Comparative evaluation of the efficiency of newer ultrahigh intensity LED with conventional LED in polymerization of composite resin

Utkarsh H. Mahajan [1], Sunil Kumar Mishra [2], Prince Kumar [3]

[1] *P G Student, Department of Prosthodontics, Rama Dental College Hospital & Research Centre, Kanpur, Uttar Pradesh, India*

[2] *HoD & Professor, Department of Prosthodontics, Rama Dental College Hospital & Research Centre, Kanpur, Uttar Pradesh, India*

[3] *Professor, Department of Prosthodontics, Rama Dental College Hospital & Research Centre, Kanpur, Uttar Pradesh, India*

Abstract

Introduction: Composite resins are generally composed of Bis-GMA and other dimethacrylate monomers. Visible light curing resin-based composite help the dentist to assess the beginning of polymerization for each applied layer. Curing technology was regularly subjected to modifications during the last decades but meanwhile the LED era is fully established. This study was done to compare the efficiency of newer ultrahigh intensity LED with conventional LED.

Materials and method: Composite resin was used and poured into stainless steel molds (diameter 6 mm, height 3 mm). The total number of specimens was 10, i.e. 5 in group I and 5 in group II. Materials used in this study were: molds with a diameter of 6 mm and a thickness of 3 mm, plastic filling, a LCU with curing times of 1 seconds, a LCU with a curing time of 20 seconds, packable composite resin and a universal testing machine to measure the diametric tensile strength test.

Result: Mean Dia mitral tensile strength of Group I is 27.57 and standard deviation was 0.07 and for Group II mean is 19.31 and standard deviation was 0.07.Mean difference of tensile strength between Group I and Group II was 8.26 which was statistically significant at the 0.05 level of significance.

Conclusion: The degree of polymerization of the composite resin restoration may be affected by the type of LCU.

Keywords: Composite resin, LCU, Universal Testing Machine, Dia metral Tensile Strength

Introduction

Over the past few years, Prosthodontic services have changed markedly due to an introduction of new materials, techniques & treatment options.[1,2] Various methods are used nowadays to restore the form and function of teeth. Out of which one of the most important and frequently used material and method for restoration is composite resin restoration. [3, 4] Dental composite resins also known as resin-based composites or filled resins. Composite resins are most generally composed of Bis-GMA and other dimethacrylate monomers (TEGDMA, UDMA, HDDMA), a padding material similar as silica and in utmost current operations, a photo-initiator. Dimethyleglyoxime is also generally added to achieve certain physical parcels similar as inflow capability. [5, 6] For the polymerization of light curing resin-based composite a dental curing light is used. The curing light used in dentistry falls under the visible blue light spectrum. [7, 9] The light emitted from dental light curing unit is emitted in a range of wavelengths and varies for each type of device. Based on viscosity of composite resin it can be divided into flow-able and packable composite resin. Packable composite resin has comparatively more filler content that flow-able resin making it superior physically and mechanically also high polymerization shrinkage rate and low mechanical properties.[5,10,11] Also packable composite do not attach to dental equipment, can be easily condensed. Disadvantages of packable composite are lesser adaptation between layers, low aesthetics when used in anterior region. For packable composite resin it is recommended to implement bulk-fill all at once technique. [6, 12, 16]With the increased use of composite resins for restorations there has been an associated increase in the LCU usage. Presently, most common type of LCU used is LED curing unit with curing time of 20 sec–40min on average. Recently, an LED curing unit with a high intensity and a short curing time with 1 second was developed.[17-19] In order to assess result of polymerization of cured

composite resin it can done based on mechanical strength. Diametral tensile strength is analyzed to analyze brittle materials like composite. In order to be used as posterior restorative material composite resins have good compressive and tensile strength in order to resist occlusal loads. Hence this study was undertaken to evaluate the curing of packable composite achieved by the newer curing units with curing time of 1second as compare to conventional curing unit with curing time of 20 seconds.

