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FRICTIONAL BEHAVIOR OF THE SLIDING OF COMPOSITE RESIN ON TEETH

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ABSTRACT

Composite resins are considered the major material of dental restorations. due to their superior aesthetics and conservative application. The behavior of the restorations is affected by curing method such as continuous and pulsed modes. The test specimens have been prepared by bulk-fill and incremental layering.

The present study investigates the effect of filling and curing techniques on frictional properties and electrification of the tested composite resin. Sliding tests were performed at 8, 10 and 12 N load to simulate oral masticatory forces. Because the friction of materials is accompanied by electrification, it necessary to measure the voltage generated from the sliding of composites resin on the teeth.

It was revealed that specimens of three layers displayed the highest friction coefficient followed by specimens of two layers and bulk-fill, while specimens of four layers showed lowest friction. Besides, water wet sliding displayed lower values of friction coefficient with the same trend compared to the dry sliding. Specimens treated by pulsed light curing gave relatively higher friction displayed by specimens of three layers while bulk-fill showed the lowest friction of higher values than that shown for specimens cured by continuous light. It was observed that pulsed treated specimens had higher hardness than continuous treated ones. It is recommended to increase the hardness of composite resin to increase friction to guarantee proper mastification.

Specimens continuously light cured of two layers displayed the highest voltage in dry sliding. While, water wet surfaces showed relatively higher voltage than dry ones. Voltage generated from dry sliding of pulsed light cured specimens was higher than that observed from specimens treated by continuous light and water wet sliding displayed higher voltage values. It seems that in pulsed light curing, the monomers have the chance to be linked to other monomers forming longer polymer chains, increasing the degree of polymerization and modifying the toughness that increases the values of the generated voltage caused by the piezoelectric effect.

KEYWORDS
Composite resin, bovine teeth, friction, voltage.

INTRODUCTION

Composite resin is extensively applied in teeth restoration, [1 - 3]. The mechanical properties of dental composite resin can be affected by various factors as technique of placement and mode of light curing. In recent study the influence of continuous and pulsed light curing for bulk-fill, two, three and four layers on abrasive wear resistance and friction coefficient of a nanohybrid dental composite was investigated, [4]. It was revealed that pulsed light curing displayed relatively lower wear. Besides, the restoration of two and three layers showed enhanced wear resistance.

Photoactivation of composite resin achieved by exposure of light-curing unit can strengthen the large restorations, [5 - 7]. The proper conventional composite resin should be made by incremental thickness of 2 mm, [8, 9]. Applying the filling materials in resin affects shrinkage polymerization shrinkage, [10]. The filling materials contained nanoparticles such as titanium dioxide, aluminum oxide, zirconium dioxide, silicon oxide and zinc oxide that were applied in restoration in several biological applications, [11 - 17].

The proper polymerization of resin composites is essential to get a long-lasting restoration of enhanced mechanical properties. Polymerization makes the monomers to be linked together to form chains of molecules that are called polymers. The monomers include carbon-carbon of double bonds (C=C) having two pairs of electrons that sharing two carbon atoms. The polymerization process has activation, initiation, propagation and termination reactions, [18 - 24], where activation initiates polymerization when the free radicals are released. While free radicals open the double bond to facilitate to be linked to the other monomers forming the polymer chains. New monomers are added to the polymer chain in the propagation process. Then the reaction ends when the number of monomers decreased in the termination phase. Then the molecular weight of all monomers linked together is the molecular weights of the polymer. The degree of polymerization increases ss the number of monomers in the chain increases, [25 - 28].

The light polymerization is called photopolymerization, where light curing polymerization is investigated, [29]. The polymerization depends on the thickness of composite resin, where 2 mm thickness is recommended. Increasing the thickness of composite resin decreases the light intensity at the bottom surface and consequently the mechanical properties decrease, [30 - 32].

The objectives of the present study are to investigates the effect of filling and curing techniques on friction coefficient and the generated voltage displayed by sliding of composite resin sliding on bovine tooth. The composite resin test specimens were prepared by bulk-fill and incremental layering using continuous and pulsed light curing.

