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Comparative evaluation of the tensile and compressive strength of three light cured bulk-filled composite core build up material: An in vivo study

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***Abstract*---**Introduction- The loss of a considerable amount of tooth structure makes retention of subsequent restorations more problematic and increases likelihood of fracture during functional loading. Different clinical techniques are there, one such technique is

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post and core. An ideal core build- up material must present excellent mechanical properties to resist the stresses that may be produced during function, providing equitable stress distributions of forces and reducing probability of tensile and compressive failures. Recent developments in flowable and restorative composite resins have resulted in a greater total depth of cure—between 4 and 5 mm for some materials. Materials and Methods: study was conducted in the department of prosthodontics and crown and bridge, including implantology along with external laboratory support and molds for tensile and compressive strength were made. Result- Based on strength, Photocore and Multicore HB may be used as alternatives to Kerr Herculite Precise; however, other physical qualities should also be considered. Conclusion-Within limited data available on recent bulk fill material that is PLT, Kerr Herculite Precis more in vitro and in vivo studies should be held for long term success of the material.

Keywords---comparative evaluation, tensile, compressive strength, bulk-filled composite.

Introduction

Aesthetics demands, as well as the awareness of patients, have increased overthe years. Tooth- colored materials in dentistry have progressed to the point where they can now be used confidently in almost every restorative situation[1]. Dental treatment and techniques have evolved from “removing the infected tooth” to “treating the infected tooth,” and in the present day scenario, a grossly decayed tooth with a lost crown structure is effectively used to support restoration and thereby restoring function, aesthetics, and psychological comfort for the patient. Special techniques and considerations are needed to restore such mutilated teeth to have a good prognosis. The loss of a considerable amount of tooth structure makes retention of subsequent restorations more problematic and increases the likelihood of fracture during functional loading. Different clinical techniques have been proposed to solvethese problems, and one such technique is post and core.

The basic objective in restoring mutilated teeth with post and core is the replacement of the missing tooth structure to gain adequate retention for the final restoration. Cores are built using metallic or non-metallic materials. In earlier years, amalgam was popular, and in later times cement-like glass ionomer and modified ionomers were used; now, improved high strength composite resins are being used to build cores. Since the advent of metal-free dentistry to achieve optimum aesthetics, a tooth-coloured non-metallic post like glass fiber, quartz fiber, zirconia, ceramic has become popular. They can be used with various composite resin core build-up materials.

Core build-up materials can be used to repair the damaged tooth structure before crown preparation and stabilize weakened parts of the tooth; as such, they are a key part of the preparation for an indirect restoration consisting of restorative material[2]. Although the long-term clinical success of an indirect restoration is mostly dependent on the amount of remaining tooth structure, the core build-up material plays an important role as well[3]. An ideal core build-up material must present excellent mechanical properties to resist the stresses that may be produced during function, providing equitable stress distributions of forces and reducing the probability of tensile and compressive failures[4].

Amalgam, glass-ionomer, and composite resin materials have typically been used as core build-up materials. 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 the bulk section, it not being technique sensitive, and corrosion products seal it. 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[5]. Glass ionomer cement (GICs) for restorative dentistry was developed by the end of the 1960s and was first described by Wilson and Kent in 1972. 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. To improve the physical properties of Glass Ionomer Cements, several modifications were made. 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.

Glass Ionomer Cement with Resin adheres to both enamel and dentin encouraging clinicians to select such materials in the core build-up procedures. But these materials have weaker mechanical properties[6].Composite resins are clinically proven dental restorative materials that are developed at the beginning of the 1960’s. Composite resins also had some pitfalls such as high technique sensitiveness, difficulties in distinguishing tooth from the core during preparation and dentine bond rupture by polymerization contraction[7]. Recently core build-up materials such as flow and bulk filled 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 [8].

