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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF THE DEGREE OF CONVERSION AND MICROLEAKAGE OF LUXACORE AND CLEARFIL PHOTOCORE BULKCURE CORE BUILD-UP MATERIALS AT VARIOUS CAVITY DEPTHS

Dr. Alia Mukhtar, *Dr. Anamika C. Borkar, Dr. Shalini Aggarwal, Dr. Shailendra S. Sonawane, Dr. Nikhil Nighot and Dr. Shirin Kshirsagar

Department of Conservative Dentistry and Endodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth Pimpri, Pune Maharashtra India

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Abbreviations

DC - Degree of conversion.
FTIR-ATR - Fourier transform infrared-attenuated total reflectance spectroscope.
GIC - Glass Ionomer Cement.
IRM - Intermediate Restorative Material.
RBC - Resin Based Composites.

ABSTRACT

Background: Selection of correct core material is vital for the success of endodontic treatment. Degree of conversion and microleakage of two bulkcure core build up materials was assessed. The two materials were different in their mode of curing; one was a light cure and the other a dual cure material.

Aims: To evaluate and compare the degree of conversion and micro leakage of two bulkcure core build-up materials at various cavity depths.

Settings and Design: In vitro- study.

Methods and Material Seventy two extracted premolars and molars were divided into six groups (n=12). The teeth were accessed and sectioned with carborundum disc below CEJ junction. Etching and bonding of all samples was done. In Group1, 2 and 3 bulkcure core build- up material Photocore was placed at depths of 4mm, 6mm, 8mm respectively. In Group 4, 5 and 6 bulkcure core build- up material Luxacore was placed at depths of 4mm, 6mm, 8mm respectively. Degree of conversion of all samples was evaluated by using FTIR-ATR spectroscopy, Microleakage evaluation was done by dye penetration method**.**

Statistical analysis: Data was analyzed by ANOVA and t test for FTIR-ATR evaluation for degree of polymerization. Chi-Square Test was used for microleakage analysis.

Results: There is no significant difference between mean values of degree of conversion of Clearfil Photocore Group 1, 2, 3 compared together. (p=0.1115). There is a significant difference between mean values of degree of conversion of Luxacore Group 4, 5, 6 compared together and there is a significant difference between mean values of degree of conversion of Clearfil Photocore groups and Luxacore groups compared together. There is a significant association between microleakage and groups 1, 2 and 3**,** and also with groups 4, 5 and 6.

Conclusion: Degree of conversion of Clearfil Photocore (light cure) was significantly higher than Luxacore (dual cure) at all cavity depths. Microleakage was significantly higher in Luxacore than in Clearfil Photocore.

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INTRODUCTION

Access to the pulp chamber for endodontic treatment is indicated as a result of extensive caries, trauma to the tooth causing fracture or loss of vitality. Before requiring restoration of the missing tooth structure, buildup is important from the microbiologic aspect as soon as possible after completion of the endodontic treatment in order to obtain coronal seal, since coronal microleakage results in endodontic failure.

Corresponding author: Dr. Anamika C. Borkar,
Department of Conservative Dentistry and Endodontics, Dr. D.Y. Patil Dental College and Hospital, Dr. D.Y. Patil Vidyapeeth Pimpri, Pune Maharashtra India.

The need for coronal seal was further recommended by endodontists who found root canal contamination when permanent crowns with inadequate margins were fabricated on provisional pulp chamber fillings (Madison and Anderson, 1992). Endodontically treated teeth get depleted of their strength and post endodontic restorations partially restore strength of the root canal treated teeth. Selection of correct core material is vital for the success of endodontic treatment. Traditionally amalgam has been used as a core material. Several cements like IRM (Intermediate Restorative Material) or GIC (Glass Ionomer Cement) have also been utilized to function as core. Composites have been used on and off as core materials since the 1950's (Sheila *et al.,* 2013). Polymerization shrinkage leading to microleakage and inadequate degree of conversion have been the two primary drawbacks of using composites as core material (Kournetas *et al.,* 2011). Piecemeal insertion of the composite and its curing is inconvenient and time consuming for both the clinician and patient. This drawback can be eliminated by the use of bulk curing core build up material (Kathy lo keefekurarray). Hence the aim of this study was to check the degree of conversion and microleakage of 2 different bulk curing core build- up materials.

