

Does Diode Laser Curing Light Cause More Thermal Risks Than LED And QTH Units?

Portia Cao, MSc¹, Aiman P. Kermani, BDS, MSc²

¹Dental student, School of Dentistry, University of Washington, Seattle, Wash.

²Dental student, School of Dentistry, University of Washington, Seattle, Wash.



SCHOOL OF DENTISTRY
UNIVERSITY of WASHINGTON

Abstract

A handheld laser curing light with collimated beam was recently introduced. The aim of this study was to assess temperature changes when using three commercially available curing lights (Table 1) on cured composite.

Our null hypothesis was that the highly collimated laser light beam would not cause greater increases in temperature (ΔT) than the higher power density LED and the QTH sources.

The cured composite was exposed to different LCUs following manufacturer's recommended exposure times. The ΔT during simulated photoactivation of different thicknesses (0, 2, 4 & 6mm) of cured composite material were recorded (n=5/group).

Despite the greatest temperature rise (4.64°C) at 0 mm, LASER consistently demonstrated the lowest temperature increase for all composite thicknesses, while QTH produced the greatest temperature increases. The results indicate that the highly collimated light beam LASER source did not cause greater increases in temperatures than the LED and QTH sources while curing composites.

Additional experiments are carried out to evaluate the hardness of the bulk-cured composites and to illustrate the temperature change during actual exothermic polymerization.

Introduction

Light curing unit (LCU) has become an essential tool for most dental practices. The quality of restoration highly depends on the light quality and proper use of LCU. However, if inadequate light-curing occurs, a variety of clinical conditions such as discoloration, pulpal irritation, post-operative sensitivity and eventual failure of the restoration can occur⁹. Currently, there are four different types of dental curing lights used in dentistry mentioned in table 1.

When using LCUs and performing restorative procedures, the risk of thermal injury is a concern. The potential risk of pulpal injury during polymerization of restorative composites is increased due to the exothermic reaction with LCUs with higher-energy output⁴, which may result in increased heat transmitted to the pulp³. The temperature increase can cause postoperative sensitivity, pain, or even pulp necrosis³.

In this *in vitro* study, the goal was to evaluate the temperature differences (ΔT) in cured composite at different thicknesses with QTH, LED, and LASER curing lights.

The null hypothesis was that the highly collimated light beam of diode lasers would not cause greater increases in temperature (ΔT) than the higher power density LED and the broader spectral QTH source for all composite block thicknesses.

Material & Methods

- 17 mm in diameter round blocks of 3M™ Filtek™ Supreme Composite, shade C1B with a thickness of 2 mm, 4 mm and 6 mm were used for each testing group
 - Thickness of 2 mm, 4 mm and 6 mm were respectively used (Figure 1).
 - 0 mm, no composite barrier, was also tested and used as the control group
- ΔT on the different composite thicknesses were demonstrated using three sources of commercially available LCUs (Table 1) and the composite was exposed to the manufacturer's recommended curing times (Table 2) (n=5/group).
- At 0 mm, all curing lights followed the recommended curing time for 6 mm of composite depth.
- LCUs were held at a standard distance of 4 mm from the superior side of the round composite blocks (Figure 2). A thermocouples temperature probe was used to measure the ΔT . It was positioned in direct contact on the inferior side of the round composite blocks (Figure 3).
- All measurements were taken in an ambient environment, with a controlled room temperature of 21.4 ± 0.5 °C.
- ΔT was calculated after each measurement.
 - $\Delta T = (T_F - T_I)$
 - T_I: Initial ambient room temperature
 - T_F: Final temperature at the end of the recommended curing time

The 2-way analysis of variance (ANOVA) test was performed to compare mean values obtained from between the different curing lights and ΔT ($\alpha=.05$).