EXPERIMENTAL

RubyFill Nano (RubyDent, Germany) was the composite resin used in the present study. It is filled by nano-sized filler particles to develop the mechanical properties. 3D Star LED Light Curing Device was applied to light curing the tested specimens using continuous and pulsed light-curing methods. A piece of bovine teeth of 25 mm long and 10 mm width applied as the counter surface was adhered to the base of the reciprocating table of the test rig, Fig. 1.

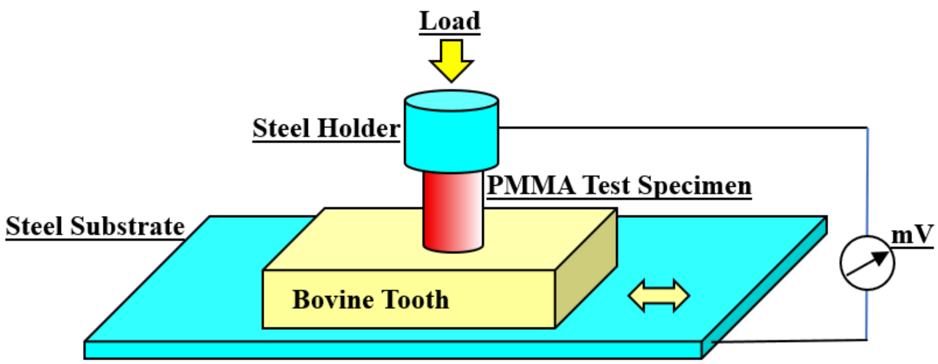

Fig. 1 Measurement of ESC generated from the sliding process.

The resin composite specimens were molded in a form of cylindrical pin of 12 mm height and 6 mm diameter using continuous and pulsed curing light. The tested specimens were bulk-fill, two layers, three layers and four layers. In the layered specimens, the composite resin was applied incrementally, with two, three and four layers. The curing time was 60 seconds from the top surface for bulk-fill specimens, while for layered specimens, every layer was cured for 60 seconds. Friction force was measured by the load cell assembled in the loading lever, then friction coefficient was determined by dividing the friction force on the applied load.

Besides, voltage generated from sliding of composite resin on bovine tooth was measured. The details of the measurement are shown in Fig. 1. The test specimens were loaded on bovine tooth at 2, 4, 6, 8 and 10 N normal load and slid for 20 mm distance. Experiments were performed at dry and water wet sliding conditions. Voltage was measured by digital voltmeter of ± 0.1 mV accuracy.

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RESULTS AND DISCUSSION

The friction coefficient displayed by the sliding of the composite resin treated by continuous curing light is shown in Fig. 2. Friction coefficient decreased as the load increased due to the heat generated during sliding at higher loads forming a layer of low shear strength of composite resin on the sliding surface. The highest friction coefficient was displayed by the specimens of three layers followed by two layers and bulk-fill specimens, while the lowest friction was shown for specimens of four layers. At water wet sliding of test specimen prepared by continuous curing light, Fig. 3, friction coefficient displayed the same trend with lower values compared to the dry sliding.