Recently, a new category of flowable RBCs—so-called bulk-fill RBCs—was introduced as bulk fill material. The particularity of the new material category is stated to be the option to place it in 4 mm thick bulks instead of the current incremental placement technique without negatively affecting polymerization shrinkage, cavity adaptation of the degree of conversion (DC). Manufacturers claimed that bulk-fill materials could achieve a depth of cure of 6 mm. Nevertheless, the idea of placing a self-adapting material as bulk, saving time as well as improving material handling, is of great interest [9]. Stronger core materials better resist deformation and fracture, provide fair stress distributions, and reduce the probability of tensile and compressive failure, leading to greater stability and a higher probability of clinical success. If other variables are considered to be equal, the strongest core material is indicated [10].

The strength of a material can be described by tensile strength and compressive strength, each of which is a measure of stress required to fracture a material.

According to Philips, 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[11]. Recent developments in flowable and restorative composite resins have resulted in a greater total depth of cure—between 4 and 5 mm for some materials. This improvement in the depth of cure may be due to greater translucency, increased photoinitiator content, or an additional photoinitiator type. Manufacturers of new dual-cure composite resins—such as Multicore HB, Clearfill Photocore PLT, and Kerr Herculite Precise—have claimed that their products can be placed in 1 layer to an unlimited depth.

According to its manufacturer, Clearfill Photocore PLT eliminates the need for flowable liners and incremental curing it "provides the ability to bulk fill all classes ofrestorations without worrying about shrinkage or voids[12]. Multi-Core HB composite is a dual curing core build-up material consisting of two components – base and catalyst and comes in four shades that provide an optimum foundation for the reconstruction of vital and non-vital teeth with part or most of the clinical crown missing[13]. Very limited research is available evaluating the basic properties of these new dual-cure composite restorative materials. In the present study, the three bulk filled light cured core build-up materials tensile strength and compressive strength were compared

Materials and Methods

This study was conducted in the department of prosthodontics and crown and bridge, including implantology along with external laboratory support. Attempts were made to standardize the procedure throughout the study to minimize the effects of variable factors on observation and final results.

Method for preparation of molds for tensile strength

The mould for the study was prepared in a split stainless steel mold, which has an interlocking system to split the mould into two halves, that is (3mm in height × 6mm in diameter) for evaluating and comparing tensile strength of three core build-up materials according to ADA Specification No 27. Stainless steel split mold was made so that when core build-up material is incorporated in the mould it will be dual-cured by light-curing unit for 20seconds from both sides and after setting, the material is removed by separating the mould by the interlocking system. Before placing the material in the mold, petroleum jelly will be applied for easy removal. According to the manufacture's instructions, all three core build-up materials are manipulated and inserted in a stainless steel split mold to evaluate tensile strength. After loading the material, it is dual-cured by the light-curing unit for 20 seconds from both sides. After setting the material, they will be removed from molds.Then materials will be placed in distilled water for 24 hours at 37˚C at room temperature. Further, samples will be tested on an Instron Universal Testing Machine at a crosshead speed of 0.5mm/min for compressive strength, and tensile strength testswill be determined in Mpa.

Method for preparation of molds for compressive strength

The mould for the study was prepared in cylindrical plexiglass mold (6mm in height× 3mm in diameter) for evaluating and comparing the compressive strength of three core build-up materials, respectively, according to ADA Specification No.27. Plexiglass split mold was made, which has interlocking system to split the mold into two halves, so that when core build-up material is incorporated in mould it will be dual-cured by light-curing unit for 20seconds from both side, and after setting, the material is removed by separating the mould by interlocking system. Before placing the material in the mold, petroleum jelly will be applied for easy removal. According to the manufacture's instructions, all the three core build-up materials are manipulated and inserted in plexiglass steel split mold to evaluate compressive strength. After loading the material, it is dual-cured by a light-curing unit for 20 seconds from both sides. After setting the material, they will be removed from molds.Then materials will be placed in distilled water for 24 hours at 37˚C at room temperature. Further, samples will be tested on an Instron Universal Testing Machine at a crosshead speed of 0.5mm/min for compressive strength tests will be determined in Mpa. 180 samples of three different core build-up materials that are; Ivoclar Vivadent Multicore HB, Clearfill Photocore PLT, Kuraray Japan, and Kerr Herculite Precis were divided into two groups 30 samples for each type of group. The group formed were as follows :