Table 1. Light Curing Units (LCU) used in this study

Code	Brand	Manufacturer
LASER	Monet™ laser curing light	AMD Lasers
LED	Demi™ Plus curing light	Kerr
QTH	Coltolux 75 curing light	Coltene

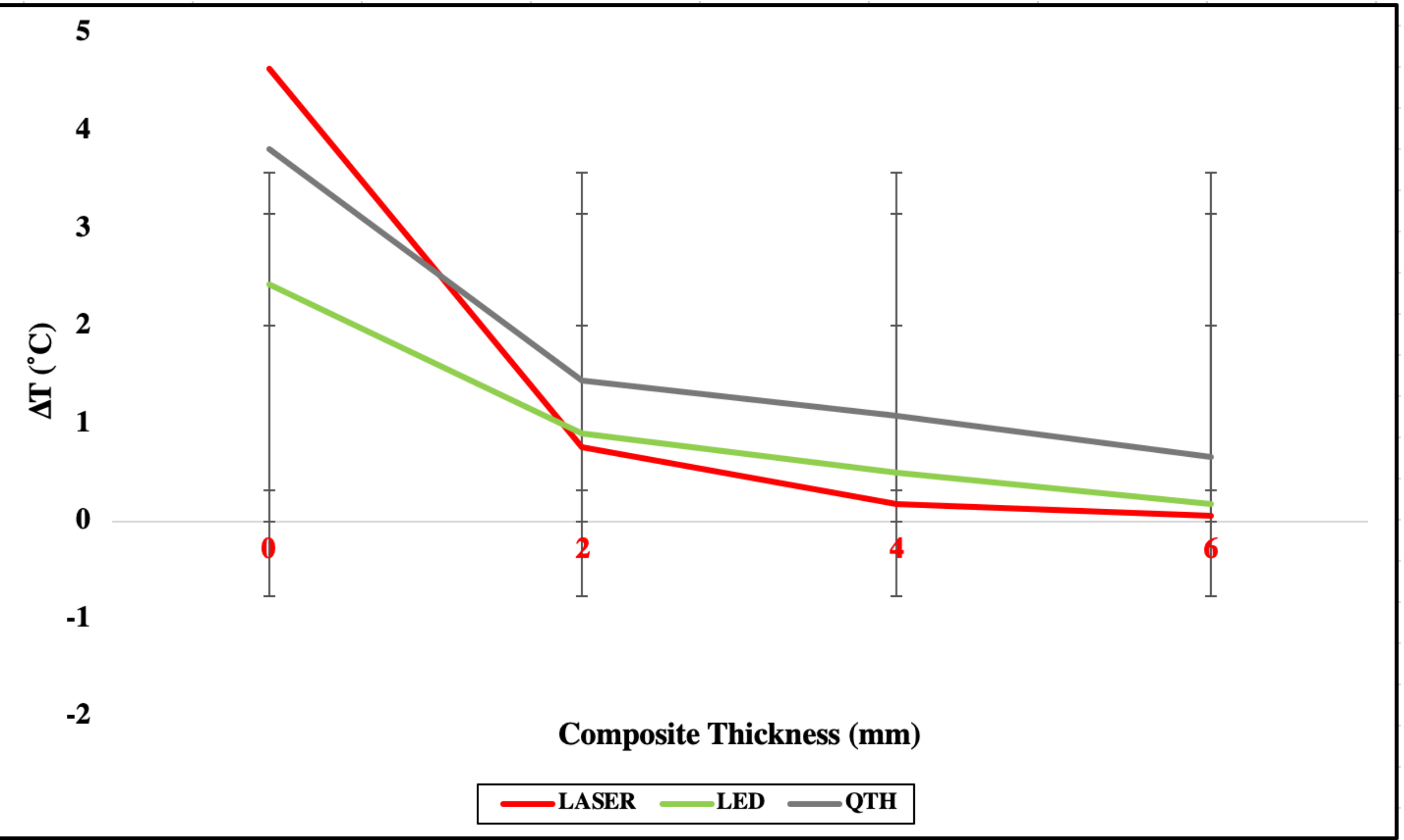
Table 2. Manufacturers recommended light curing times