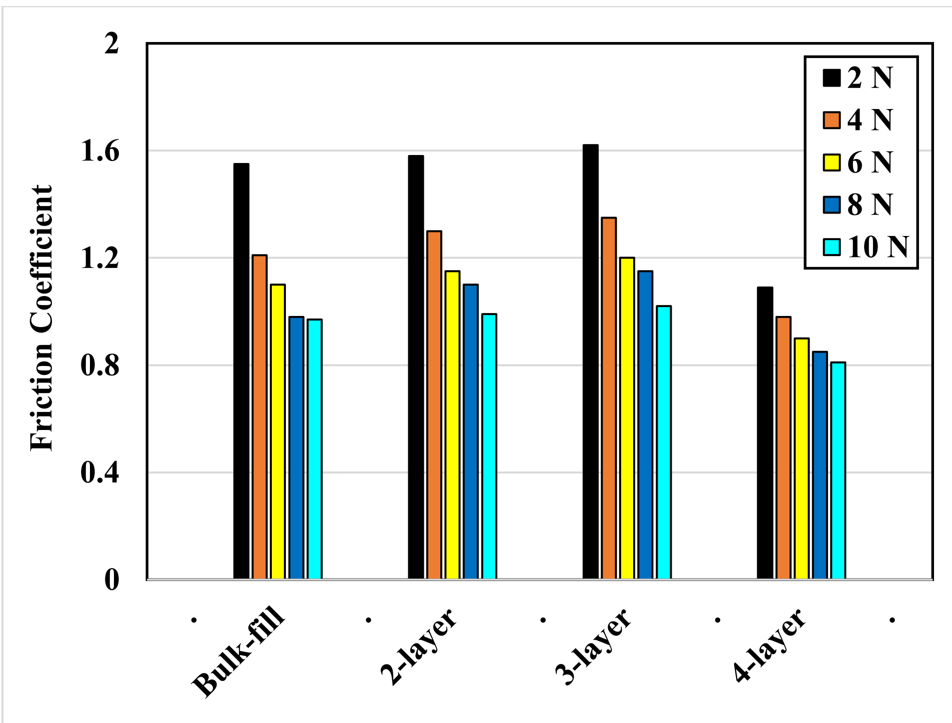

Fig. 2 Friction coefficient displayed by the dry sliding of test specimen prepared by continuous curing light.

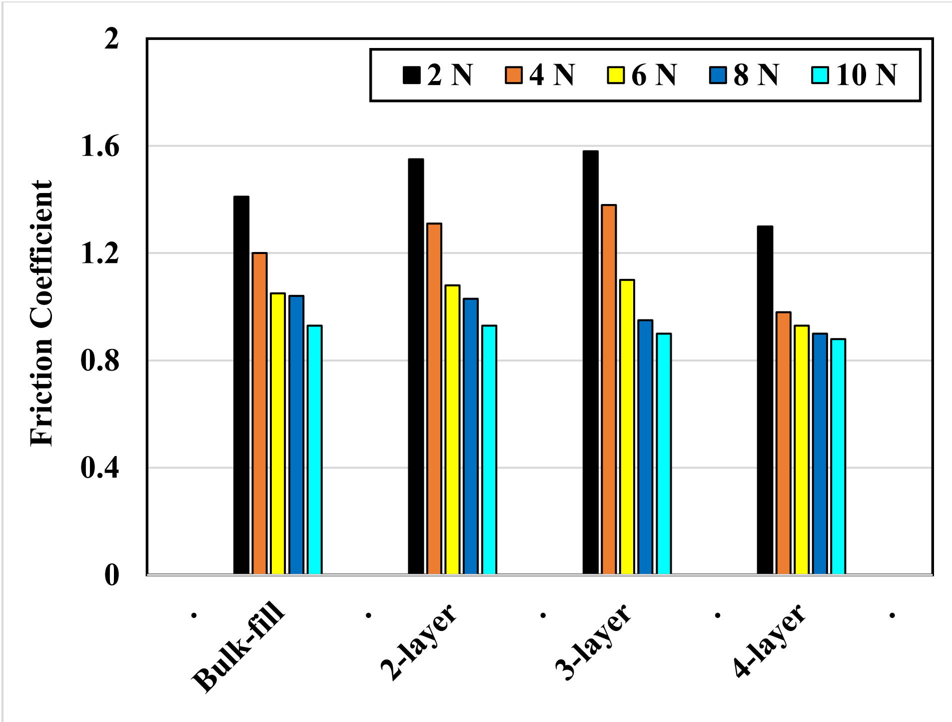

Fig. 3 Friction coefficient displayed by the water wet sliding of test specimen prepared by continuous curing light.

As for pulsed light curing, specimens prepared in two layers showed the highest friction coefficient followed by the three layers specimensm while bulk-fill gave the lowest friction values, Fig. 4. Generally, friction values were higher than that observed for specimens prepared by continuous ligh curing. Friction values at water wet sliding, Fig. 5, displayed drastic decrease compared to the specimens molded by continuous ligh curing, where the highest friction value did not exceed 1.34. Specimens of four layers showed relatively lower values than the other test specimens. The hardness of the test specimens were measured in Shore D, Fig. 6. The pulsed test specimens showed higher values than continuous test specimens. It was observed that friction coefficient increased as the hardness increased. at dry and water wet sliding. This observation recommends increasing the hardness of composite resin to get higher friction values in order to guarantee proper mastification.

