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ORIGINAL ARTICLE

A comparative evaluation of flexural strength of four different post-endodontic restorative materials: An *in vitro* study

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Abstract

Background: The flexural strength greatly influences the selection of core material because core must withstand forces due to mastication and parafunction for many years.
Aim: This study aimed to evaluate the flexural strength of four different post-endodontic restorative materials.
Materials and Methods: A total of 40 specimens were fabricated in a plexiglass mold divided into four groups of each 10 each type of material (n = 10), namely as high copper (Cu) amalgam (DPI Alloy), nanohybrid composite (Ivoclar Vivadent), dual-cure core build-up composite (LuxaCore Z, DMG), and flowable (dual cure) composite (Rebilda DC, VOCO). All the materials were mixed according to the manufacturer's recommendations and rectangular plexiglass split molds of dimension 25 ± 1 mm {length} × 2 ± 1 mm {height} × 2 ± 1 mm {width} were used for fabricating samples for flexural strength. The samples were immersed in distilled water at 37°C for 15 min. The specimens were then ground and polished with 600 grit sandpaper and stored in water at 37°C for 24 h before testing. The flexural strength was tested using a universal Instron testing machine determined at a crosshead speed of 1 mm/min. Statistical analysis was performed using one-way ANOVA which was applied to verify the existence of statistical significance between group variations, followed by the Tukey test for *post hoc* comparison.
Results: The fracture resistance was higher for the groups with Rebilda DC (66.67 ± 0.41) and LuxaCore Z (62.35 ± 0.34), which presented no statistically significant difference ($P > 0.05$) but was significantly higher than in those with nanohybrid composite and high Cu amalgam ($P < 0.05$).
Conclusion: It was concluded that dual-cure core build-up materials (LuxaCore Z and Rebilda DC) had superior flexural strength than other two materials. The strength of LuxaCore Z was less than Rebilda DC but more in comparison amalgam and nanohybrid composite.

Introduction

For longevity of endodontically treated teeth, predisposing factors are integrity and durability of post-endodontic restorations. These teeth have been proven to be more brittle and are prone to fracture under an occlusal load compared with vital teeth due to changes in strength and modulus of elasticity. Intracoronal strengthening of these teeth may be necessary to prevent fracture, particularly in posterior region of the mouth in which stresses generated by occlusal forces can lead to fracture of unprotected cusps.[1] Endodontically treated teeth or fractured teeth are reconstructed with the help of core build-up materials.[2] Strength of core materials is thought to be important because core usually replaces a large bulk of tooth structure and resist multidirectional forces acting on the tooth.[3]

For endodontically treated tooth, many different restorative materials such as high copper (Cu) amalgam, visible light-cured resin composite, autocured titanium-containing composite, polyacid-modified composite, resin-modified glass ionomer, and a silver cermet cement are used to build up the lost tooth structure.[4] Most of these materials were not specially developed for this purpose, but as a consequence of properties such as fluoride release, pleasing colors, adhesion to tooth structure, fast setting rates, choice of curing mechanism, and handling properties, they have found their use as core build-up procedures.[3]

Since it is strength and dimensionally stability, amalgam has been the core of choice. Many microstructural changes related to both the corrosion-prone environment and elevated temperature are undergone by a set amalgam restoration in the mouth and mechanical forces applied to the restoration. High Cu amalgams generally perform better clinically, but all amalgams to some extend corrode in the mouth. Corrosion is deemed to be a positive factor since there is reduction in the due microleakage due to the presence of the corrosion products at the margins, making the restoration self-sealing.[4]

Resin composites have properties such as good esthetics and ease of workability and are globally used as direct restorations. Physical and mechanical properties of composites are mainly decided by the filler particle type, composition, size, and weight percentage such as compressive and flexural strength, wear resistance, and hardness.[5] One of the leading causes of composite failures is fracture which is related to the mechanical properties such as compressive and flexural strengths. Multitude of factors has an impact on the strength of these materials such as quality and depth of cure, light source, properties of light-curing source, filler matrix ratio, filler quantity, and particle size.[6] Multiple filler combinations in resin composites with varying compositions (silica, quartz, and glass), configurations (micro and macro particles), and resin-filler ratio have been employed.[7]

Bulk fill materials are introduced to allow for ease of core restoration placement in a single increment (low viscosity), adequate restorative adaptation, and improved mechanical properties since they have more filler content.[6] Dual-cure composites have been developed as core buildup materials that help in overcoming the limitations of extended chairside time, reduced interlayer strength, and increased interfacial porosity. Dual-cure composites also show improved depth of cure, monomer to polymer conversion, and polymerization, due to the effect of continued chemical curing after photoactivation.[6]

Hence, this study aimed to evaluate and compare the flexural strength high Cu amalgam, nanohybrid composites, and dual-cure composites.

