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AN IN VITRO EVALUATION OF COMPRESSIVE AND TENSILE STRENGTH OF FOUR RECENT CORE BUILD UP MATERIALS- A COMPARATIVE STUDY

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ABSTRACT

Context: Mechanical properties such as compressive strength and tensile strength of core build up materials play an important role in efficacy and longevity of the tooth and its restoration. **Aims:** To compare the compressive & tensile strength of four different core build up materials- Paracore, Luxacore Z Dual, Fluorocore and Multicore. **Methods and Material:** A total of 200 specimens divided into four groups, 50 of each material were fabricated and subjected the universal testing machine to determine the compressive strength & tensile 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:** Paracore showed the highest compressive strength and tensile strength than the rest of the materials. **Conclusions:** It was concluded that Paracore is the best suited material for core build up.

KEYWORDS: Compressive strength, Tensile 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.[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.[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.[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.
Tensile strength is important because dental restorations are exposed to tensile stresses from oblique or transverse loading of their complex geometric forms.[2]

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 and tensile strength of four different direct core build up materials:

- Para Core (Coltene Whaledent, USA)
- Luxacore Z Dual (DMG –Dental Milestones Guaranteed, Germany)
- Fluorocore (Dentsply Caulk, USA)
- Multi Core (Ivoclar Vivadent)

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.[7]

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.[8]

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.

METHODOLOGY

A total of 200 specimens were made -50 (25 for compressive strength and 25 for tensile strength) of each material namely Paracore, Luxacore, Fluorocore, Multicore. 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. Tensile strength was measured from dumb bell shaped specimens, 25mm in length and 5 mm in diameter. A two part stainless steel mold was used to prepare the specimens. 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.

Measurement of properties

All tests were carried out on an Instron universal testing machine. 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 was 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.

Tensile strength was determined at a cross head speed of 1 mm/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.

Tensile strength was calculated from the formula:

$$T = 2F/\pi dh,$$

Where F is the maximum applied load (N); d is the mean diameter of the specimen (mm); and h the length (height) of specimen (mm).

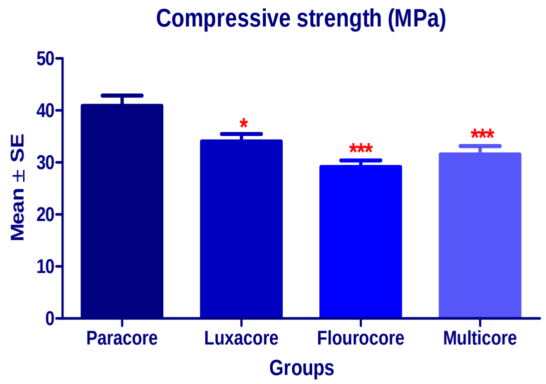
RESULT

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). 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%) (Fig.1).

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



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

Fig. 1. Comparison of mean compressive strength between four groups.

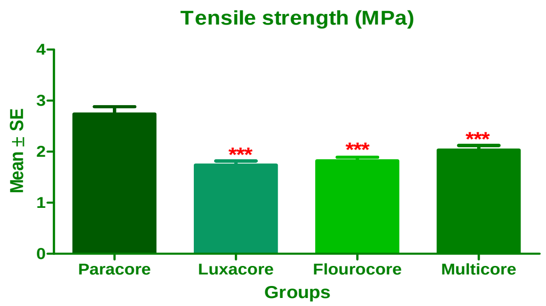
The observed tensile strength (MPa) of four groups is summarised in Table 2. Table 2 shows that the mean tensile strength of paracore was the highest followed by multicore, flourocore and luxacore the least (paracore > multicore > flourocore > luxacore).

Comparing the mean tensile strength of four groups, ANOVA showed significantly different tensile strength among the groups (F=20.26, P<0.001).

Further, comparing the mean difference in tensile strength between groups, Bonferroni test showed significantly (P<0.001) different and higher tensile strength in paracore as compared to luxacore (36.5%), flourocore (33.5%) and multicore (25.7%) (Fig. 2). However, it did not differ (P>0.05) between luxacore, flourocore and multicore i.e. found to be statistically the same.

Table 2: Summary statistics of tensile strength (Mpa) of four groups.

Groups	n	Min	Max	Mean	SE	Median	95% CI of mean
Paracore	25	1.25	3.90	2.74	0.14	2.78	2.44 to 3.04
Luxacore	25	1.12	2.65	1.74	0.08	1.64	1.58 to 1.90
Flourocore	25	1.14	2.48	1.82	0.07	1.86	1.67 to 1.97
Multicore	25	1.44	3.02	2.03	0.09	2.00	1.85 to 2.22



***P<0.001- as compared to Paracore

Fig 2. Comparison of mean tensile 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. 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.[9] Colotux 2.5 curing light of 400 Mw/cm^2 intensity was used for 40 seconds. Kramer[10] 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[11] who advocated the use of Universal Testing machine to evaluate the physical properties of core building materials. The tensile strength testing was done with the help of Universal Testing Machine at a cross head speed of 1 mm/min. This method was in accordance to the study done by Alvaro Della Bona et al[12] who advocated the same speed on Universal Testing machine to evaluate the tensile strength of core building materials.

The composition of a material plays a vital role in its mechanical properties. According to M.A Rafiee,[13] 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.

The determination of tensile strength by the direct application of tensile load is suspect given that external stresses are generated by gripping the samples during testing, with the effect that the results may incorporate unacceptable errors. One way to overcome this problem is to use dumb –bell shape and a diametral compression test. In accordance to study by Sheils Passos et al[3], dumb bell specimens of were used in the study.

In this type of testing, the specimen is submitted to a compressive load in the diametral plane, which is perpendicular to the longitudinal axis.[12] It was developed to investigate brittle materials with little or no plastic deformation. It is a common method for measuring tensile strength because it avoids some of the difficulties inherent in direct and flexural tensile testing.[14]

The diametral tensile strength test may reveal different values for apparently similar materials. However this variation has been explained by the difference between the polymer matrix, size of fillers and bond between fillers and matrix.[12]

Considerable differences in compressive strengths and tensile 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.[9]

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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