Curing Light	Recommended curing times
AMD Lasers, Monet™ Laser Diode (LASER)	1 second for 2 mm of composite 2 seconds for 4 mm of composite 3 seconds for 6 mm of composite
Kerr, Demi™ Plus Light-Emitting Diode (LED)	5 seconds for universal composite shades A3 and lighter with 2 mm depth 10 seconds for universal composite shades A3.5 and darker
Coltene, Coltolux 75 Quartz-Tungsten-Halogen (QTH)	10 seconds for universal composite shades A2 with 2 mm depth

Table 3. Mean $\pm$ SD of temperature change (ΔT) in °C (n=5)

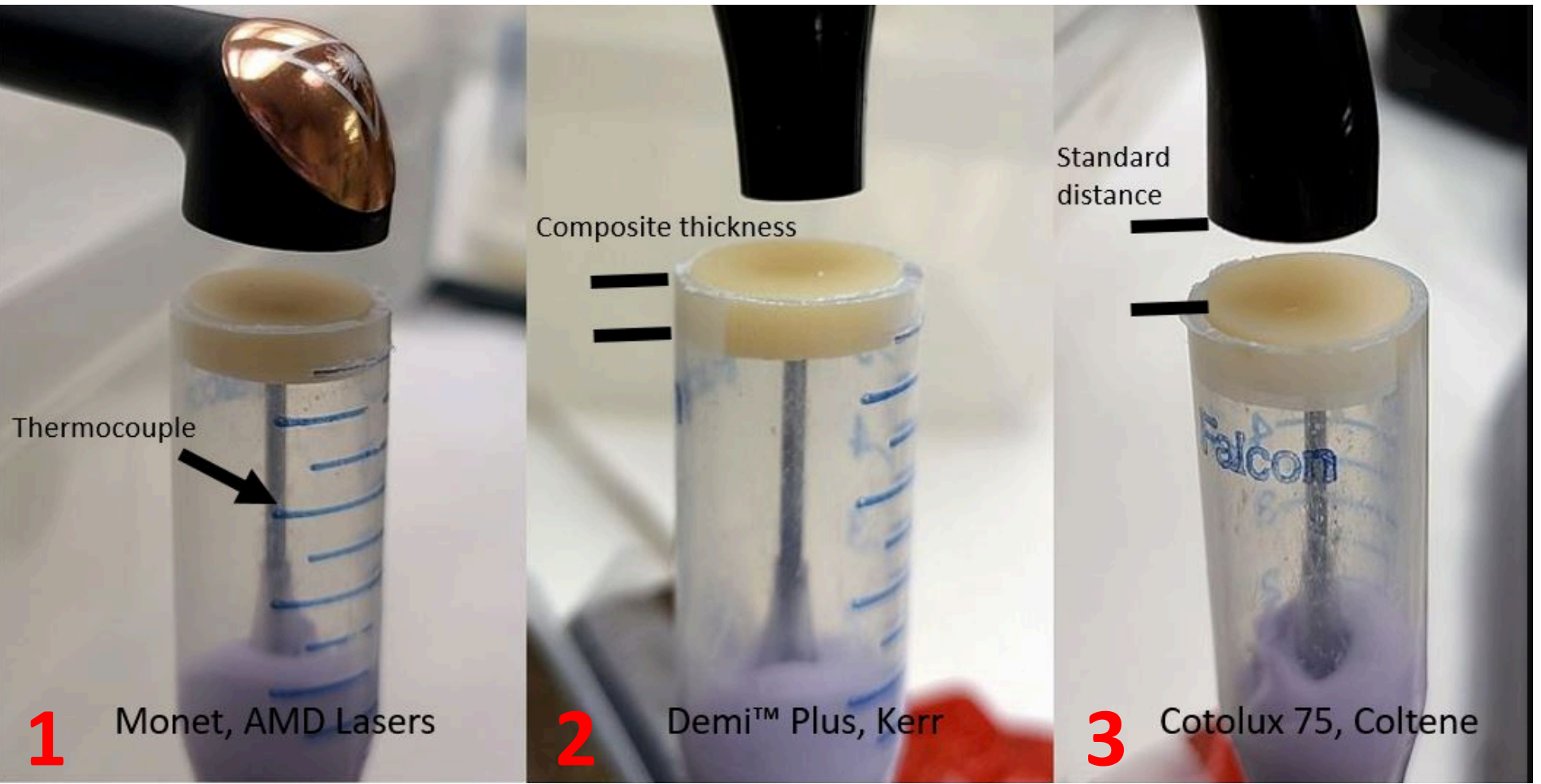
Curing Light	0 mm	2 mm	4 mm	6 mm
AMD Lasers, Monet™ Laser Diode (LASER)	4.64 $\pm$ 0.34	0.76 $\pm$ 0.26	0.18 $\pm$ 0.08	0.06 $\pm$ 0.05
Kerr, Demi™ Plus Light-Emitting Diode (LED)	2.44 $\pm$ 0.11	0.90 $\pm$ 0.10	0.50 $\pm$ 0.07	0.18 $\pm$ 0.04
Coltene, Coltolux 75 Quartz-Tungsten-Halogen (QTH)	3.82 $\pm$ 0.53	1.44 $\pm$ 0.11	1.08 $\pm$ 0.14	0.66 $\pm$ 0.11