Materials and Methods

This in-vitro study was abstracted, planned and conducted in Rama Dental College and Hospital, Kanpur. Testing was conducted in Department of mechanical engineering in Indian Institute of Technology Kanpur. Before real execution, outline of study was prepared and discussed with institutional committee. Following the approval (02/IEC/RDCHRC/2021-22/055), sampling and testing was initiated. Composite samples were made with the help of composite resin. There was no difference in material used for both the groups. Five samples were made for curing with the help of conventional LCU and 5 samples were made for curing with newer ultra-high intensity LCU. The specimen was made using cylindrical stainless steel mold with diameter of 6 mm and a height of 3 mm, petroleum jelly was applied as separating media. Using plastic filling instrument and the bulk technique was implemented for pouring the composite resin material in the mold.8 In Group I (Fig. 1) the curing was performed for 20 second using the LED curing unit. For Group II (Fig. 2), procedure to make the sample was same as followed for Group I, but the curing process was performed using newer ultra-high intensity LCU.[9] Then the specimen was taken out of the mold, and the edges of the sample prepared were cleaned. The diametral tensile strength was tested using a digital universal testing machine [10] (Fig 3). Before the test, the specimens were measured three times using caliper to check that all the specimens were of equal dimensions. The specimens were then placed one at a time on the universal testing machine with the load in an upright position.[11] The specimens were kept under load continuously with 250 kgf at a rate of 0.5 mm/min until broken (Fig. 4). The maximum load value was taken just before the specimen broke.[12] The calculation was done by using the diametric tensile strength formula: $2P/\pi Dt$.

Statistical Methodology:

All the measured data and points were copied and sent for statistical evaluation using statistical software Statistical Package for Social Science version 22 (IBM Inv., Armonk, New York, USA). The noteworthy data was subjected to student T- test statistical test to obtain p values, mean, standard error.

Figure 1: Samples of Group-I

Figure 2: Samples of Group-II

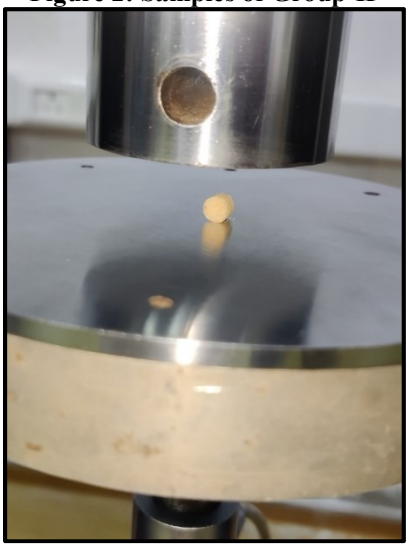

Figure 3: Universal Testing Machine with Composite Sample

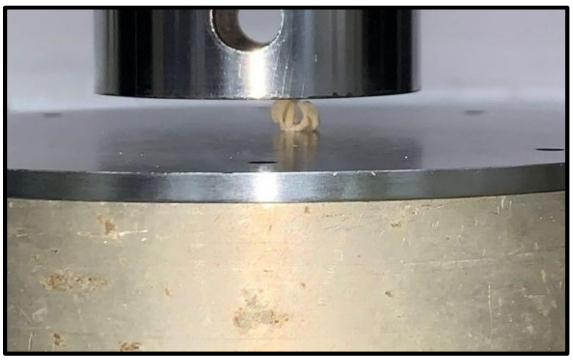

Figure 4: Universal Testing Machine with composite sample fracture

Results

The diametral tensile strength of 5 samples in group I cured using 20 second LED curing unit was presented in table 1. Reading for group I were as follows 27.59MPa, 27.47MPa, 27.66MPa,27.56MPa and 27.58MPa.The 5 samples in group II comprised of samples cured by using 1second LED curing unit as shown in table 2. Reading for Group II were as follows 19.23MPa, 19.29MPa, 19.33MPa, 19.28MPa and 19.41MPa. Statistical analysis of the diametral tensile strengths of the two groups was shown in table 3. The independent t-test analysis revealed statistically significant difference ($p<0.001$) between two groups (Table 3). For Group I mean was 27.57 and standard deviation was 0.07 and for Group II mean was 19.31 and standard deviation was 0.07. Mean difference of tensile strength between Group I and Group II was 8.26 which was statistically significant at the 0.05 level of significance. The statistical result indicates that the composite resin cured by conventional light curing unit for 20second was found better than newer ultra-high intensity LED light curing unit for 1 second.

