عمق التصليب لمادة تيجان وجسور مؤقتة متصلبة ضوئياً

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الملخص

خلفية البحث وهدفه: استخدمت مؤخراً مواد لصناعة التيجان والجسور المؤقتة ذات تصلب ضوئي عن طريق تشكيلها من دفعة واحدة كاملة عند صناعة الجسر المؤقت. إن التصليب الضوئي لطبقات ثخينة من هذه المادة، كما هو الحال في الدمى والوصلات الثخينة، يمكن أن يكون مشكلة بسبب عدم استطاعة الضوء الوصول إلى مركز المادة. وتهدف الدراسة الحالية لقياس الثخانة العظمى للمادة التي يمكن تصليبها بشكل كامل.

مواد البحث وطرائقه: استخدمت في هذا البحث تعليمات الأيزو رقم 4049 لقياس عمق التصليب . وحضّر أربعون نموذجاً من مادة التيجان والجسور المؤقتة ذات التصليب الضوئي Transcen Temp C&B LC), Nexbio co,Korea **اللون:A1) وأجري التصليب بجهاز LED لمدة 30–40–50–70 و 100 ثانية. أزيلت الطبقة غير المتصلبة من أسفل كل نموذج بالكشط، وقيست ثخانة المادة المتبقية المتصلبة بشكل كامل باستخدام مقياس الثخانة الميكانيكي وقسّمت على اثنين.**

النتائج: بلغ عمق التصليب 3.7 ملم عندما تم تصليب المادة لمدة 30 ثانية. وإطالة زمن التصليب لأربعين دقيقة زاد عمق التصليب بما يقارب نصف ملمتر (عمق التصليب 4.14ملم و p=0.001). ازداد عمق التصليب مع زيادة مدة تطبيق الضوء. بلغت الثخانة الأعظمية للطبقة المتصلبة (4,8 ملم) بتطبيق الضوء لمدة 100 ثانية. إلا أن عمق التصليب الذي تم الوصول إليه بتطبيق الضوء لمدة 100 ثانية لم يختلف اختلافاً جوهرياً عن التصليب الذي تم الوصول إليه بالتطبيق لمدة 70 ثاينة والذي بلغ 4.6 ملم.(p=0.31).

الاستنتاج: إن عمق التصليب الناتج عن تطبيق الضوء لمدة ثلاثين ثانية لن يضمن تصلُّب كتلة المادة. وإن إطالة زمن التطبيق سيزيد من عمق التصليب زيادةً ملحوظة. وإنّ زمن التصليب المثالي المنصوح به في الدراسة الحالية 70 ثانية.

كلمات مفتاحية: جسور مؤقتة – تصليب ضوئي–عمق التصليب.

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The Depth of Cure of a Light Cured Temporary Crown and Bridge Material

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Abstract

Background and Aim of study: Light cured temporary crown and bridge materials have been recently used in prosthetic dentistry to fabricate provisional bridges in a single bulk increment. The photo-polymerization of thick layers of this material, such as pontics and connectors, may be problematic due to the inability of the light to reach the center of the material. This study aims at measuring the maximum thickness of the material that can be completely cured.

Materials and methods: ISO specification number 4049 has been used in this study to test the depth of cure. Forty specimens of a light cured temporary crown and bridge material (Transcen Temp C&B LC, color A1, Nexbio co, Korea) has been prepared. Each specimen been cured with LED curing light for 30,40,50,70 and 100 seconds curing times. The uncured mass of the material at the bottom of each specimen has been scraped away and the remaining thickness measured with a mechanical caliper and divided by two.

Results: When the material was cured for 30 seconds, the depth of cure reached 3.7mm. Prolonging the curing time to 40 seconds increased significantly the depth of cure by 0.5 mm (4.14mm. depth of cure, P=0.001). The depth of cure further increased as the time of cure prolonged. The maximum depth of cure reached 4.8 mm has been reached with 100 seconds application time.However, applying the light for 70 seconds resulted in 4.6 mm depth of cure which is nearly the same depth of cure as when applying the light for 100 sec.(P=0.31).

