The effect of a plastic-wrapped LED light curing unit and curing distance variances on diametral tensile strength of composite resin

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Abstract. A method to control infection when using a light-emitting diode (LED) curing unit (LCU) is to wrap it in a transparent plastic barrier (cling wrap). The influence of a plastic-wrapped LCU and curing distance variances on diametral tensile strength of composite resin was evaluated. A total of 60 disc-shaped specimens were formed and cured using plastic-wrapped and unwrapped LCUs. The specimens were divided into six groups with curing distances of 0.5 to 5 mm. The diametral compression test was done using a universal testing machine. A statistically significant difference was found between the wrapped and unwrapped groups. Therefore, the use of a plastic-wrapped LCU influences the diametral tensile strength of composite resin.

1. Introduction
Infection control during patient therapy is important in dentistry. Dentists use a light curing unit (LCU) during tooth filling to cure composite resins made of light-activated materials. However, there is a risk of cross-infection using this device. Many kinds of LCU exist with various light sources, with the most common having a light-emitting diode (LED) [1,2].

Various methods exist to prevent cross-infection through the LCU, such as use of disinfectants and autoclaves. However, the negative effects of these methods decrease the quality of the LCU [3]. One method that is not only effective and efficient, but also cost-effective and does not cause any negative effects is the use of cling wrap to cover the tip of the LCU [4–6].

Composite resin is a filling material that is activated by light. It has the same color as tooth enamel, and has good esthetic, physical, and mechanical properties [7]. Therefore, composite resin is used for anterior or posterior tooth filling [8].

Maan Ibrahim previously analyzed the effect of covering the tip of the LCU on the quality of composite resin and showed no difference in resin strength when activated by an uncovered or covered LCU [8]. However, that study also demonstrated a difference in light intensity between the uncovered and covered LCU.

When using an LCU for posterior tooth filling, problems occurred when the tip of the LCU could not reach an ideal position because the posterior tooth was hard to reach and the tooth cusp increased the distance between the LCU and the surface of the filling material. This distance caused a decrease in light intensity, which can negatively affect some mechanical properties of the filling material [10].
Coutinho et al. showed that covering the tip of the LCU with cling wrap decreased and increasing distance affected the conversion degree of composite resin [11].

One mechanical property of composite resin is tensile strength, which allows the filling material to accept or resist maximal pressure before it cracks [12]. A diametral compression test will demonstrate the diametral tensile strength of composite resin [13].

This study analyzed the effect of using cling wrap to cover the tip of the LCU and of varying the distance of the LCU tip from the filling material surface on the diametral tensile strength of light-activated composite resin.

2. Methods
This experimental study was performed at the Dental Material Laboratory of the Faculty of Dentistry Universitas Indonesia, from October to December 2013. This study involved 60 specimens (30 lit by a cling-wrapped and 30 by an uncovered LCU unit) divided into six groups of five specimens each with curing distances of 0.5, 1, 2, 3, 4, and 5 mm from the surface of the material.

The filling material used was GC SOLARE X shade A3 micro-fine hybrid composite resin. This universal filling material can be used for posterior or anterior tooth filling. Specimens were formed into a disk ±3.0 mm thick and ±6.0 mm in diameter based on American Dental Association (ADA) No. 27 specifications. The plastic cling wrap used in this study was made of polyvinyl chloride (PVC) 12.5 µm thick.

The mold was filled in 2 mm increments based on the manufacturer’s directions. After the second filling, the surface material was covered by a Mylar matrix and compressed by a glass slab. When finished, the matrix was removed. Curing in this study was performed using a LEDMax 450 Hilux LED curing unit after achieving a flat and dense surface material. All specimens were cured for the same time based on the manufacturer’s instructions (20 seconds). For the covered LCU group, curing was performed after the tip of the LCU was covered by cling wrap, and the surface of the material was ensured to be flat with no bubbles or overlapping. The variation in distance curing was altered using the help of microscope slide glass.

The specimens were immersed in a plastic pot containing Aquadest and incubated at 37°C for 24 hours. All specimens were tested with the Shimadzu AG-5000E Universal Testing Machine, with a maximum load of 250 kgf and crosshead speed of 0.5 mm/min. Specimens were positioned in the center of the testing machine. Pressure was applied until the material cracked and the diametral tensile strength was measured. Data were analyzed statistically by two-way analysis of variance (ANOVA) to determine the effects of a cling-wrapped LCU tip and curing distance on composite resin tensile strength. The Tukey test was performed to determine the difference in curing distance in specimen groups cured by a cling-wrapped LCU.