Materials and Methods

A total of 40 rectangular specimens of dimensions (25 ± 1 × 2 ± 1 × 2 ± 1 mm) were fabricated in a plexiglass mold with four different materials, namely ($n = 10$): Group I – high Cu amalgam (DPI alloy), Group II – nanohybrid composite (Ivoclar Vivadent), Group III – LuxaCore Z (DMG), and Group IV – Rebilda DC (VOCO).

The four restorative materials described in Table 1 were mixed according to manufacturer's instructions and filled in the glass mold and covered with a glass plate on both sides. The specimens were cured with light-emitting diode-curing unit (440–480 nm). Later, the specimens were placed into a water bath for 15 min at 37°C for complete setting. The specimens were then ground and polished with 600 grit sandpaper and stored in water at 37°C for 24 h in an incubator before testing. The specimen was carefully removed from water bath and blot dried with blotting paper. Later, all the specimens were then subjected under the universal testing machine for flexural strength testing.

Flexural strength testing

Each specimen was loaded under the universal testing machine (ACME Engineers, India, Model No. UNITEST-10) [Figure 1] with a crosshead speed of 1 mm/min, maintaining the distance between supports of 14 mm. The force was then applied on the specimens at the midpoint, i.e., 7 mm from the supports until it fractures. The flexural strength was measured in MPa.

Flexural strength was calculated using the following equation:

$$\Sigma=3PL/2bd$$

Where, P: Fracture load, L: Span between supports, d: Thickness, and b: Width

Statistical analysis

One-way ANOVA was applied to verify the existence of statistical significance between group variations, followed by the

Table 1: Different restorative materials included in this study

Groups	Material used	Brand name	Composition
I	High copper amalgam	DPI alloy	40%–60% silver, 27%–30% tin and 13%–30% copper, and 1% zinc, indium, and palladium
II	Nanohybrid composite	Ivoclar Vivadent	Powder – flouroaluminosilicate glass particles, light initiators (camphoroquinone) liquid –polyacrylic acid, HEMA, water
III	LuxaCore Z	DMG	Barium glass, pyrogenic silicic acid, nanofillers, zirconium oxide in a bis-GMA-based resin matrix
IV	Rebilda DC	VOCO	Bis-GMA, UDMA, DDDMA, silica, dl-camphorquinone, barium borosilicate glass ceramic, dl-camphorquinone, dibenzoyl peroxide, accelerators, filler content: 71 wt.%, 57.3 vol%

Tukey test for *post hoc* comparison [Table 2]. Significance level was set at $P < 0.05$

Results

The values were recorded for flexural strength (MPa) in the four groups [Table 3] which are high Cu amalgam (DPI), nanohybrid composite (Ivoclar Vivadent), LuxaCore Z (DMG), and Rebilda DC (VOCO), respectively. Higher mean flexural strength was recorded for Rebilda DC (66.77 ± 0.41 MPa) followed by LuxaCore Z (62.25 ± 0.34 MPa) and nanohybrid composite (54.71 ± 0.41 MPa), respectively. Lowest flexural strength was recorded for amalgam (23.33 ± 0.62 MPa) as shown in Graph 1. The difference in mean flexural strength between four materials was found to be statistically significant ($P < 0.001$). The results are given in Table 3.

Discussion

Strength is the most important aspect for the selection of a material as stronger the material better is their ability to resist deformation and fracture. Endodontically treated teeth can be expected to survive in the oral cavity based on the final restoration. Hence, it is a vital step to determine the success of endodontically treated tooth.[8] According to the study conducted by Tronstad *et al.*, a good restoration, especially in endodontically treated teeth, is important for the longtime success of such treated teeth.[9] To withstand the forces of mastication and polymerization shrinkage stresses, core build-up materials should have high flexural strength similar to that of tooth structure (dentin).[10] If the modulus of elasticity does not match to that of dentin and it is too high between the tooth and the restoration, interfacial stresses may lead to thermal, mechanical, and shrinkage strain on the material.[11,12] Hence, materials that can withstand such stresses should ideally be used as core build-up material.

