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Effect of Curing Technique and Emax Type on the Polymerization of Dual Cure Resin Cement

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Abstract

Objective: The objective of this study was to evaluate the effect of different types of curing techniques and composition of two different types of emax materials on degree of conversion and polymerization of dual cure resin cement after 24 hours. **Material and Methods**: Resin cement discs (90 total) were made by polymerization through two types of Emax discs: Ivoclar IPS e.max (n=30) and GC LiSi Press (n=30). 30 samples without an Emax disc were used as controls. For each group, three subgroups according to the type of curing technique were determined: 10 samples were made by a continuous curing technique, 10 samples were made with a soft start curing technique, 10 samples were made by an intermittent curing technique. Each of 90 resin discs were evaluated with the degree of conversion test by Fourier transform infrared spectroscopy (FTIR) after 24 hours. **Results**: GC LiSi Press had a higher polymerization rate than Ivoclar IPS e.max. The intermittent curing technique sub-group had the highest polymerization rate compared to the other techniques independent of the emax type. Significant differences between each type of emax and curing procedure type were found using a one-way ANOVA test ($p<0.05$). **Conclusion**: GC LiSi Press allowed for more light curing in comparison to Ivoclar IPS e.max, and the intermittent curing technique increased polymerization rate of dual cure resin cement. The degree of conversion for dual cure resin cement was directly influenced by the type of emax veneer and the curing method.

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Introduction

In recent years, the field of dentistry has used an increasing number of cosmetic materials; this could be because of the need to satisfy patient needs and new fabrication developments methods [1].

All-ceramic restorations (those lacking a metal substrate) can be used in the aesthetic area because of their increased translucency [2,3]. Lithium disilicate glass ceramics are the most widely used ceramic system because of its good strength (350–450 MPa), ideal adhesion to tooth structures, easy production and superior aesthetic qualities [4]. To improve the appearance of an anterior tooth, the laminate is a conservative substitute for full covering. One of the most common restorations in aesthetic dentistry during the past few decades is laminate veneers [5]. The current method of restoration fabricating technologies ensures tooth-colored restorations is computer-aided design and computer-aided manufacturing (CAD/CAM) system [6] which is simple, time efficient and quick using resin and ceramic materials in a timely way [7,8].

For many years, resin luting cements have been utilized in dental restorations such as crowns, bridges, inlays, and onlays. Glass fillers and polymerizable methacrylates are the main component of resin cement, and they can be cured by light-curing, self-curing, or both methods [9]. For indirect restorations, the methacrylate-based resin material must chemically bond to the surfaces, which is often accomplished in two or three steps. Micromechanical retention for ceramic restorations incorporating silica is achieved by etching the surface with hydrofluoric acid (HF) and then priming it to become hydrophobic and resin friendly. Additional hydroxyl groups on the ceramic substrates are chemically activated by etching [10].

Dual-cure materials, which combine the advantages of light-curing with chemical polymerization, have gained a lot of popularity [11]. However, it was stated that exposure to light is required for the resin cements to achieve the highest possible degree of conversion rate [12]. This is significant as the lack of polymerization for the self-curing form of also produces reduced mechanical characteristics and increased solubility of resin cements with two curing times [13].

Hardness testing is frequently employed as a straightforward and trustworthy technique to assess appropriate resin cement polymerization [14,15].

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Degree of conversion (DOC) is the percentage of C=C double bonds that are changed into C-C single bonds or the amount that monomers react to produce polymers [16].

Several studies in the literature seem to support the idea that different curing techniques improve the polymerization of direct resin materials [17]. These techniques are based on the knowledge that a slower conversion rate improves material flow, which lowers the resin's shrinkage stress and so helps avoid gap development [18].

The longevity of resin-bonded ceramic restorations is largely dependent on adequate polymerization. Color change may result from incomplete resin cement polymerization, postoperative sensitivity, toxicity from leftover monomer, and reduced bond strength, which raises the risk of cavities and microleakage [19].

To the best of our knowledge, no research has assessed how the Emax type and curing technique affect the degree of conversion of dual-cured resin cement. This study aimed to assess how the degree of conversion of dual-cure resin cement is affected by Emax type and curing technique.