Figure 4. Results of the mean temperature change (ΔT) in °C of tested LCUs and composite thicknesses.



Figures 1,2,&3.

1. Thermocouple in direct contact with composite
2. Composite thickness
3. Standardized distance of 4 mm between the curing light and composite



Results

The results of ΔT mean measurements for all curing lights are shown in Table 3.

- At 0 mm:
 - ΔT was the highest for all curing lights.
 - LASER had the highest ΔT , 4.64 $\pm$ 0.34 °C, curing time for 3 seconds
 - LED obtained the lowest ΔT , 2.44 $\pm$ 0.11 °C, curing time for 15 seconds.
- At 2,4, and 6 mm:
 - LASER demonstrated the lowest ΔT while QTH became the highest ΔT .
 - At 6 mm, all curing lights demonstrated the lowest ΔT despite the longer curing times. LASER had the lowest ΔT , 0.06 $\pm$ 0.05 °C, while QTH had the highest ΔT , 0.66 $\pm$ 0.11 °C.

It is clear that an increase in composite thickness resulted in a decrease in ΔT .

The two-way ANOVA analysis revealed a statistical significance in curing light types, thicknesses, and their interactions (p< 0.01).

Conclusions

Within the limitations of this *in vitro* study, the following conclusions were drawn:

- LASER consistently demonstrated the lowest temperature increase for all composite thicknesses despite the greatest temperature rise (4.64°C) at 0 mm (control).
- When the round composite blocks were tested, QTH produced the greatest temperature increase.
- Although the tested light-curing units caused a temperature rise, none exceed the critical ΔT value of 5.5°C.
- The 2 mm thickness composite block showed the greatest thermal variation after being exposed to the light-curing source, while the 6 mm thickness composite block showed the least thermal variation. Therefore, the greater the thickness of composite, the less chance of heat being transmitted.

References

1. Armellin E, Bovesecchi G, Coppa P, Pasquantonio G, Cerroni L. LED Curing Lights and Temperature Changes in Different Tooth Sites. BioMed research international. 2016;2016.
2. Santini A, Watterson C, Miletic V. Temperature Rise Within the Pulp Chamber During Composite Resin Polymerisation Using Three Different Light Sources. The open dentistry journal. 2008;2(1):137–141.
3. Kubo S. Longevity of resin composite restorations. The Japanese dental science review. 2011;47(1):43–55.

Acknowledgements

We would like to thank Daniel Chan and Kwok-Hung Chung for their mentorship and assistance during this study.