Table 1: Diametral Tensile Strength (MPa) of Group I (Conventional LED)

S. No.	Group I	Diametral Tensile Strength (MPa)
1	Sample 1	27.59
2	Sample 2	27.47
3	Sample 3	27.66
4	Sample 4	27.56
5	Sample 5	27.58

Table 2: Diametral Tensile Strength (MPa) of Group II (Ultra-high intensity LED)

S.No.	Group II	Diametral Tensile Strength (MPa)
1	Sample 1	19.23
2	Sample 2	19.29
3	Sample 3	19.33
4	Sample 4	19.28
5	Sample 5	19.41

Table 3: Mean comparison of tensile strength (MPa) between Group 1 and Group 2 using student t-test

Group	Sample size	Mean	SD	Mean difference	t value	P value	Result
Group 1	5	27.57	0.07	8.26	192.760	<0.001	Significant [P< 0.05]
Group 2	5	19.31	0.07				

Discussion

Kikko[13] conducted a study on effect of light guide tip diameter of LED light curing unit on polymerization of light cured composite resin and they have come to a conclusion that the polymerization of the light cured composite resin is hampered by the light irradiation of the light curing units. Insufficient polymerization has been related with inferior mechanical properties and bond strength due to non-polymerized monomer. According to Casselli et al[14] there is a direct association between degree of conversion of monomer and the mechanical properties of its composite, for example fracture resistance and amount of surface conversion. Factors influencing the degree of composite resin conversion include its composition, intensity of light emitted, filler content in resin matrix, activator or initiator magnitude. They have come to a conclusion that amount of conversion relies on the total energy that is exposed to the composite resin during light curing stage. Correr et al[3] conducted a study in which they assessed that with the polymerization depth the hardness values reduced towards deeper layers. They have come to a conclusion that polymerization depth of light-cured composites rest on the composition, shade and translucence of the restorative material, concentration of the light source and distance from the tip of the light-curing device to the material surface. All those factors impact the amount of light that reach the deepest layers of the material the degree of conversion in these areas was low and the

physical properties of the material, including Knoop hardness were affected negatively if the light was insufficient. In a study conducted by Guiraldo et al[15]the statistical difference found when comparing the top and bottom hardness numbers can be described by the reason that from the top surface inward as a result of light absorption and scattering by the composite restorative itself amount of light available to excite the photo initiator dramatically decreases. Light attenuation causes lower excited photo initiator molecules. They have come to a conclusion that the mobility of the emerging polymer chains gradually became more restricted as a result of the increase in viscosity, decrease in free volume, photo-induction of micro-gels and entanglement. Whereas, the hardness rest on the extent of the reaction and the degree of cross-linking formed during the monomer curing process.[15] Ariani et al[8]conducted a study on effect of light intensity and curing time of the newest LED unit with curing time of 1 second and conventional LED curing unit with curing time of 20 seconds on diametral tensile strength of composite resins. They have concluded that the mean diametral tensile strength of composite cured with newest LED units with curing time of 1 second had a value of 44.218±2.71MPa and that of Conventional LED with curing time of 20 seconds had a value of 45.916±4.48MPa. Almost similar result obtained in the present study with diametral tensile strength of composite resin cured with 20 second of curing time had a mean value of 27.57MPa and the composite resin cured with 1 seconds of curing time had a mean value of 19.31MPa. In the present study results obtained were a lot similar to the previous studies. After testing all the composite samples on Digital Universal Testing Machine readings obtained were for the diametral tensile strength were evaluated. The final report of evaluation suggested that the composite resin cured with conventional Light Curing Unit (LCU) for 20 seconds was better compared to the newer ultra-high intensity Light Curing Unit (LCU) for 1 second.

Conclusion

Within the scope and limitations of this study authors concluded that the degree of polymerization of the composite resin restoration may be affected by type of LCU. The clinician must choose appropriate LCU during composite resin restorations, especially in deep cavities. The composite resin cured by conventional Light Curing Unit for 20second was found better than newer ultra-high intensity LED Light Curing Unit for 1 second.