Material and Methods

We used a dual cure resin cement (FGM, Joinville, Brazil and A2 shade) and two types of lithium disilicate (Ivoclar IPS e.max Press ingots and GC Initial Lisi Press shade A2) (Table 1). The thickness of discs that were fabricated was 1.2mm. Since color shade and thickness have direct effect on the light transmission, for this study we kept the color shade and thickness of Emax constant. Figure 1 summarizes the design of the study. Each group was subdivided into three subgroups according to the type of curing technique: continuous mode with 700mW/cm^2 intensity, soft start mode with 150Mw/cm^2 followed by 700Mw/cm^2 intensity and intermittent curing technique with 700Mw/cm2 [22].

A total of 90 dual resin cement samples were put within an elastomeric mold that was 1 mm thick. Each sample's upper surface was covered with individual mylar strips to separate them from the Emax disk [18].

After that an Emax disc sample was put on top of the resin cement and loaded with 200 g for 60 seconds, an LED-curing light was then used to cure the resin cement in three curing techniques at zero distance from Emax discs [19]. All samples of resin cement disc were stored in a dry and black container for 24 hours at room temperature before polymerization.

Following a 24-hour storage period, an ATR-FTIR spectroscopy equipment was used to evaluate the degree of conversion (DOC).

Each specimen of resin cement was placed on the surface of the zinc selenide pellet (Specac) of ATR-FTIR to obtain the absorption spectra of the non-polymerized (C=C) and polymerized (C-C) forms of the specimens. 64 pictures at a resolution of 4 cm were obtained from the 1500–1800 cm region. This region contains the reference peak of the aromatic component (discovered at 1608 cm) and the strength of the aliphatic carbon double-bond (C=C) absorption peak [23,24]. Both peaks are present in materials having aromatic vinyl bonds of bisphenol and aliphatic bonds of the methacrylate functional group. The following formulas were then used to calculate the DOC of each distinct resin cement specimen [25,26]:

DOC (%) = 100 [1 – (R polymerized/R non-polymerized)]

R = the ratio of the absorbance peaks at 1608 cm and 1638 cm

Results

The highest mean value of (DOC) was observed among controls. Mean value of GC emax was higher than Ivoclar's. The intermittent technique of curing had the highest mean value of DOC compared to the rest.

To determine whether there were significant differences between the subgroups within each group, the analysis of variance (one way ANOVA) was performed. Figure 2 shows the three scenarios had the same patterns of response with differences in the absolute value ($p<0.005$).

Figures 3, 4, and 5 show the chart of entire FTIR/ATR spectra for zero cure (unset) dual cure resin cement material for controls, Ivoclair and GC.

Discussion

This study assessed how various porcelain veneer types (Ivoclar and GC emax veneer) and different curing techniques (continuous, soft start and intermittent) affected the polymerization DOC of dual cure resin cement. The null hypothesis of this research was rejected because different types of emax veneer showed direct effect on DOC.

The highest mean value of DOC was obtained in the controls. Ivoclar emax disk had lower DOC than GC emax disk likely because of the difference in composition of the two materials. IPS e.max Press (Ivoclar, Vivadent) creates pressable ingots of lithium disilicate glass ceramic, a synthetic glass-based porcelain. IPS, the microstructure of e.max Press is composed of approximately 70% glass-matriculated lithium disilicate ($Li_2Si_2O_5$) crystals, which range in length from 3 to 6 µm [27]. While initial LiSi Press (GC emax) consist of lithium disilicate micro-crystals equally dispersed in a glass matrix [18], so microcrystalline containing material showed lower scattering of light and more light transmission through it [28].

In each group we found that intermittent curing technique had the highest mean value of polymerization. This method uses a dark gap between each exposure. The polymerization reaction proceeds slowly at this phase. Three to five minutes of delay results in the largest reduction in shrinkage [29]. Additionally, the polymerization process may allow for stress release because to the lengthy curing process that allows resin cement to flow [30,31].

Many authors attribute these results to elongation of pre-gel stage that would permit the material to flow to get the volumetric reduction [32,33]. Other writers contended that chain relaxation, rather than viscous flow, would be a more acceptable explanation for the observed stress alleviation [34,35].

From the results of this research we observed that soft start curing technique had the lowest mean value of DOC. Soft-start polymerization uses a low irradiance at first, then a high irradiance cure toward the end. Better material flow is made possible by a slower rate of conversion. Before curing, the material retains its flexibility for a long time, which also reduces contraction stresses and improves marginal adaption [19,36].