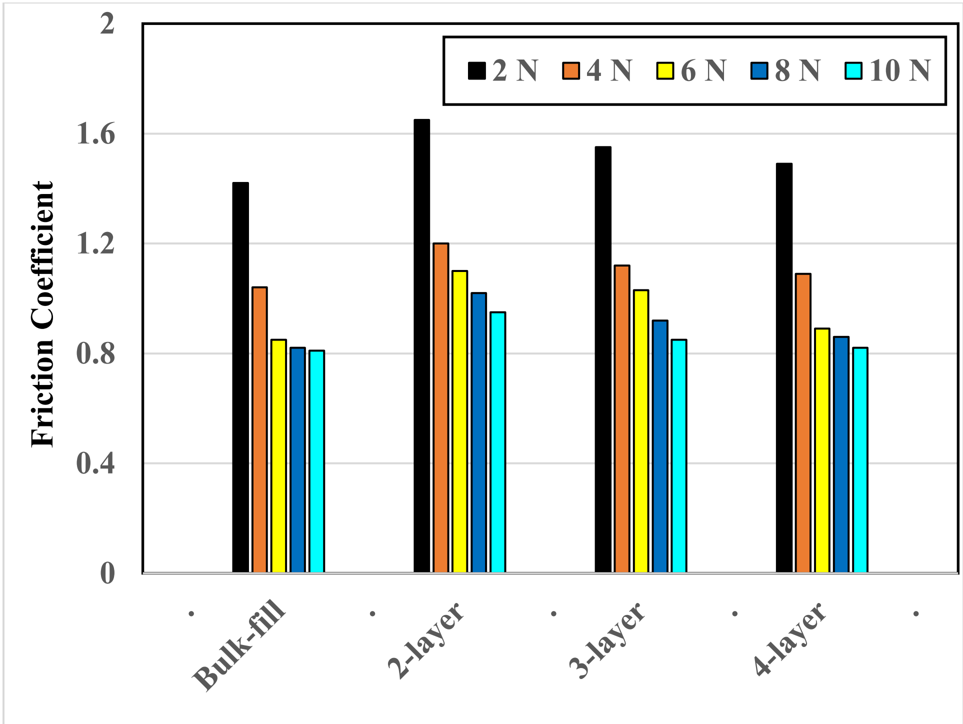

Fig. 4 Friction coefficient displayed by the dry sliding of test specimen prepared by pulsed curing light.

