A comparison between the effect of LASER and WATER BATH on heat-cured acrylic denture base material vitro study

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ABSTRACT

Curing stage by utilizing Water Bath (W.B.) one of the stages of making a denture, in this investigation, we assess the influence of utilizing W.B. and diode laser light of frequency (1064nm) with force 50mW on samples of heat-curing acrylic (PMMA) on transverse strength of this material. We utilized a sample with dimension (8x 0.8x0.3) cm. 40 samples utilized in this investigation, 20 illuminated by laser with deferent span time of light, and the staying 20 samples prepared by regular W.B. procedure. We estimated the samples’ dimension when prepared by the two procedures. From a correlation on the influence of these two procedures on the quality of the samples by utilizing t-test, we reason that the samples that illuminated with laser become more quality and when we increment the term time (p>1), while there are no concedes between the samples that rewarded with ordinary W.B. (p>0.05). We presumed that utilizing laser be more accomplishment in improving the quality of heat-curing acrylic material that utilized for denture base.

INTRODUCTION

Acrylic can be defined as one of the plastic materials used to produce dentures. The acrylic resin was first introduced as a denture base in early 1930, when it was employed as a proper thermo-plastic material, being moulded by injection moulding under heat and pressure from completely polymerized blank into the shape of the denture (Woelfel et al., 1960).

The method of using acrylic resin in the form of liquid monomer and powder polymer was introduced in 1937 and was known as the "dough method" most of the present-day acrylic is supplied in this form (Woelfel et al., 1960). Such material is essential for dentures since it is considered to be moldable. It adapts to changes in the mouth over the years. This is most commonly used for complete and partial dentures.

Since the 1930s, the PMMA was utilized (Woelfel et al., 1960). It has been specified via good clinical outcome, decreased costs and simple handling. They include monomer and polymer; they are mixed, the mix requires curing, that might be heat- or self-curing (Craig, 1993).

Traditional polymerization cycle was considered to be long, low-temperature water bath polymerization in which acrylic resin has been processed for 6hrs at a temperature of 74°C (Rahal et al., 2004). Also, there was cycles post-polymerization including terminal boiling at a temperature of 100 Cel-
sium for 30mins (i.e. short term) or over 1hr (i.e. long term) (Phoenix, 2003). The characteristics contributing to the efficiency of acrylic resins as denture bases were the good esthetic characteristics, low solubility, low water sorption, good strength, easily repaired, besides, free from toxicity, have the capability of accurately producing the dimensions and details of the pattern, effortlessness of moulding as well as processing approach (Vallittu et al., 1998).

Notwithstanding the curing stage utilized, the nearness regarding un-reacted residual monomer in denture base acrylic resins was inevitable. It might induce problems for patients and clinicians, while approaches should be used in the laboratory as well as clinical settings to reduce exposure (Schneider et al., 2002). A residual monomer is an incomplete conversion related to monomers into a polymer, that results in irritation, inflammation, also allergic responses regarding oral mucosa (Hasan, 2002). Besides, the mechanical properties level related to residual monomer were associated with the conditions of polymerization. In the case where the terminal boils have been utilized in the cycles of polymerization, the levels related to residual monomer have been reduced significantly (Shibayama et al., 2009).

Presentation of the laser in dentistry, during the 1960s, via Miaman, Lasers used in dental practices might be ordered via various approaches: based on the used lasing medium, for instance, solid laser and gas laser; based on tissue applicability, soft and hard tissue laser; based upon the wave-length range, and risks which are related to laser application (Arora et al., 2011).

Laser-Cured Activation Polymerization related to composite resin using an argon laser: Samples polymerized by argon laser with wave-length of 488 and 514.25 nm. Also, their transverse, compressive and tensile strengths were higher than those prepared with the blue light-curing unit. Laser-cured activation may find an application with light-cured denture base materials (American Dental Association, 1975).

Polymerization related to composite resin using argon laser; Samples polymerized by argon laser with wave-length of 488 and 514.25 nm. Also, their transverse, compressive and tensile strengths were higher than those prepared with the blue light-curing unit. Laser-cured activation may find an application with light-cured denture base materials (Ahluwalia, 2009).