METHODS

72 freshly extracted intact, non-carious permanent premolars and molars were stored in formalin (10%) until use to avoid dehydration. Teeth were divided into six groups

Group 1: Clearfil Photocore (DMG, Germany) (light cure) at 4mm of cavity depth; (n=12).
Group 2: Clearfil Photocore at 6mm of cavity depth (n=12).
Group 3: Clearfil Photocore at 8mm of cavity depth. (n=12).
Group 4: Luxacore (Kuraray) (dual cure) at 4mm of cavity depth (n=12).
Group 5: Luxacore at 6mm of cavity depth (n=12).
Group 6: Luxacore at 8mm of cavity depth (n=12).

All samples were embedded in wax till cemento-enamel junction. Access opening was done followed by cleaning of pulp chamber with the use of irrigating solutions sodium hypochlorite and normal saline, alternatively. Last irrigation was done with normal saline. Wax was removed. Then all teeth were sectioned with carborundum disc at levels below cement enamel junction. Depth of pulp chamber was measured by periodontal probe. Etching of all samples was done for 15sec with 37% phosphoric acid. Samples were rinsed with water. Bonding agent was applied on the cavity walls of all samples then cured with LED unit for 20sec.

To evaluate degree of conversion at various cavity depths: In Group1, 2 and 3 Photocorebulkcure core build- up material was placed at depths of 4mm, 6mm, and 8mm, cured for 20sec with LED light as specified by manufacturer respectively. In Group 4, 5 and 6 bulkcure core build- up material Luxacore was placed at depths of 4mm, 6mm, and 8mm, cured for 40sec with LED light as given by manufacturer respectively. Pre polymerization reading of both materials was taken after placement in FTIR-ATR (fourier transform infrared) spectroscopy (Nexus, Thermo Nicolet, Madison, USA). Then post polymerization reading was taken again using FTIR-ATR (Fourier Transform Infrared- Attenuated Total Reflectance) spectroscope (Figure 1). To determine the percentage of the remaining unreacted double bonds, the Degree of Conversion was measured by assessing the variation in peak height ratio of the absorbance intensities of methacrylate carbon double bond peak at 1.634 cm^{-1} and that of an internal standard (IS) peak at 1.608 cm^{-1} (aromatic carbon double bond) during polymerization, in relation to the uncured material. (Figure 2)

$$\text{DC height\%} = \frac{[1 - (1.634\text{Cm}^{-1}/\text{IS})\text{ peak after curing }]}{(1.634\text{cm}^{-1})/\text{IS})\text{ peak before curing}} \times 100$$

To evaluate microleakage at various cavity depths: All samples were kept at 37 degrees C, 100% humidity and thermally cycled for 500 cycles. Then all the samples in group 1 to 6 were sealed with nail varnish except 1mm beyond the margins of the restoration and then immersed in 0.5% of fuschin basic dye for 24 hrs. Samples were then sectioned mesio-distally with carborundum disc and assessed for microleakage under a stereomicroscope (Figure3) using the scoring criteria and the results were recorded.