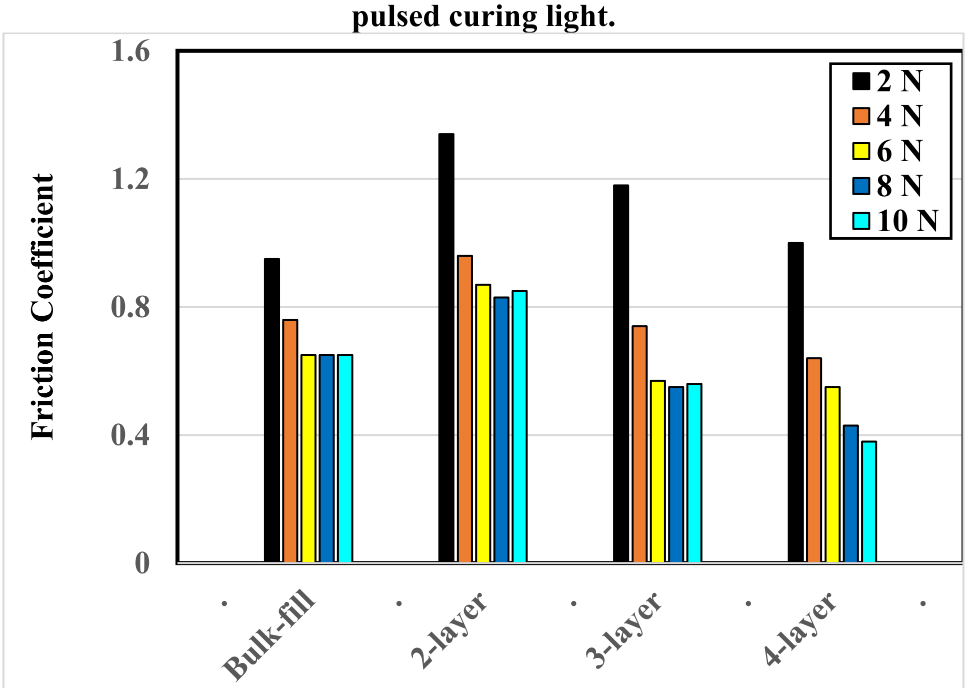

Fig. 5 Friction coefficient displayed by the water wet sliding of test specimen prepared by pulsed curing light.

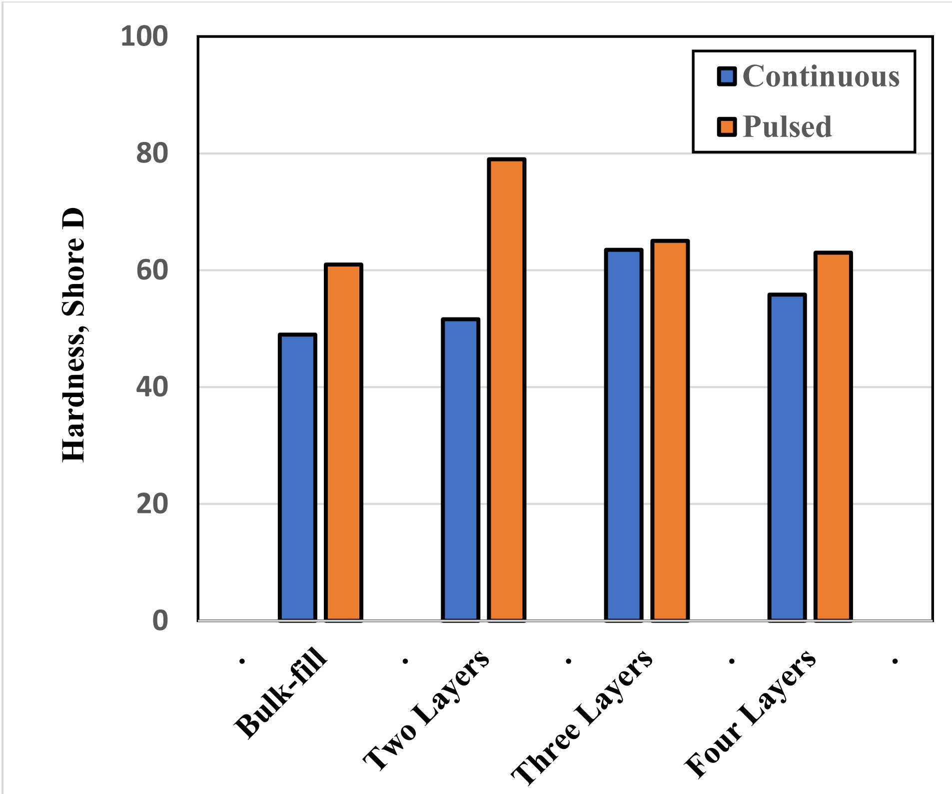

Fig. 6 Hardness of the test specimens.

It is known that human teeth, particularly their hydroxyapatite (HA) component, generate electrostatic charges (ESC) through the piezoelectric effect, as result of the mechanical stress. Dentin generates higher ESC than enamel. Besides, electrical current can be generated from amalgam fillings due to galvanism. Electromagnetic fields of electric toothbrushes can induce electrical currents in teeth. The presence of electric current, in the mouth caused by the dissimilar materials of dental restorations that act as oral galvanism in the medium of saliva, influences the nerves by an electric shock leading to pain, weakness and difficulty moving a limb, [33 – 37]. It can be recommended to measure the voltage generated from the sliding of composite resin on teeth.