Conclusion: The depth of cure reached with light application for 30 seconds doesn't guarantee the polymerization of the mass. Increasing the curing time will improve the depth of cure significantly. The optimal recommended curing time concluded from this study is 70 seconds.

Key words: Temporary Bridge, Light cure, Depth of cure.

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Introduction and review of literature:

Light cured temporary crown and bridge materials have been recently used in prosthetic dentistry .These materials are presented as a single component stick of viscous photo-polymerizable dough that can be shaped and cured directly in the patient's mouth using the block or the ball technique[1]. After tooth preparation, the dentist should neat a piece of the material, place it over the prepared teeth and sculpt a bridge or a crown after asking the patient to bite on it in different directions. To prevent the material from locking in possible undercuts, the prosthesis should initially be cured intraoraly for a short period of time then completely cured out of the mouth from all directions as recommended by the manufacturer[2]. An advantage of this technique is that the pontics are fabricated without the need for a mold which is not always available when the patient has tooth loss. Additionally, a functional path of the patient's occlusion is generated on the occlusal surface of the temporary prosthesis which may result in better occlusal patterns [3-4]. Prefabricated crown forms of uncured photo-polymerizable resin are also recently available from one manufacturer (3M ESPE) for faster fabrication of a single crown [5]. However, curing the material directly on the teeth without a mold has been shown to cause more shrinkage and misfit of the temporary fixed dental prosthesis[6].

The mechanical properties of light cured temporary crown and bridge materials have been studied in the literature. One light cured temporary crown and bridge material (Revotec LC, GC America Inc.) has been shown to be mechanically similar to other auto-polymerized and dual-polymerized materials in one study[7]. However, other studies showed that the flexural strength of the light cured temporary crown and bridge materials is less than that of the bisacryl based materials[8] and less than that of the heat polymerized materials[9]. On contrary, wear resistance of light cured temporary crown and bridge materials has been shown to be significantly higher than that of the other materials[10]. In addition, these materials have less biological effects on the dental pulp [11], better acceptance by the gingival tissues [12], better resistance to staining than the chemical cure temporary materials [13] and good resistance to dietary solvants[14].

It is noted that the depth of cure of light cured temporary crown and bridge materials has not been studied anywhere in the dental literature.

The composition of light cured temporary crown and bridge materials is similar to the restorative materials [15] so it is expected that their light activation properties should be also similar . It has been shown that the insufficient light cure of the photo-polymerisable restorative materials results in decreased conversion rate of the monomers to polymers, increased risk of monomer leaching and reduced wear resistance[16]. The efficiency of light polymerization of dental materials depends on many variables such as the light source, the light refractory index of the material and the time of application. During photo polymerization, the light has a limited capability to penetrate the mass of the material so insufficient time of cure may lead to a decreased thickness of the cured layer [17]. Provisional bridges may contain large masses of the material in the pontics and connectors areas. In these areas insufficient cure may lead to increased flexure and decreased strength of the provisional bridge.

Aim of study: this study aims at measuring the thickness of the material that can safely be cured when the light source is applied according to the manufactures recommendation instructions and other curing times.

Materials and Methods:

In this study, ISO standard number 4049 has been used to measure the depth of cure according to the recent Academy of Dental Materials guidance[18].

A piece of light cured temporary crown and bridge material (Transcen Temp C&B LC, color A1, Nexbio co, Korea) has been condensed in a plastic cylinder with 6mm diameter and 10mm length (cut from a white plastic straw). The specimen has been immediately light cured from one direction using hand held wireless LED light with an energy output of 700 mw/cm^2 calibrated with a special radiometer Fig 1.

Fig 1: Radiometer used to calibrate the led curing light and the tested material.

The specimen has been initially cured for ten seconds to mimic the clinical situation, where the operator is obliged to remove the bridge from the prepared teeth to prevent possible undercuts as recommended by the

manufacture. After that, the specimen has been additionally cured for 20,30,40,60 or 90 seconds depending on the group .Then, the plastic cylinder has been cut longitudinally with a scalpel and the uncured material at the bottom of the specimen scraped away until hard resistance was felt from the remaining cured mass fig2 .