Figure 1. Ftir-Atr Setup

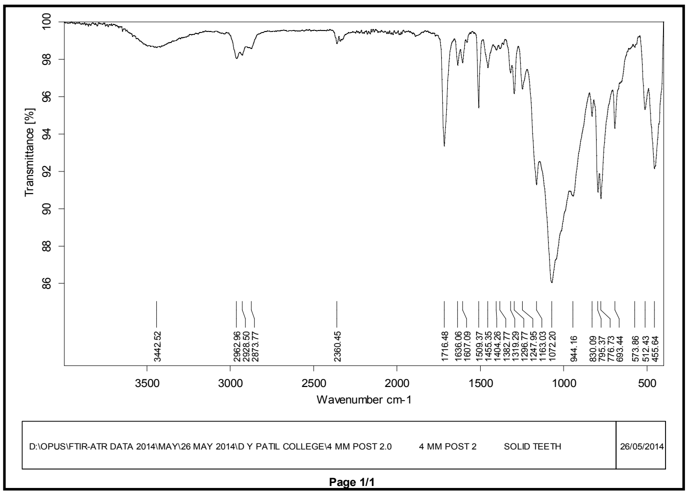


Figure 2. Post- polymerisation Image for Clearfil Photocore at 4mm depth

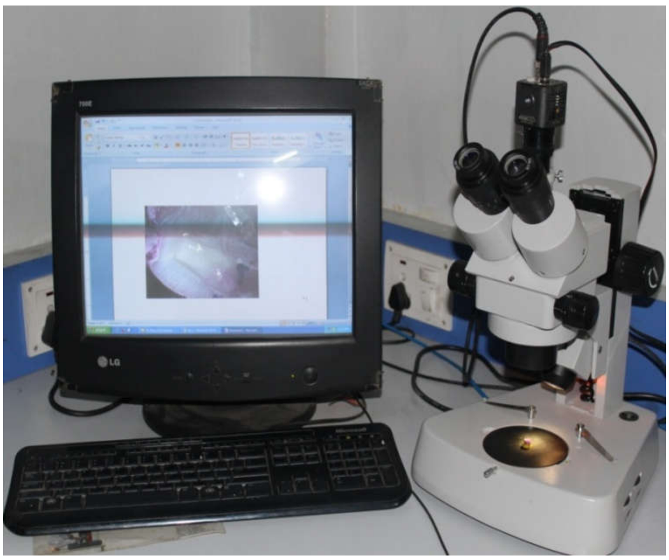


Figure 3. Microleakage analysis by stereomicroscope and image analysis system

Scoring criteria for microleakage

0 = no dye penetration
1 = dye penetration till one third of crown
2 = dye penetration till two third of crown
3 = dye penetration till CEJ. (Full crown)

Statistical analysis: Data will be analyzed by ANOVA and t test for FTIR-ATR evaluation for degree of polymerization. Chi-Square test was used for microleakage analysis.

RESULTS

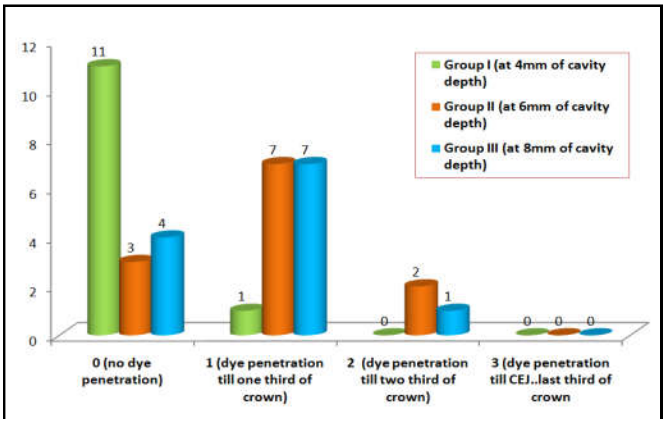
By applying One –Way ANOVA test for repeated measures the variation among column means are not significantly greater than expected than chance and by applying Tukey-Kramer multiple comparison test there is no significant difference between mean values of degree of conversion of Clearfil Photocore Groups 1, 2 and 3 compared together. (p=0.1115). There is a significant difference between mean values of values of degree of conversion of Luxacore Groups 4, 5 and 6 compared together. (p<0.001) and there is a significant difference between mean values of degree of conversion of Clearfil Photocore Group (1, 2, 3) and Luxacore Group (4, 5, 6) compared together. (p<0.001) (Table 1, 2). By applying Chi-Square test there is a significant association between microleakage and groups 1, 2, 3 (p=0.024)**.** There is a highly significant association between microleakage and group 4, 5, 6 (p=0.0040). (Graph 1and 2)

Table 1. Mean values of Degree of conversion of clearfil Photocore (Group I, II, III)

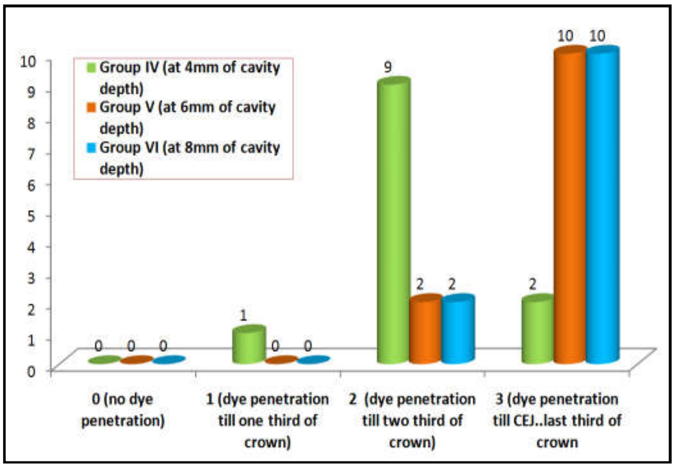
Photocore	Mean values of Degree of conversion (%)
	Mean ± SD
Group I 4mm (n=12)	84% ±1.24%
Group II 6mm (n=12)	83.12% ±2.18%
Group III 8mm(n=12)	82.47% ±1.14%