Flexural forces are nothing but non-axial forces acting on the tooth surface during mastication. Since human dentition is better adapted to resist compression, tooth enamel is more resistant to compressive forces than to flexural forces. If any restorative material replaces the tooth structure, it should resist non-axial forces too; hence, flexural strength testing is important.[13] Flexural strength testing in this present study was done by three-point bending test which is based on the International Organization for Standardization specification No. 9917–2 as described by literature for polymer-based materials and is widely used for comparative purposes. It is usually recommended because specimen fabrication and load application are simple.[14] The three-point bending test is still the

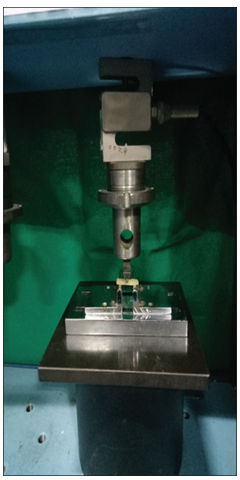
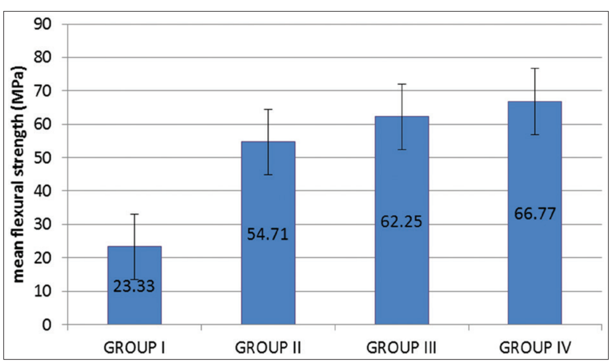


Figure 1: Universal testing machine checking the strength of the material



Graph 1: Mean percentage of flexural strength among different groups

Table 2: Mean percentage of flexural strength among different test groups

Groups	Number of samples (n=10)	Mean±standard deviation	P-value
Group I	10	23.33±0.62	<0.001*
Group II	10	54.71±0.41	
Group III	10	62.35±0.34	
Group IV	10	66.77±0.41	

*P<0.05 significant using one-way analysis of variance (ANOVA)

Table 3: Results

Samples	Group 1	Group 2	Group 3	Group 4
1	23.14	54.55	62.03	67.1
2	22.89	54.67	62.55	66.16
3	22.9	54.61	62.29	66.63
4	23.5	55.04	62.8	67.31
5	22.6	53.8	62.4	66.67
6	24.55	54.44	61.78	66.23
7	24.09	54.7	62.09	66.45
8	23.76	55.27	61.93	67.14
9	23	54.98	62	67.25
10	22.96	55.06	62.7	66.82

choice for evaluating flexural strength due to the lower standard deviation, the lower coefficient of variation, and the less complex crack distribution produced by it when compared to those produced by other test designs such as the biaxial flexural test, although some studies have suggested alternative flexural test designs.[15]

In the present study, resin composite core showed better flexural strength compared to silver amalgam core which is similar to the study by Bonilla *et al*.[2] This could be due to the micromechanical bonding (Monoblock effect) of resins to the tooth structure. Results of this study are consistent with the study conducted by Kumar and Shivrayan[3] which showed that resin composite cores have higher flexural strength than silver amalgam cores.

For cores, amalgam has been considered to be the material of choice. Both mechanical tests and finite element analyses have indicated that amalgam cores have superior performances in comparison to resin composite cores.[11] To glass ionomer, resin-modified glass ionomer, or glass ionomer cermet cores, amalgam cores are certainly to be preferred.[16] The dark color of amalgam may not be esthetic, but it is easy to differentiate from tooth structure during tooth preparation. Unfortunately, the relatively slow set of amalgam delays rotary preparation of amalgam cores and has limited its use.[17]

LuxaCore showed comparatively lower results with Rebilda DC, as shown in Tables 3 and 2 as both are dual-cure materials. The nanotechnology used in LuxaCore dual eliminates particle agglomeration by incorporating a proprietary coating process during particle manufacture. LuxaCore dual (DMG) and Rebilda DC possess strength, flexibility, and insulation properties similar to that of dentin, according to manufacturers.[18] Fillers used such as aluminoborosilicate glass, fumed silica, and titanium oxide, which could be the reason for their high strength. These results were similar to the study conducted by Ahn and Sorensen,[19] in this study, Rebilda DC showed higher flexural strength compared to LuxaCore Z.

According to a study conducted by Walcher *et al*. showed that LuxaCore Z surprisingly had lowest values of flexural strength (82.94 Mpa) which had the highest amount of fillers compared to the other materials used in this study. According to him, this could be due to zirconium dioxide used as fillers into the cement as the silanization process, in this case, may not be as efficient as for other fillers, influencing the mechanical strength of the material.[20] Furthermore, according to the study by Bitter *et al*. showed that LuxaCore had higher flexural strength and less water sorption compared to self-adhesive resin cement.[21]

Stronger core materials better resist deformation and fracture, provide more equitable stress distributions, and reduced probability of tensile or compressive failure, greater stability, and greater probability of clinical success although the perfect core material does not yet exist, the results of this study indicate that both LuxaCore and Rebilda DC may be indicated for use as core materials in specific clinical situations.