- Group 1 (n=30) Multicore HB
- Group 2(n =30) Photocore PLT
- Group 3 (n=30) – Kerr Herculite Precis
- Ninety samples of each group that is tensile and compressive strength were further equally divided into 3groups (n=30) of core build-up materials.
- Group A (n=90) Tensile strength
- Group I (n=30) Multicore HB
- Group II (n=30) Photocore PLT
- Group III (n=30) Kerr Herculite
- GROUP B (n=90) CompressiveStrength
- Group I (n=30) Multicore HB
- Group II(n=30) PhotocorePLT
- Group III (n=30) Kerr herculite precis

Samples of every group were prepared according to the methodology mentioned above. Following each group was kept separately and prepared for testing the tensilestrength and compressive strength.

Results

The data was compiled and analyzed using software IBM SPSS (statistical package for social sciences) version 21.0 at a 95% confidence interval. Descriptive and analytic statistics were done. The mean and standard deviation was tabulated. As the data followed significant differences post hoc test was used, and analysis of variance (ANOVA) test was used to check the mean differences among groups wherever appropriate.

Mean and standard deviation of maximum load fortensile strength (Table 1)

The mean and standard deviation of Maximum Load for tensile Strength in Group

I : Multi-Core HB Maximum Load (N) was 955.35 ± 167.690, in Group II: Photo Core PLT Maximum Load (N) was 1127.15 ± 236.365 and in Group III: Kerr herculite Precise Maximum Load (N) was 663.35 ± 212.873.

Mean and standard deviation of tensile strength in thethree groups (Table 2)

The mean Tensile strength (39.844 ± 8.369) was found to be highest in Group II. The mean compressive strength in Group I was 33.78 ± 5.931, and in Group III was 23.45 ± 7.529.

Mean and standard deviation of maximum load for compressive strength (Table 3)

The mean and standard deviation of Maximum Load for compressive Strength in Group I: Multi-Core HB Maximum Load (N) was 544.70 ± 134. 612, in Group II: Photo Core PLT Maximum Load (N) was 727.50 ± 133.497 and in Group III: Kerr herculite Precise Maximum Load (N) was 390.866 ± 79.245.

Mean and standard deviation of compressive strength in the three groups (Table 4)

The mean Compressive strength (103.07 ± 18.926) was found to be highest in Group II. The mean compressive strength in Group I was 77.14 ± 19.029, and in Group III was 55.17 ± 11.487.

Comparison of tensile strength between th groups (Table 5)

When the comparison of tensile strength was made between the groups, the differences were found to be statistically significant. The mean difference in tensile length was -6.055 between Group I: Multi-Core HB & Group II: Photo Core PLT and this difference was statistically significant ($p=0.006$). The mean difference in tensile strength between Group I: Multi-Core HB & Group III: Kerr herculite Precise was 10.33, and this difference was statistically significant ($p<0.05$). The mean difference in tensile strength between Group II: Photo Core PLT & Group III: Kerr herculite Precise was 16.385, and this difference was statistically significant ($p<0.05$).

Comparison of compressive strength between thegroups (Table 6)

When the comparison of compressive strength was made between the groups, the differences were found to be statistically SIGNIFICANT. The mean difference in compressive length was -25.929 between Group I: Multi-Core HB & Group II: Photo Core PLT and this difference was statistically significant ($p<0.05$). The mean difference in compressive strength between Group I: Multi-Core HB & Group III: Kerr herculite Precise was 21.976, and this difference was statistically significant ($p<0.05$). The mean difference in compressive strength between Group II: Photo Core PLT & Group III: Kerr herculite Precise was 47.905, and this difference was statistically significant

Statistical analysis

All the data was collected and analyzed and since the results were statistically significant, the null hypothesis was rejected that there was no difference in the three core build-up materials.