Table 2. Mean values of Degree of conversion of Luxacore (Group VI, V and VI)

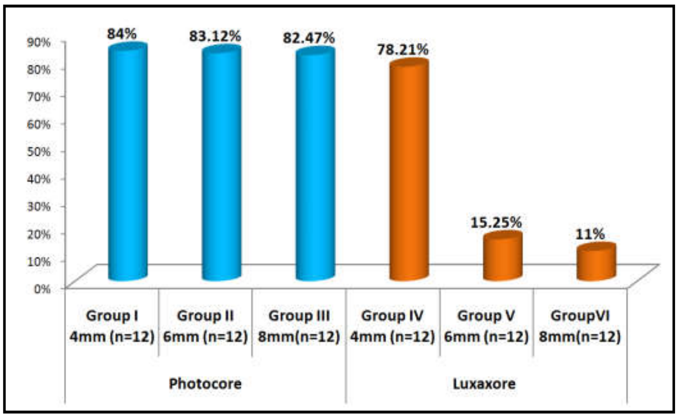
Luxacore	Mean values of Degree of conversion (%)
	Mean ± SD
Group IV 4mm (n=12)	78.21% ± 15.22%
Group V 6mm (n=12)	15.25% ± 0.63
Group VI 8mm(n=12)	11% ± 0



Graph 1. Comparison of microleakage scores of bulkcure core build-up materials Clearfil Photocore in Group I (at 4mm of cavity depth), Group II (at 6mm of cavity depth) and in Group III (at 8mm of cavity depth)



Graph 2. Comparison of microleakage scores of bulkcure core build-up materials Luxacore in Group IV (at 4mm of cavity depth), Group V (at 6mm of cavity depth) and in Group VI (at 8mm of cavity depth)



Graph 3. Mean values of Degree of conversion of Clearfil Photocore and Luxacore Groups

DISCUSSION

It is important for the dentist to restore the form and function of endodontically treated teeth. Any access for root canal treatment, conservative as it may be, results in loss of tooth structure. Pulpless teeth have weak buccal and lingual walls, lacking adequate support. The reduced amount of dentin, damage of the anatomic structure, and apparently, loss of the tooth's internal strength, render the tooth susceptible to fractures, following endodontic treatment (Ami Smidt and Eyal Venezia, 2003).The restoration of endodontically treated teeth offers many challenges for the restorative dentist because of the large percentage of failures (Combe and Shaglouf, 1999). The three basic materials used for immediate buildup restoration are (l) Amalgam (2) Resin composites (3) Reinforced glass ionomers cement. Kovarik *et al.* (1992) made a comparison of these buildup materials combined with prefabricated posts for restoring extracted teeth under simulated mastication forces. They found that amalgam had the lowest failure rate, followed by resin composites, and glass ionomers causing the greatest number of failures. Recently, a new category of Resin Based Composites (RBC) was introduced. The particularity of the new material category is stated to be the option to place it in more than 4 mm thick bulks instead of the current incremental placement technique, without negatively affecting polymerization shrinkage, cavity adaptation or the degree of conversion (DC). Moreover, manufacturers stated that the polymerization shrinkage of these materials is even lower when compared to commonly used flowable and conventional RBCs. Manufacturers claimed that bulk fill materials can achieve a depth of cure of 9 mm, though no published investigations are available till now to confirm these statements (Pascal Czasch and Nicoleta Ilie, 2013). So this study was conducted to evaluate degree of conversion and microleakage of two bulk cure core build up materials at various cavity depths. Materials used in this study were Luxacore dual cure (DMG, Germany) and Photocore light cure (Kuraray). Luxacore dual cure can be automatically mixed and dispensed with intraoral tips. It 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. Manufacturers claim depth of 4mm can be bulk cured at 20s more than 4mm can be cured with 40s of light cure (Bowen, 1963). Clearfil Photocore is an aesthetic light-cured hybrid composite which is heavily filled and especially developed for the construction of reliable core build-ups. This material cures completely to a depth of 9 mm in just 20 seconds (Rouhollahi *et al.,* 2012). FTIR (ATR) Real-time measurements were made with a (FTIR) spectrometer with an attenuated total reflectance (ATR) accessory (Nexus, Thermo Nicolet, Madison, USA). One of the most common methods to determine the extent of double-bond conversion is Fourier transform infrared spectroscopy (FTIR), which can detect the stretching vibrations of carbon-carbon double bonds involved in polymerization (William Cunha Brandt *et al.,* 2010).