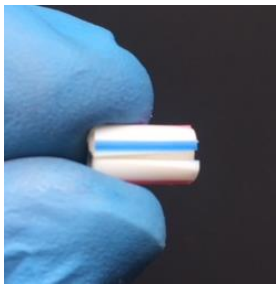


Fig 2: specimen removed from the plastic mold before scraping the uncured material.

Five groups, each containing eight specimens has been prepared in the same manner using a total of 30,40,50,70 and 100 seconds curing times. Fig 3

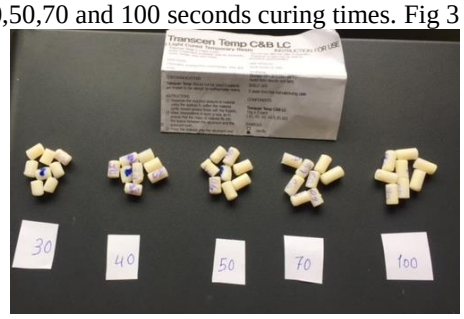


Fig 3: The specimens after measurement.

Finally, each specimen has been measured with a mechanical caliper to the nearest 1/10 mm and the result divided by two to obtain the completely cured thickness as defined by the ISO standard. Fig 4

Fig 4: measuring the thickness of the cured material with a caliper.

One specimen has been cured in a light box (Translux EC light curing Unit, Kulzer, Germany), fig 5, for 30 seconds to be used as a control for maximum polymerization.This specimen was cured completely form all sides.

The results has been arranged in an excel 2007(Microsoft) worksheet and statistically analyzed using student's t test for comparison between averages at $P<0.05$ level.

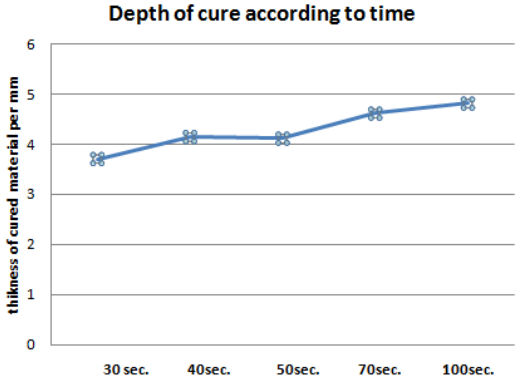
Results:

The average thicknesses of the specimens in each group together with the standard deviation and t test results of comparisons between the groups are presented in table 1

Table 1: The average thicknesses, standard deviation and t test results.

curing times per seconds	30	40	50	70	100
	3.75	3.75	4	5	5
	3.75	3.9	4	5.5	4.5
	3.5	4	4.2	4.75	5
	3.65	4	4.3	4.25	5
	3.5	4.5	4.2	4.75	5
	3.75	4.35	4	4.2	4.5
	3.75	4.5	3.95	4.2	5
	4	4.15	4.25	4.25	4.5
avarage thikness per mm	3.70625	4.14375	4.1125	4.6125	4.8125
standard deviation	0.161328	0.280863	0.138228589	0.474906	0.258775
t test with the baseline (30seconds)		0.001874	9.21689E-05	0.030693	9.34E-06
t test with each previous group		0.001874	0.781799576	0.012618	0.313307

In general, the depth of cure increases as the time of cure is prolonged. Any increase in the curing time compared to the 30 seconds baseline cure is significant and beneficial for the curing procedure. However, this positive relationship between time and depth of cure is not linear and steady, Graph 1.



Graph 1: The depth of cure increases as the time of application is prolonged.