References

1. Soh MS, Yap AU, Siow KS. Influence of curing modes on crosslink density in polymer structures. J Dent. 2004; 32:321–326.
2. Dionysopoulos D, Kolinioti-Koumpia E, Kotsanos N, Dionysopoulos P. Correlation between depth of cure and distance between curing light tip and resin surface. Balk J Stom. 2011;15:70-75
3. Correr B, Sinhoreti MA, Sobrinho L, Tango-Schneider R, Consani S. Effect of the increase of energy density on knoop hardness of dental composites light-cured by conventional QTH, led and xenon plasma arc. Braz Dent J. 2005; 16(3):218-224.
4. Hervás-García A, Martínez-Lozano MA, Cabanes-Vila J, Barjau-Escribano A, Fos-Galve P. Composite resins. A review of the materials and clinical indications. Med Oral Patol Oral Cir Bucal. 2006; 11(2):215-220.
5. Cramer NB, Sainsbury JW, Bowman CN. Recent advances and developments in composite dental restorative materials. J Dent Res. 2011; 90(4):402-416.
6. Cunha LG, Alonso RC, Pfeifer CS, Correr-Sobrinho L, Ferracane JL, Sinhoreti MA. Photo initiator concentration and modulated photo activation: influence on polymerization characteristics of experimental composites. J App Adhes Sci. 2014; 2:10-21.
7. Kilaru KR, Hinduja D, Kisyooe KH, Kumar S, Rao RN. Comparative evaluation of compressive strength, vickers hardness and modulus of elasticity of hybrid and packable (condensable) posterior composites - an in-vitro study. Anna Essen Dent. 2012; 4(2):9-16.
8. Ariani D, Herda E, Eriwati YK. Effects of light intensity and curing time of the newest LED Curing units on the diametral tensile strength of micro hybrid composite resins. J Phys Conf Series. 2017.
9. Karla MCO, Ailla CRA, Renzo AC, Simonides C. Shrinkage stress and degree of conversion of a dental composite submitted to different photo activation protocols. Acta Odonto Latinoam. 2012; 25(1):114-121.
10. Alkhudhairy FI. Wear Resistance of Bulk-fill Composite Resin Restorative Materials Polymerized under different Curing Intensities. J Contemp Dent Pract. 2017; 18(1):39-43.
11. Mahn E. Critical criteria for the successful curing of composite materials. Rev Clin Perio Implant Rehab Oral. 2013; 6(3):148-153.
12. Lovell LG, Lu H, Elliott J, Stanberry J, Bowman C. The effect of cure rate on mechanical properties of dental resins. Dent Mater. 2001; 17:504-511.
13. Kikko N. Effect of light guide tip diameter of LED-light curing unit on polymerization of light-cured composites. Dent Mater. 2005; 21(3):217-223.
14. Casselli DS, Worschech CC, Paulillo LA, Dias CT. Diametral tensile strength of composite resins submitted to different activation techniques. Braz Oral Res. 2006; 20(3):214-218.
15. Guiraldo R, Consani S, Consani RLX, Fugolin P, Berger S, Lopes M et al. Evaluation of the light energy

transmission and bottom/top rate in silorane and methacrylate-based composites with different photo activation protocols. J Contemp Dent Prac. 2011; 12(5):361-367.
16. Papadogiannis Y, Lakes RS, Palaghias G, Helvatjoglu-Antoniades M, Papadogiannisc D. Fatigue of packable dental composites. J Dent Mater. 2007; 23:235–242.
17. Laura C, María V, Héctor T, Álvaro M, Josefa F, Jesús R. Curing effectiveness of resin composites at different exposure times using LED and halogen units. J Clin Exp Dent. 2009; 1(1):8-13.
18. Santos G. Composite depth of cure obtained with QTH and LED units assessed by micro hardness and micro-Raman spectroscopy. J Dent Mater. 2007; 32(1):79-83.
19. Sung-Ae S, Hyoung-Mee R, Bock H, Yong-Hoon K, Jeong-Kil P. The effect of resin thickness on polymerization characteristics of silorane-based composite resin. J Restor Dent Endo. 2014; 39(4):310-318.

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