Table 1
Mean and Standard Deviation of Maximum Load for Tensile Strength

	N	Mean	Std. Deviation
Group I: Multi-Core HB Maximum Load (N)	30	955.3500	167.69097
Group II: Photo Core PLT Maximum Load (N)	30	1127.1500	236.36574
Group III: Kerr herculite Precise Maximum Load (N)	30	663.3500	212.87349

Table 2
Mean and Standard Deviation of Tensile Strength in the three groups

	N	Mean	Std. Deviation
Group I: Multi-Core HB Tensile strength	30	33.7890	5.93175
Group II: Photo Core PLT Tensile strength	30	39.8440	8.36966
Group III: Kerr herculite Precise Tensile strength	30	23.4590	7.52957

Table 3
Mean and Standard Deviation of Maximum Load for Compressive Strength

	N	Mean	Std. Deviation
Group I : Multi Core HB Maximum Load (N)	30	544.7000	134.61244
Group II : Photo Core PLT Maximum Load (N)	30	727.5000	133.49713
Group III : kerr herculite Precise Maximum Load (N)	30	390.8667	79.24568

Table 4
Mean and Standard Deviation of Compressive Strength in the three groups

	N	Mean	Std. Deviation
Group I : Multi Core HB Compression strength	30	77.1480	19.02945
Group II: Photo Core PLT Compression strength	30	103.0770	18.92620
Group III: Kerr herculite Precise Compression strength	30	55.1720	11.48790

Table 5
Comparison of Tensile Strength between the groups

	F	Sig.
Between Groups	38.150	.000

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Sig.
Group I: Multi-CoreHB	Group II: Photo Core PLT	-6.05500*	.006
	Group III: kerr herculite Precise	10.33000*	.000
Group II: Photo CorePLT	Group I: Multi-Core HB	6.05500*	.006

	Group III: kerr herculite Precise	16.38500*	.000
Group III: Kerr herculite Precise	Group I: Multi-Core HB	-10.33000*	.000
	Group II: Photo Core PLT	-16.38500*	.000

Table 6
Comparison of Compressive Strength between the groups

(I) GROUP	(J) GROUP	Mean Difference (I-J)	Sig.
Group I: Multi-CoreHB	Group II: Photo Core PLT	-25.92900*	.000
	Group III: kerr herculite Precise	21.97600*	.000
Group II: Photo CorePLT	Group I: Multi-Core HB	25.92900*	.000
	Group III: kerr herculite Precise	47.90500*	.000
Group III: Kerr herculite Precise	Group I: Multi-Core HB	-21.97600*	.000
	Group II: Photo Core PLT	-47.90500*	.000

Discussion

A core build-up is a restoration placed to provide the foundation for a restoration that will endure the masticatory stress that occurs in the oral cavity for prolonged periods and to provide satisfactory strength and resistance to fracture before and after crown preparation[13].The selection of materials is based primarily on ease of handling with due consideration being given for mechanical properties and manipulative variables. Among mechanical properties, the compressive strength of core materials is important because cores usually replace a large bulk of tooth structure, and they should provide sufficient strength to resist intraoral compressive and tensile forces that are produced in function and parafunction[3]. The development of flowable composites appeared in the 1990s as an important advancement in restorative dental materials. Flowables are low viscosity resin composites obtained from formulations with 20–25% lower filler loading than conventional composites. First- generation flowable were used only as liners due to their low elastic modulus.

The second-generation flowable developed since 2000 promise increased mechanical properties and are proposed for use in bulk restorations[14]. The manufacturers claimed that bulk-fill materials could achieve a depth of cure of 6 mm[15]. The compressive strength has an important role in the mastication process since several of the masticatory forces are compressive. According to Mitra et al., the Tensile Strength and Compressive Strength test value of nanocomposites are superior to hybrid or microhybrid composites and significantly higher than those of the microfill materials[16]. Cobb et al stated that while packable composites had certain advantages over conventional composite resins in ease of handling, their physical properties, such as Tensile Strength and Compressive Strength values, were not superior to those of the conventional hybrid composites tested. On the other hand, the results of the study on the physical properties of packable resin composites by Kelsey et al indicate that the condensable composite products showed higher tensile Strength values than those of the conventional hybrid resin composites[17].

All light-cure resins require multiple layers when restoring deep box forms, which partially negates the time savings and convenience. SonicFill, QuiXX, and X-tra fil exhibited the greatest depth of cure across all lights tested. Only the dual-cure resin, HyperFIL-DC, was truly "bulk-fill," auto-polymerizingto any depth within 2–4 minutes after dispensing. In this study, the aim is to compare and evaluate the three different bulk filled light cure core build-up material. The stainless steel split mold and plexiglass split mold were prepared, and three core build-up materials were inserted into the moulds, and they were dual-cured from both sides for 20 seconds. Evaluation and comparison of three core build-up materials were done, and the data were analyzed using the one-way analysis of variance (ANOVA) andthe 'post hoc' test.