The measurements of the voltage generated from the sliding of composite resin on bovine tooth are shown in Figs. 7 – 10. At dry sliding of the test specimens cured by continuous light, Fig. 7, test specimens prepared in two layers showed the highest voltage, where the highest value reached 59 mV at 10 N load. The generated voltage significantly increased with increasing the applied load as result of the increase of the contact area. Water wet surfaces displayed higher voltage values, Fig. 8. It seems that water worked as electrolyte and facilitated the distribution of ESC on the sliding surfaces. The highest voltage value exceeded up to 174 mV.

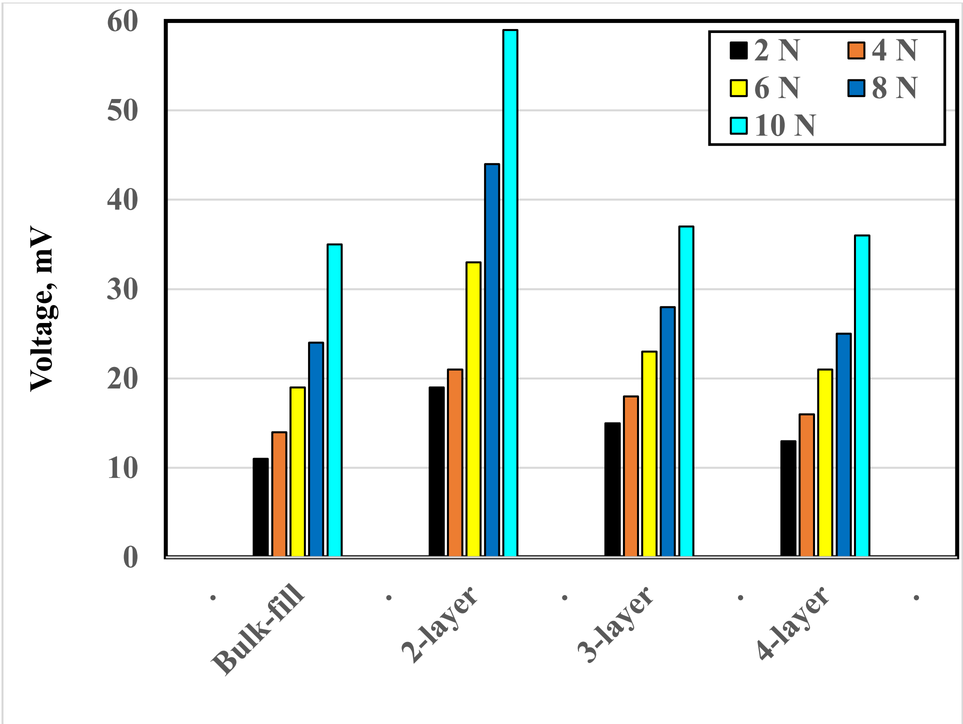

Fig. 7 Voltage generated from the dry sliding of the test specimens prepared by continuous curing light on bovine tooth.