At 30 seconds curing time which is recommended by the manufacturer, the average depth of cure obtained was 3.7 mm. Prolonging the curing time to 40 seconds

increased the depth of cure to 4.14 mm. This difference is statistically significant (P= 0.0018) when compared to the 30 seconds curing time. In other words, ten seconds increase in curing time increases the depth of cure by nearly 0.5 mm. However, prolonging the curing time to 50 seconds cured an average of 4.11 mm, which is nearly the same thickness as in the 40 seconds group. The extra 10 seconds curing time from 40 to 50 seconds didn't improve the depth of cure significantly (P=0.78).

Curing the material for 70 seconds resulted in a significantly thicker layer of cured material (4.6 mm on average) than when cured for 50 seconds (P=0.03) . A further increase in the curing time to 100 seconds resulted in the maximum of 4.8 mm depth of cure. However, this improvement is only marginal and insignificant (P=0.31) when compared to the 70 seconds curing time. Curing the material for one minute and 40 seconds didn't increase the depth of cure compared to 70 seconds curing time.

Discussion:

The light cured temporary crown and bridge material used in this study can be cured efficiently to a depth of 3.7mm when the light is applied for 30 seconds as stated in the manufacturer's instructions. This depth of cure is sufficient for temporary single crowns, since the crown thickness rarely exceeds 3mm. However, a 3.7 mm depth of cure may present a problem when constructing provisional bridges. The buccolingual dimensions of some posterior teeth may reach 9.87 mm and the occluso gingival dimensions 9.99mm according to one Brazilian study.[19] Subsequently, there is a risk of the material in the center of the pontic not to be reached by the light when constructing provisional bridges if the material is cured for only 30 seconds. Increasing the curing time to 70 seconds results in a 4.6 mm depth of cure. When the light source is applied from both the lingual and buccal directions this curing time should theoretically be sufficient to reach the core of the pontic and cure the thickest parts of the provisional bridge.

The current study shows that even a small increase in the curing time from 30 to 40 seconds may significantly improve the depth of cure by 0.5 mm. The deepest depth of cure (4.8mm) has been reached with the longest light application; but, there is no point in prolonging the curing time to one minute and 40 seconds that results in nearly the same depth of cure as if the light is applied for one minute and 10 seconds.

Other methods used to increase the depth of cure have been proposed in the dental literature. Changing the light source intensity or quality (LED vs. quartz) wouldn't increase the depth of cure to more than 4 mm, according to a study which tried to increase the depth of cure of the restorative materials.[20] It should be mentioned that post cure polymerization occurs after the initial photo cure of the composite mass for a period of 24 hours which increases the degree of convergence by nearly 15% [21-22]. The clinician can warn the patient to avoid biting on hard food for the first 24 hours in order to let the composite reach its highest degree of convergence. Another method to increase the depth of cure would be the use of a special light box that can be attached to some in office curing units. This box has mirrors that reflect the light and produces heat which may shorten the curing time and improve the depth of cure [23-24]. The author has experimentally cured a specimen of the material used in this study for 30 seconds in a light box (Translux EC light curing Unit, Kulzer, Germany) which resulted in complete hardening of the specimen form all sides, Fig 5.This may be a subject for a further research on the topic and may be a promising technique for indirect cure of composite restorations in the dental office.

Fig 5: Light box for additional curing.

Some studies indicated that increasing the application time of the light cure will increase depth of cure of restorative sealants which depends on the type of the curing unit.[25] Recently,bulk fill restorative composites has been used to increase the depth of cure in class 2 preparations where the light is unable to reach the bottom of the preparation. It has been shown that increasing the time of cure for such composites will mariginaly increase the depth of cure as stated by the authors.[26] Interestingly, increasing the time of cure of bulk filled composites does not increase the surface hardness of the cured composite as shown in one study.[27]

Conclusion:
Light application for 30 seconds cured 3.7 mm of the light cured temporary crown and bridge material. This depth of cure may be problematic for large pontics and connectors where the light cannot reach the center of the material. Increasing the curing time will significantly improve the depth of cure. The optimal curing time suggested by this study is 70 seconds which can cure a distance of 4.6mm. Prolonging the curing time for more than this duration only results in slight improvement of the curing depth since the material reaches its highest capacity of cure before that time.

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