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COMPARATIVE EVALUATION OF TENSILE STRENGTH OF FOUR RECENT CORE BUILD UP MATERIALS: AN IN VITRO STUDY

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ABSTRACT
Context: Mechanical properties such as 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 tensile strength of four different core build up materials Paracore, Luxacore Z Dual, Fluorocore and Multicore. **Methods and Material:** A total of 100 specimens divided into four groups, 25 of each material were fabricated and subjected the universal testing machine to determine the 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:** Group 1 namely Paracore showed the highest tensile strength than the rest of the groups. **Conclusions:** It was concluded that Paracore is the best suited material for core build up in terms of tensile strength.

KEYWORDS: 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. 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 build up.[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]

Tensile strength is important because dental restorations are exposed to tensile stresses from oblique or transverse loading of their complex geometric forms.[7]

Tensile strength is generally determined by subjecting a rod, wire, or dumb bell shaped specimen to tensile loading(a uniaxial tension test). Since such a test is quite difficult to perform for brittle materials because of alignment and gripping problems, another test has become popular for determining the property for brittle dental materials. It is referred to as the diametral compression test. This test is used for materials that exhibit elastic deformation and little or no plastic deformation.[6]

The present in – vitro study is being undertaken to evaluate the 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. Using Parabond adhesive along with Paracore provides excellent retention to enamel and dentin providing lasting restoration. Parabond is a composite cured self conditioning adhesive.[8]

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.[9]

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 tensile 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). 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. 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 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.

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 will be 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).

RESULTS

The observed tensile strength (MPa) of four groups is summarised in Table 1. Table 1 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) (Table 2).

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%) (Table 3 and Fig. 3). However, it did not differ (P>0.05) between luxacore, flourocore and multicore i.e. found to be statistically the same (Table 3).

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

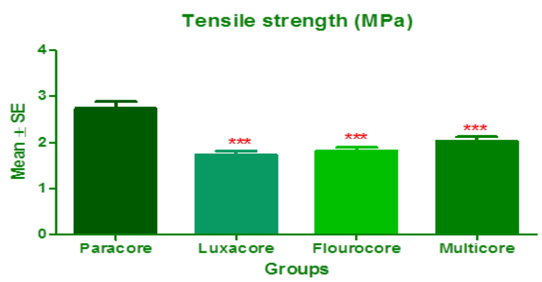
Groups	n	Min	Max	Mean	SE	Median	95% CI of mean
Paracore	25	1.25	3.90	2.74	0.14	2.78	2.44 to 3.04
Luxacore	25	1.12	2.65	1.74	0.08	1.64	1.58 to 1.90
Flourocore	25	1.14	2.48	1.82	0.07	1.86	1.67 to 1.97
Multicore	25	1.44	3.02	2.03	0.09	2.00	1.85 to 2.22

Table 2: Comparison of mean tensile 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	15.44	3	5.15	20.26	<0.001
Residual	24.38	96	0.25		
Total	39.82	99	5.40		

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

Bonferroni's multiple comparison Test	Mean Diff.	t value	P value	95% CI of diff
Paracore vs. Luxacore	1.00	7.00	P < 0.001	0.6140 to 1.382
Paracore vs. Flourocore	0.92	6.43	P < 0.001	0.5324 to 1.300
Paracore vs. Multicore	0.70	4.95	P < 0.001	0.3208 to 1.089
Luxacore vs. Flourocore	-0.08	0.57	P > 0.05	-0.4656 to 0.3024
Luxacore vs. Multicore	-0.29	2.06	P > 0.05	-0.6772 to 0.0908
Flourocore vs. Multicore	-0.21	1.48	P > 0.05	-0.5956 to 0.1724



***P<0.001- as compared to Paracore.

Fig. 3. 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. 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]

Considerable differences in tensile strengths were discerned among the four materials. The strongest material was Para Core and the differences in tensile strength of each group were statistically significant indicating clinical significance as well.

Colotux 2.5 curing light of 400 Mw/cm^2 intensity was used for 40 seconds. Kramer[13] 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 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[11] 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,[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.

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.[10]

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.[11] 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.[12]

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.[11]

As manufacturer’s 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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