Conclusion

Within the limitations of this *in vitro* study, it was concluded that Rebilda DC had the highest flexural strength of the four materials tested in this study. The strength of LuxaCore Z was less than Rebilda DC but higher than other conventional materials such as amalgam and nanohybrid composite. Further, *in vitro* and *in vivo* studies concern regarding long-term clinical success of the core build-up materials should be evaluated. Hence, further research for the same is required.

References

1. Eapen AM, Amirtharaj LV, Sanjeev K, Mahalaxmi S. Fracture resistance of endodontically treated teeth restored with 2 different fiber-reinforced composite and 2 conventional composite resin core buildup materials: An *in vitro* study. J Endod 2017;43:1499-504.
2. Bonilla ED, Mardirossian G, Caputo AA. Fracture toughness of various core build-up materials. J Prosthodont 2000;9:14-8.
3. Kumar G, Shivrayan A. Comparative study of mechanical properties of direct core build-up materials. Contemp Clin Dent 2015;6:16-20.
4. Bahsi E, Colak M, Atakul F, Celik Y. Investigation of fracture resistance of different core materials. J Int Dent Med Res 2012;5:85-90.
5. Malhotra N, Mala K, Acharya S. Resin-based composite as a direct esthetic restorative material. Compend Contin Educ Dent 2011;32:14-23.
6. Alkhudhairy F, Vohra F. Compressive strength and the effect of duration after photo-activation among dual-cure bulk fill composite core materials. Pak J Med Sci 2016;32:1199-203.
7. Pallav P, De Gee AJ, Davidson CL, Erickson RL, Glasspoole EA. The influence of admixing microfiller to small-particle composite resin on wear, tensile strength, hardness, and surface roughness. J Dent Res 1989;68:489-90.
8. Safi L, Forouzanfar M, Alizadeh F. An *in vitro* evaluation of fracture resistance of endodontically treated teeth with different restorative materials. J Contemp Dent Pract 2016;17:549-52.
9. Tronstad L, Asbjørnsen K, Døving L, Pedersen I, Eriksen HM. Influence of coronal restorations on the periapical health of endodontically treated teeth. Endod Dent Traumatol 2000;16:218-21.
10. Combe EC, Shaglouf AM, Watts DC, Wilson NH. Mechanical properties of direct core build-up materials. Dent Mater 1999;15:158-65.
11. Watts DC. Elastic moduli and visco-elastic relaxation. J Dent 1994;22:154-8.
12. Rüttermann S, Alberts I, Raab WH, Janda RR. Physical properties of self, dual, and light-cured direct core materials. Clin Oral Investig 2011;15:597-603.
13. Reis RF, Borges PC. Alternative methodology for flexural strength testing in natural teeth. Braz Dent J 2005;16:45-9.
14. Rodrigues Junior SA, Zanchi CH, Carvalho RV, Demarco FF. Flexural strength and modulus of elasticity of different types of resin-based composites. Braz Oral Res 2007;21:16-21.
15. Chung SM, Yap AU, Chandra SP, Lim CT. Flexural strength of dental composite restoratives: Comparison of biaxial and three-point bending test. J Biomed Mater Res B Appl Biomater 2004;71:278-83.

16. DeWald JP, Arcoria CJ, Ferracane JL. Evaluation of glass-cermet cores under cast crowns. Dent Mater 1990;6:129-32.
17. Miyamoto S, Takagawa T, Nozaki A, Yanaka N, Nakamura Y, Imai Y, *et al.* Study on fatigue toughness of dental materials 1. Compressive strength on various luting cements and composite resin cores. Nihon Hotetsu Shika Gakkai Zasshi 1989;33:966-76.
18. Agrawal A, Mala K. An *in vitro* comparative evaluation of physical properties of four different types of core materials. J Conserv Dent 2014;17:230-3.
19. Ahn SG, Sorensen JA. Comparison of mechanical properties of various post and core materials. J Korean Acad Prosthodont 2003; 41:288-99.
20. Walcher JG, Leitune VCB, Collares FM, de Souza Balbinot G, Samuel SMW. Physical and mechanical properties of dual functional cements-an *in vitro* study. Clin Oral Investig 2019;23:1715-21.
21. Bitter K, Schubert A, Neumann K, Blunck U, Sterzenbach G, Rüttermann S, *et al.* Are self-adhesive resin cements suitable as core build-up materials? Analyses of maximum load capability, margin integrity, and physical properties. Clin Oral Investig 2016; 20:1337-45.

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