Starting the light-activation process with a low light intensity allowed for a low degree of convergence and prolonged maintenance of a higher level of molecular mobility inside the polymer matrix. Goracci et al. [37] introduced the "slow and gradual polymerization" in 1992 for that reason. This technique entails polymerizing the initial composite layer with progressively increasing light intensity over the course of four minutes to extend the phase of the early setting of the composite. This allows polymerization shrinkage to occur while the molecules still can change their direction to compensate for the internal stress, reducing the contraction stress that develops during the final setting and making it resistant to the bonding's adhesive forces [37].

A light source with a consistent intensity is applied to the resin cement for an established period in continuous curing [38], mean value of DOC of this type of curing technique was more than soft start and less than intermittent curing technique in the result of this study.

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Conclusions

- Composition of emax veneer had direct effect on the polymerization of resin cement, Initial LiSi Press GC with microcrystalline structure transported more light from light cure unit to resin cement in comparison to the IPS e.max Press Ivoclar Vivadent.
- Curing technique had direct effect on polymerization of resin cement, intermittent curing technique displayed more degree of conversion for resin cement than continuous and soft start curing technique.
- Effect of Continuous curing technique was increase in (DOC) of resin cement more than soft start curing technique.

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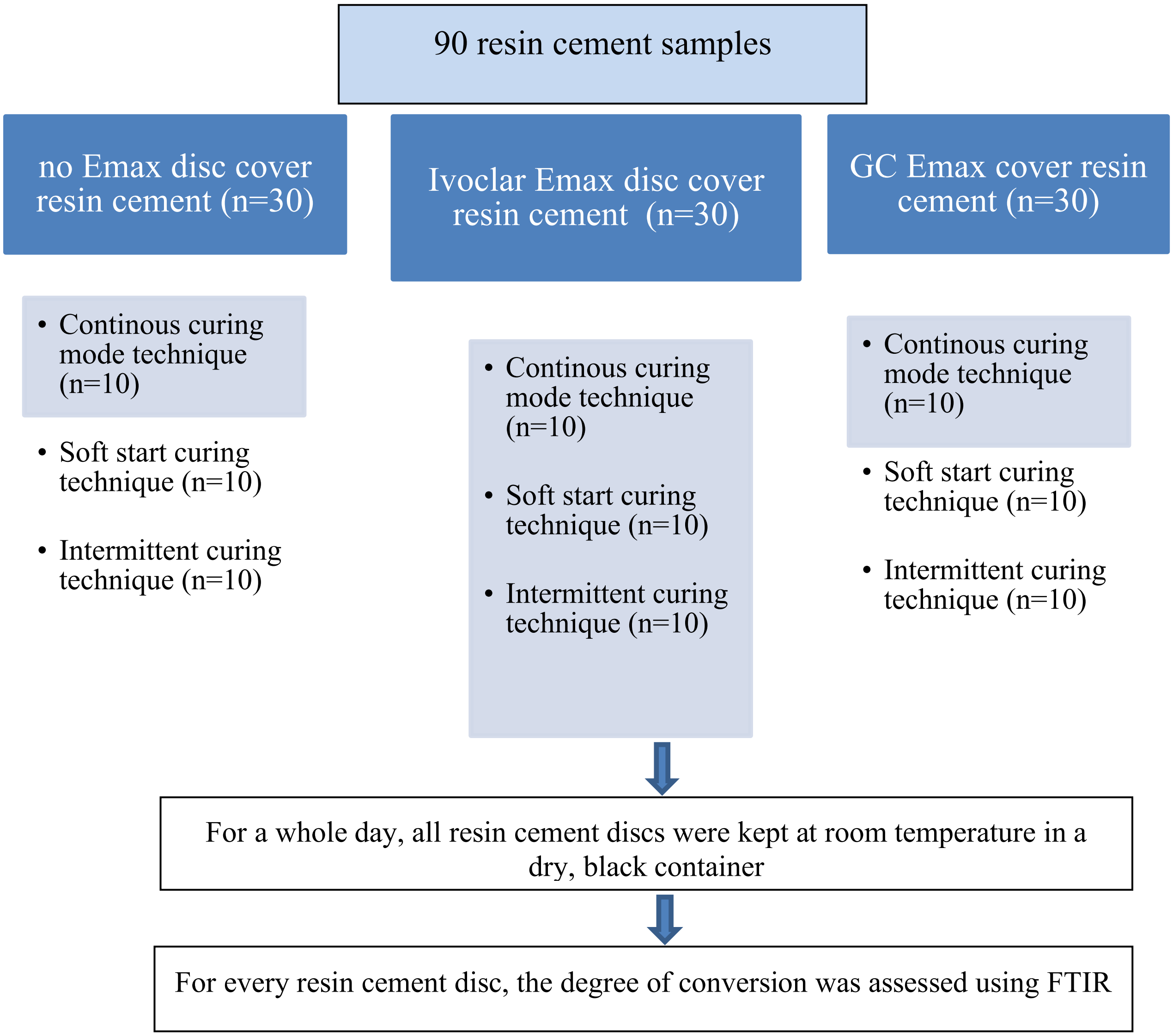