With the data obtained from this study on measuring the tensile and compressive strength of three light-cured bulk fill core build-up materials, it wasobserved that Clearfill Photocore PLT showed superior tensile and compressive strength in comparison to both Multicore HB and Kerr Herculite Precis after fabrication and after storage in distilled water for 24 hours. This increased tensile and compressive strength of bulk-fill material compared to universal composite resin concurs with the study done by Atabek Didem et al., who tested that compare the flexural strength and compressive strength of new sonic activated bulk fill with other bulk fill resins and a universal posterior composite resin. The bulk fill material presented significantly higher compressive strength than another group[18]. Similar results were obtained by Narsimha Jayanthi Vinod et al. and BulemYuzugullu et al.[19,20].

Direct comparison to other studies was not possible due to differences in materials, methodology, and specimen configuration. A review of the limited research on tensile and compressive strength of bulk filled light cured core build-up materials also showed this property to be material specific. According to Kovarik et al., Composite resins have also gained acceptance as a choice of core materials. They offer an advantage over amalgam in that they can be prepared immediately and impressed for restoration with a full casting[22,21]. According to Peter Schmage et al., Core resins differ in their application consistency, that is, from "packable" to "flowable," and in their curing mode, that is, from auto polymerizing to dual curing. The volume and size of fillers and their silanization, as well as the matrix of a resin composition, strongly influencestrength, hardness, and especially wear of materials.

According to George C.Cho et al., Compressive strength is considered to be a critical indicator of success because a high compressive strength is necessary to resist masticatory and parafunctional forces. Tensile strength is important because dental restoration is exposed to tensile stresses from oblique or transverse loading of their complex geometric forms [23]. It is therefore suggested that core build-up with Photocore PLT significantly stronger than the other core materials. The CS of PhotocorePLT was slightly stronger than that of Multicore HB and Kerr Herculite Precise, which is formulated to use as a core material.

According to Mitra et al., the DTS and CS test values of nanocomposites are superior to hybrid or microhybrid composites and significantly higher than those of the microfill materials. The CS value for Kerr Herculite Precise was found to be lower than that of other materials tested.

Kerr Herculite Precise material was weaker than the other materials in CS and DTS tests used in the study, which is following the results of other studies on the physical and mechanical properties of core build-up materials. Consequently, in terms of CS, Photocore PLT, which is an organically-modified ceramic, and Multicore HB, which is a packable composite resin having zirconia/silica filler particles in its chemical composition, could be considered the most appropriate materials for core foundations. Cobb et al.stated that while packable composites had certain advantages over conventional composite resins in ease of handling, their physical properties, such as DTS and CS values, were not superior to those of the conventional hybrid composites tested.

PhotocorePLT and MulticoreHB may be considered the most appropriate as core foundation materials. Strength is only one criterion for the selection of core material, but it is crucial. Stronger materials resist deformation and fracture better, provide equal stress distribution and reduced risk of tensile or compressive failure and have greater stability and probability of clinical success. Other properties, such as shear bond strength to dentin, coefficient of thermal expansion, and fluoride release, should be considered in their selection as core foundation materials; however, these criteria were not the scope of our study. No current material is ideal. For clinical success, dentists must be aware of the properties of materials, choose materials accordingly, and manipulate them properly. The results of this study indicate that based on strength alone, Photocore PLT and Multicore HB may be used as alternatives to Kerr Herculite Precise; however, other physical qualities should also be considered, and long-term clinical experiences must be studied for correlation with the in vitro laboratoryresults.

Conclusion

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

- As there is limited data available on recent bulk fill material that is Clearfill Photocore PLT, Kerr Herculite Precis more in vitro and in vivo studies should be held for long term success of the material.
- Tensile strength and compressive strength of Kerr Herculite Precis slightly decreased after storing for 24 hours in distilled water

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