials. It is named “Universal” after the fact that it can perform many standard tensile and compression tests on materials, components and structures.

Compressive strength was determined at a-cross head speed of 0.5mm/min. Load was applied vertically on the lateral portion of the cylinder, producing tensile stresses perpendicular to the vertical plane passing through the centre of the specimen.

Compressive strength will be calculated using the formula:

$S=F/A$

where S is the compressive strength, expressed in MPa, F is the load needed to break the specimen, expressed in Newtons, and A is the area of the surface where the force is applied to the specimen, expressed in mm2.

RESULT

The observed compressive strength (MPa) of four groups is summarised in Table 1. It shows that the mean compressive strength of paracore was the highest followed by luxacore, multicore and flourocore the least (paracore > luxacore > multicore > flourocore).

Comparing the mean compressive strength of four groups, ANOVA showed significantly different compressive strength among the groups (F=10.43, P<0.001) (Table 2). Further, comparing the mean difference in compressive strength between groups, Bonferroni test showed significantly (P<0.05 or P<0.001) different and higher compressive strength in paracore as compared to luxacore (16.7%), flourocore (28.7%) and multicore (22.9%) (Table 3 and Fig.2).

Table 1: Summary statistics of compressive strength (Mpa) of four groups.

Groups	n	Min	Max	Mean	SE	Median	95% CI of mean
Paracore	25	25.13	60.67	40.90	1.96	39.89	36.86 to 44.94
Luxacore	25	22.67	46.50	34.07	1.39	33.60	31.19 to 36.95
Flourocore	25	20.31	43.05	29.15	1.26	29.35	26.55 to 31.74
Multicore	25	19.43	46.28	31.55	1.58	31.36	28.29 to 34.82

Table 2: Comparison of mean compressive strength between groups by ANOVA.

Source of variation (SV)	Sum of square (SS)	Degrees of freedom (df)	Mean square (MS)	F value	P value
Groups	1928.00	3	642.70	10.43	<0.001
Residual	5913.00	96	61.59		
Total	7841.00	99	704.29		

Table 3: Comparison of mean difference in compressive strength between groups by Bonferroni test.

Bonferroni's multiple momparison test	Mean Diff.	t value	P value	95% CI of diff
Paracore vs. Luxacore	6.83	3.08	P < 0.05	0.8498 to 12.81
Paracore vs. Flourocore	11.75	5.29	P < 0.001	5.772 to 17.73
Paracore vs. Multicore	9.35	4.21	P < 0.001	3.368 to 15.33
Luxacore vs. Flourocore	4.92	2.22	P > 0.05	-1.058 to 10.90
Luxacore vs. Multicore	2.52	1.13	P > 0.05	-3.462 to 8.498
Flourocore vs. Multicore	-2.40	1.08	P > 0.05	-8.384 to 3.576

*P<0.05 or ***P<0.001- as compared to Paracore

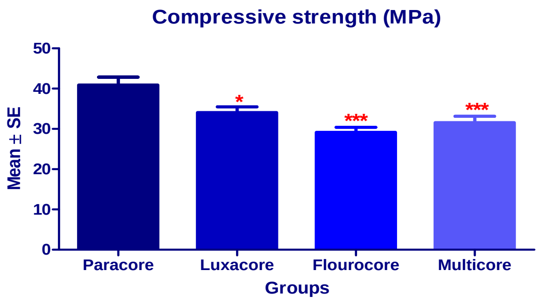

Fig. 2: Comparison of mean compressive strength between four groups.

DISCUSSION

With the advances in the field of conservative dentistry & endodontics, pulpally involved teeth which were formerly considered for extraction can now be retained. Due to the altered physical characteristics following endodontic therapy, all teeth need some form of restorative treatment. There are various core materials used in the past, such as Amalgam, Glass Ionomer Cement (GIC), Modified GIC and Composite Resin. Prepared composite resin cores have better strength than prepared GIC cores and prepared Amalgam Cores.[2] Composite resin cores have been widely used owing to their high compressive strength, good adhesive properties, low modulus of elasticity, and their economic affordability. Besides that, they are tooth colored, they do not darken the teeth. As they set quickly, core and tooth preparations can be completed using rotary instruments without delay.[5] From a variety of composite resin core materials available today, four materials were selected which are widely used in clinics these days viz Para Core , Luxacore Z Dual, Fluoro Core and MultiCore.[2]

The study was done using stainless steel cylindrical mould of 6mm length and 4 mm internal diameter to make standardized specimens. Antara Agarwal et al in their study also used these dimensions fror preparation of the samples.[11] Colotux 2.5 curing light of 400 Mw/cm^2 intensity was used for 40 seconds. Kramer[12] et al in his study postulated that all the core build up materials be subjected to polymerization by light curing unit for 40 seconds.

In the present study, the compressive strength testing was done with the help of Universal Testing Machine at a cross head speed of 0.5mm/min. This method was in accordance to the study done by Gulbin[13] who advocated the use of Universal Testing machine to evaluate the physical properties of core building materials.

The composition of a material plays a vital role in its mechanical properties. According to M.A Rafiee,[14] increasing the volume fraction of filler particles in composite resin would heighten the probability of fracture because the crack needs less energy in the less dense microstructure. Hence, minimal particle size leads to higher strength.

Considerable differences in compressive strengths were discerned among the four materials. The strongest material was Para Core and the differences in compressive strength of each group were statistically significant indicating clinical significance as well. Para Core shows excellent strength because the macroscopic size of the unidirectional fiber bundles used in fiber reinforces the resins and improves its mechanical properties. The presence of fibers affects the fracture process that results in interrupting crack growth progression and thus enhances the fracture toughness of the fiber reinforced composite material. Also it is a dual cure material which ensures complete cure, thereby improving the strength of the material.[11]

As manufacturers information regarding the tested materials is not conclusive, therefore further research will be helpful to establish these core build up materials as an ideal one imparting good strength along with good clinical success.

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