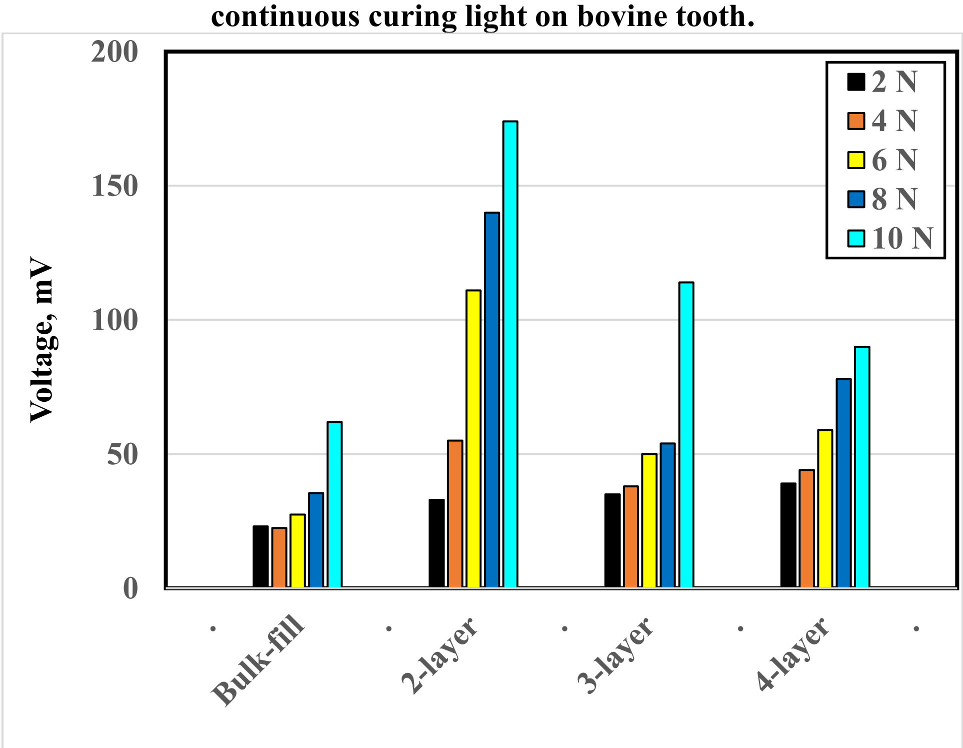

Fig. 8 Voltage generated from the water wet sliding of the test specimens prepared by continuous curing light on bovine tooth.

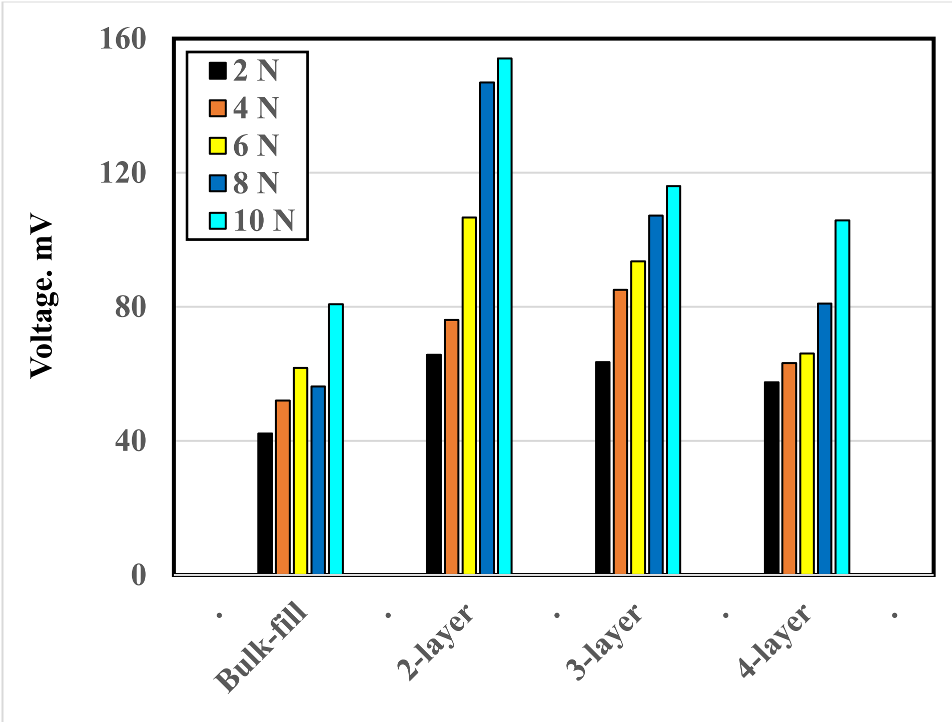

Fig. 9 Voltage generated from the dry sliding of the test specimens prepared by pulsed curing light on bovine tooth.