In our study, the material Clearfil Photocore (light cure) reached the highest DC at all levels when compared with Luxacore, (Graph 3). The manufacturer guarantees placing the RBCs in 8 mm bulks and light curing for 20 s without a loss in DC and mechanical properties, it saves time and handling would be very easy. Our results confirm this claim. The high degree of conversion of Photocore can be because of the difference in organic matrix (monomer type, monomer concentration and photo initiator concentration), greater filler size and translucency. As Polydorou and Ceballos (Polydorou *et al.,* 2008) demonstrated the effect of these factors in their study, light scattering in composite with a smaller particle size can cause a lower depth of cure and degree of conversion, especially those similar in size to the wavelength of emitted light. Photocore with a higher filler size (1-10 μ) have a higher depth of cure with 0.01-3.5 μ filler particle size (Polydorou *et al.,* 2008). Translucency is another factor in the depth of curing. Glass particles have an important role in light transmission (Howard *et al.,* 2010). Photocore contains silanated glass powder and silanated barium glass powder which are not found Luxacore. Glass and its translucency can cause a high depth of curing and hardness for the composite.[10] In our study significant difference observed in all groups of Luxacore, DC of Group 4 Luxacore was higher than Group 5, 6. This can be explained by the continuous growth of polymer chains after mixing, resulting in higher molecular oligomers, and most probably consuming higher amounts of double bonds during the very early stages of the reaction (Andrzejewska, 2001). However the degree of conversion significantly decreased in Group 5 and Group 6. After 4mm less degree of conversion and polymerization was seen. This can be due to decreased depth of penetration, resulting in decrease depth of cure (Andrzejewska, 2001). The various methods to detect microleakage include the dye leakage method, the use of color producing microorganisms, radioactive isotopes, the air pressure method, neutron activation analysis, electrochemical studies, scanning electron microscopy, thermal and mechanical cycling, and chemical tracers (Gonzalez and Abu Kasim, 1997). Researchers suggested the use of a dye with a particle diameter equal to the bacterial size or somewhat smaller (around 2 lm). For this reason, we used a 0.5% solution of the basic fuschin in our study as its particle size is less than that of the bacterial size. Also, basic fuschin dye provides an excellent contrast with the surrounding environment along with a perfect and easy visualization of the prepared cavity in the digital images (Ernst *et al.,* 2008). For Thermo cycling, the temperature range of 5ºC- 55ºC with a dwell time of 30 seconds for 500 cycles was used according to the ISO TR11405 standard, and this is the estimate of the range that has been reported on the surfaces of molar teeth in the mouth of the patient (Agarwal *et al.,* 2012). In our study microleakage was seen in both groups. It was found that no material could completely eliminate microleakage. However, there is statistical significant difference between two bulk cure materials. Luxacore shows a greater percentage of microleakage than Clearfil photo core (Graph 1, 2). Luxacore at all levels (4mm, 6mm, 8mm) have shown microleakage, whereas Clearfil Photocore has shown slight microleakage in Group II and III(6mm and 8mm), no microleakage was seen in Group I (4mm) depth in Photocore. Microleakage in Group IV (4mm) can be attributed to high polymerisation shrinkage due to high degree of conversion, whereas, microleakage in Group V, VI (6mm, 8mm) can be due to inadequate degree of conversion. Inadequate curing degree affects the chemical and physical properties of the resin composite, such as water absorption, discoloration, wear resistance, strength elution of the possible irritant, toxicity, hardness, marginal breakdown, bond between the tooth, adhesive and the restoration (Aguiar *et al.,* 2017). Microleakage of Clearfil Photocore can be attributed to a high degree of conversion. A high degree of conversion increases the polymerization shrinkage leading to debonding, enamel cracks, microleakage or gap formation, postoperative sensitive major drawback of this material is its polymerization shrinkage which is one of the main cause for the loss of marginal integrity, and secondary caries (Opdam *et al.,* 1998).

Conclusion

Within the limitations of the study following conclusions can be drawn: Clearfil Photocore may most likely be approved for increased increments because of the relatively high DC. Degree of conversion is significantly higher till 8mm, however microleakage is seen at 6mm, 8mm. The result of this in vitro study need to be confirmed by further in vivo studies.

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