3. Results
The diametral pressure test was performed in 60 specimens and the diametral tensile strength was measured. Table 1 shows the decreasing mean tensile strength of specimens cured by a cling-wrapped LED curing unit. The decrease occurred at all curing distances and was compared to that of all specimens cured by an uncovered LED curing unit.

| Curing Distance | Mean Diametral Tensile Strength (MPa) |
|-----------------|--------------------------------------|
|                 | No Wrap                               | Wrap                   |
| 0.5 mm          | 36.17 ± 3.61                          | 31.67 ± 3.49           |
| 1 mm            | 34.35 ± 5.28                          | 31.42 ± 2.95           |
| 2 mm            | 31.88 ± 3.45                          | 30.23 ± 5.91           |

Table 1. Mean Composite Diametral Tensile Strength
There was a decrease in mean diametral tensile strength in both groups as the curing distance increased. All specimens showed a decrease in mean diametral tensile strength at the 1, 2, and 3 mm curing distances. For the uncovered LCU groups, the decrease continued in specimens at the 4 and 5 mm curing distances. However, in specimens cured by a cling-wrapped LCU, the tensile strength was enhanced when curing distance increased from 3 mm to 4 mm.

Two-way ANOVA results showed a significance effect of cling-wrapped LED curing units on the diametral tensile strength of composite resin ($P = 0.005$). However, there was no difference between diametral tensile strength and curing distance ($P = 0.05$).

Because our results demonstrated no differences in diametral tensile strength of specimens cured by the cling-wrapped LED curing unit, the Tukey test was performed to determine the effect of curing distance. The results showed no difference between curing distance and diametral tensile strength of the composite resin cured by the cling-wrapped LED curing unit ($P > 0.05$).

4. Discussion

The results showed a difference between diametral tensile strengths of GC Solare X composite resin cured by a cling-wrapped and an uncovered LED curing unit. The difference was assumed to be due to the difference in light intensity between the covered and uncovered LED curing units. The light intensity from the cling-wrapped unit was assumed to have been decreased by the plastic film covering the tip. This was supported by the data of Maan Ibrahim [8], who showed that a plastic cover on the tip of an LCU led to decreased light intensity.

Diametral tensile strength is a mechanical property of composite resin that depends on several factors, one of which is conversion degree. Conversion degree is the percentage of a total monomer molecule that is converted to polymer during a polymerization reaction [14]. In the polymerization process, the converted monomer would form a polymer chain through a molecule condensing process, resulting in contraction of the material [15]. If the intensity of energy were greater, the degree of conversion also would be greater. This is caused by the photoinitiator molecule, which was activated by the high light intensity. In the end, if many monomers were converted, the mechanical properties, including diametral tensile strength, of the composite resin also would be greater [14].

The decreased diametral tensile strength was assumed to be due to the use of cling wrap, which also is supported by the results reported by Coutinho et al. [11], who showed that cling wrap used to cover an LCU changed the light intensity and decreased the conversion degree of composite resin. The cling wrap that covered the LCU tip reduced the light intensity of the LCU due to the light dispersion phenomenon [11].

Also in our study, the Tukey test results demonstrated that variation in curing distance did not show any significant effect on diametral tensile strength of the composite resin. However, a decrease in composite resin diametral tensile strength due to the decreased light intensity on the composite resin occurred at any curing distance from 1 to 5 mm.

The diametral tensile strength for composite resin in our study group ranged from 30 to 55 MPa [15]. However, at 3, 4, and 5 mm curing distances with the cling-wrapped LED curing unit, the value obtained was in the normal range despite the inadequate light intensity on the composite resin in those groups. As explained previously, the inadequate light intensity led to decreased conversion degree indicated by the low diametral tensile strength [14].

Though our results demonstrated that using cling wrap on the tip of the LED curing unit to prevent cross-infection has an effect on composite resin diametral tensile strength, treatment of patients must be based on ADA and Centers for Disease Control and Prevention (CDC) guidelines [16].

### Table 1. Continue

| Curing Distance | Mean Diametral Tensile Strength (MPa) |
|-----------------|---------------------------------------|
| 3 mm            | 31.43 ± 4.84                          |
| 4 mm            | 31.40 ± 4.53                          |
| 5 mm            | 30.52 ± 2.58                          |
| Total           | 32.63 ± 4.28                          |

**Discussion**

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Though our results demonstrated that using cling wrap on the tip of the LED curing unit to prevent cross-infection has an effect on composite resin diametral tensile strength, treatment of patients must be based on ADA and Centers for Disease Control and Prevention (CDC) guidelines [16].
Furthermore, other studies also must be done to demonstrate that the use of cling wrap will not have any detrimental effects on the composite resin, such as studies with a prolonged duration of curing and decreased incremental thickness so that better polymerization could be gained.

5. Conclusion
It is concluded that the use of cling wrap on the tip of the LED curing unit has an effect on composite resin diametral tensile strength. However, the variation in curing distance (0.5, 1, 2, 3, 4, and 5 mm) from the surface of the material did not show any significance difference in composite resin strength when cured by a cling-wrapped LED curing unit.

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