Figure 1. Study design schematics.

Table 1. Materials used in this study.

Materials	Composition	Manufacture	Color
Allcem dual resin cement	Bis-EMA/BisGMA/TEGDMA, -Silicate glass -Barium aluminum -Silicon dioxide 62% weight [20]	FGM, Brazil	A2
Initial LiSi Press	Equivalently distributed lithium disilicate microcrystals in a glass matrix dispersed in a glass matrix [21].	GC	A2
IPS e.max Press	About 70% of Li2Si2O5 and lithium disilicate crystals are immersed in a glassy matrix [21].	Ivoclar Vivadent	A2

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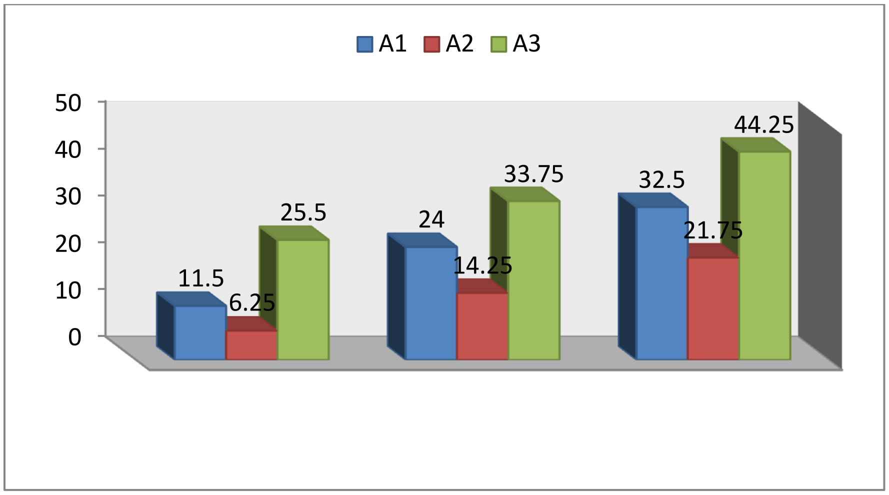

Figure 2. Mean values of DOC for all groups and subgroups. Ivoclar (to the left), GC (in the middle), and controls (to the right). Blue is continuous polymerization, red is soft start, and green and intermittent.

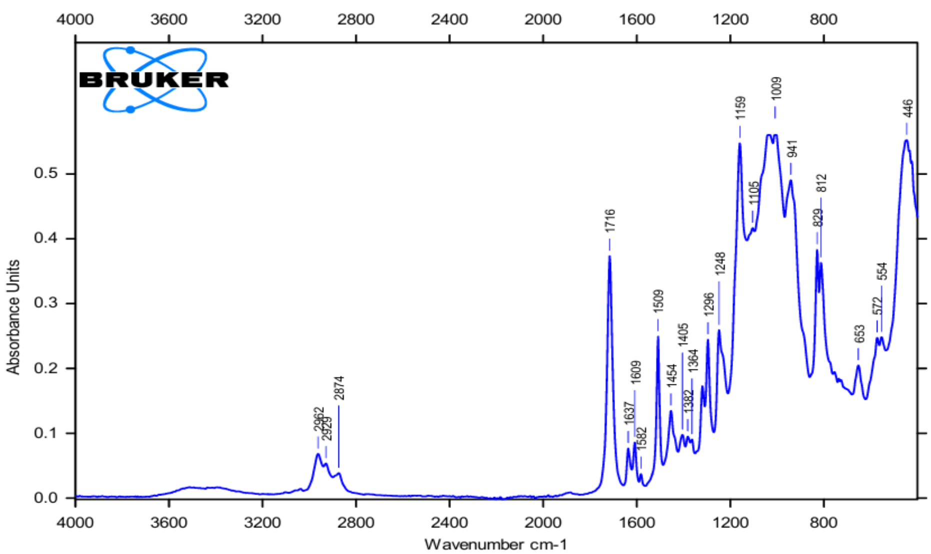

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Figure 3. Diagram of full spectra of unset (zero cure) resin cement.