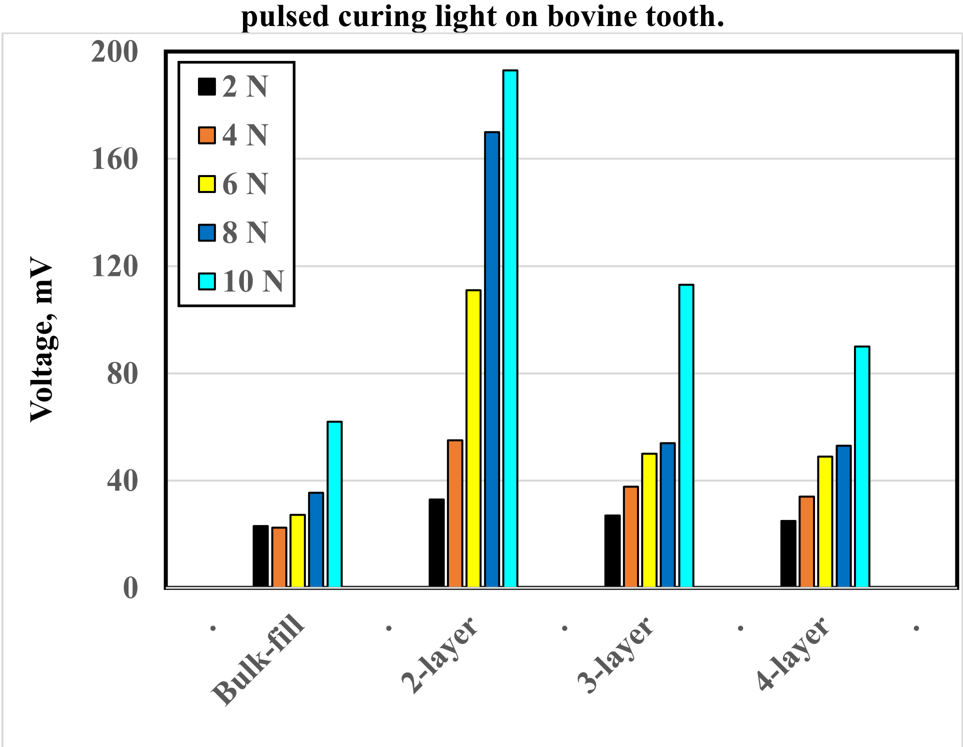

Fig. 10 Voltage generated from the water wet sliding of the test specimens prepared by pulsed curing light on bovine tooth.

Specimens treated by pulsed curing light generated higher voltage values of after dry sliding on teeth than that treated by continuous light, Fig. 9. The same trend was

observed, where the two layers displayed the highest voltage values. At 10 N load the voltage reached 154 mV. At water wet sliding, voltage recorded higher values up to 193 mV. This behavior can be explained on the fact that pulsed light curing gives the monomers the time to be linked to other monomers to form polymer chains, while in continuous curing this chance is unavailable. Increase of the number of monomers in the chain increases the degree of polymerization and modifies the mechanical properties such as toughness and elasticity. This in turn increases the values of the generated voltage caused by the piezoelectric effect.

CONCLUSIONS

1. Friction coefficient displayed by the sliding of composite resin treated by continuous curing light decreased as the load increased.
2. Specimens of three layers displayed the highest friction coefficient followed by specimens of two layers and bulk-fill, while specimens of four layers showed lowest friction.
3. At water wet sliding, friction coefficient displayed lower values with the same trend compared to the dry sliding.
4. Specimens treated by pulsed light curing showed the highest friction displayed by specimens of three layers while bulk-fill showed the lowest friction, where the values were higher than that recorded for specimens cured by continuous light. In water wet sliding, friction experienced drastic decraese.
5. Pulsed treated specimens had higher hardness values than continuous treated specimens. Because friction coefficient increased with increasing the hardness, it is recommended to increase the hardness of composite resin to increase friction to guarantee proper mastification.
6. At dry sliding, specimens continuously light cured of two layers displayed the highest voltage. Water wet surfaces showed higher voltage values than dry ones.
7. Pulsed light cured specimens generated higher voltage values after dry sliding than that observed from specimens treated by continuous light. Water wet sliding recorded higher voltage values.
8. In pulsed light curing, the monomers have enough time to be linked to other monomers to form longer polymer chains, increase the degree of polymerization and modifies the as toughness that increases the values of the generated voltage caused by the piezoelectric effect.

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