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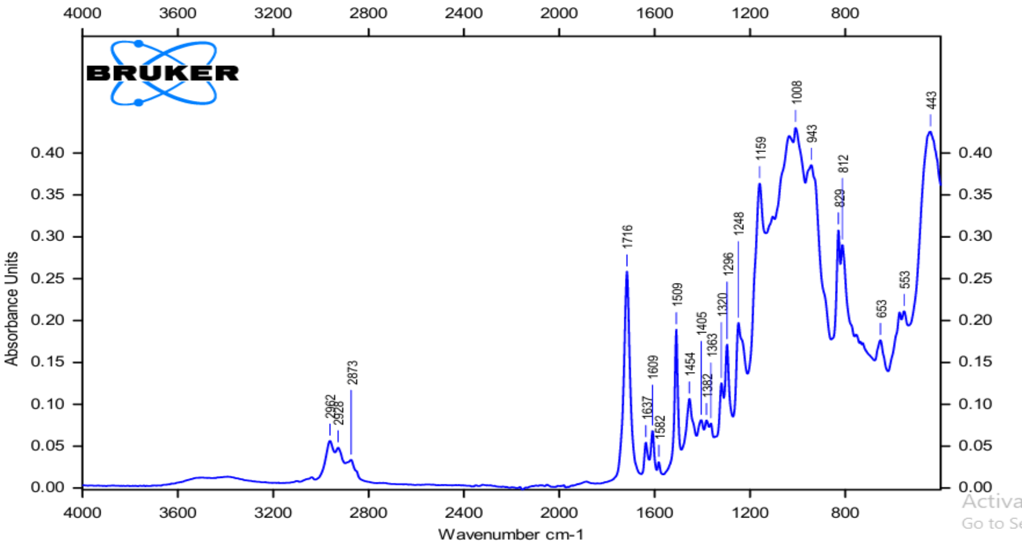

Figure 4. Diagram of full spectra of polymerized controls.

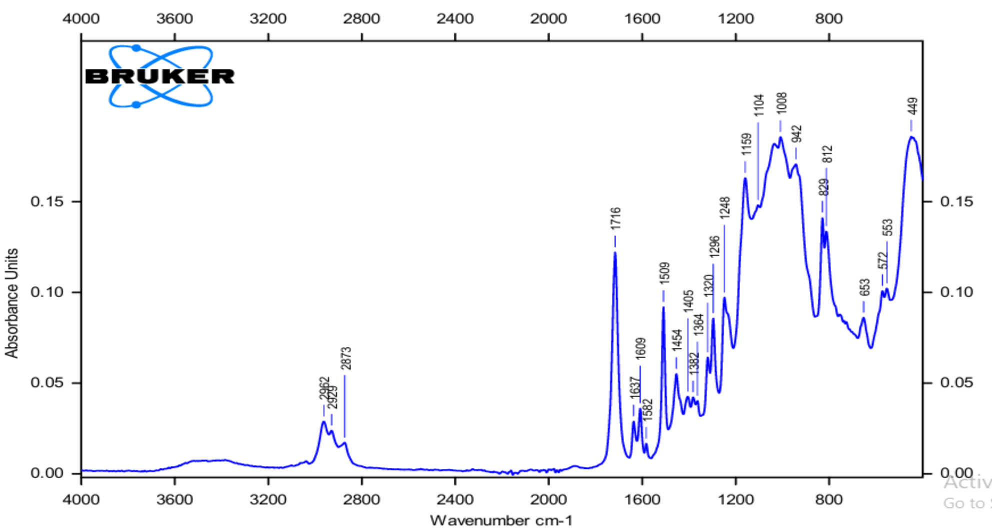

Figure 5. Diagram of full spectra of polymerized GC emax.