The stuffed flasks are typically positioned in a temperature-controlled W.B. for a predetermined time for polymerizing resin, acrylic resins concerning denture bases could be polymerized as well with the light as formed via using the laser (Shibayama et al., 2009).

The presented work is developed for evaluating the physical characteristics of transverse strength as well as the porosity concerning traditional long-term cured acrylic resin with the use of novel fibre flask that has been created via the fibreglass. While, the light energy created via the laser might have four interactions with target tissue (Al-Nori et al., 2007; Pick and Miserendino, 1995). {Absorption, Transmission, Reflection and Scattering}.

In the case when absorbing the laser, it will elevate the temperature and creates photo-chemical impacts based on water content regarding tissues (Goldman et al., 1987; Frentzen and Koort, 1990).

In the case when reaching a temperature of 100°C, water vaporization in the tissue will happen, a process referred to as ablation. At a temperature, not more than 100°C, yet over about 60°C, the proteins will denature, with no vaporization of underlying tissues (Harashima et al., 2005).

On the other hand, at a temperature over 200 Celsius, the tissue will be dehydrated and after that burned, leading to unwanted effects referred to as carbonization (Pero et al., 2011). Besides, the absorption needs light absorber, indicated as chromophores, that have a specific affinity for certain wave-length values of the light. In contrast, vital chromophores in the intra-oral delicate tissues were Melanin, Water, Hemoglobin and in the dental hard tissues, Hydroxyapatite and Water. Various laser wave-length values have many coefficients of absorption in terms of such primary tissue components, which will make the selection of laser procedure-dependent (Al-Nori et al., 2007; Pelagalli et al., 1997; Walsh, 2003). According to the application on many tissues, using the laser application in the dentistry might be classified in the following way: hard tissue application and soft tissue application (Einstein, 1917). There were two scenarios, hard lasers, like Neodymium Yttrium Aluminum Garnet (Nd: YAG), diode laser and Carbon dioxide (CO2) offering soft and hard tissue applications, yet have drawbacks (Fujiyama et al., 2008). Because of the elevated cost and the possibility for thermal injuries to the tooth pulp, while, in soft or cold laser types, based on semi-conductor diode devices, that were low-costs and compact devices utilized. Besides, a dental laser was a type of laser explicitly used in dentistry or oral medical procedures. In the USA, using lasers on gums has been initially endorsed via FDA in the mid-1990s, and being utilized on hard tissue like he teeth or bone of...
mandible, which have been approved in 1996 (Fornaini et al., 2007).

MATERIALS AND METHODS

Master wax plates with a length of 8cm, a width of 0.8cm and thickness of 0.3 cm (Figure 1) have been prepared for the porosity test and transverse strength utilizing modelling wax (T.P. regular, Major Prodotti Dentari, SPA, Italy). Utilizing dental stones (Silky Rock, Whipmix Louisville, U.S.) as one of the investment materials, such wax plates have been invested in the flasks. Following wax elimination, fine brush (no. zero) is utilized for spreading the separating medium (Isol Major, Major Prodotti Dentari, SRI, Italy) on exposed warm as well as clean stone mould surfaces. At the same time, the powder and fluid related to heat curing resins (Major Base2, Major Prodotti Dentari, SPA, Italy) have been proportioned as well as blended via the guidelines of maker. After that, the flasks have been packed with acrylic resin materials (PMMA). Furthermore, the packing has been carried out at dough stage that has been specified via resin’s clean separation from the walls of glass mixing jar.

Figure 1: The samples with dimensions (8x0.8x0.3) cm length, width, thickness

Heat – Curing Activation

The flask containing the samples is immersed in a water bath at a specified temperature (74 °C) for a specified time (8 hr.), the technique applied for all the 20 samples of acrylic resin material (PMMA) by using a metal flask of brass. As shown in Figure 2.

Curing cycle for laser technique

By using diode laser light of wave-length (1064 nm), the sample was divided into four groups each of 5 samples, according to the duration time of irradiation which is A, B, C, D, and as follow:

Group A: Irradiated for 10 mins.
Group B: Irradiated for 15 mins.
Group C: Irradiated for 20 mins.
Group D: Irradiated for 25 mins.

The samples situated in fibre glass flask (Figure 3) and then putting in a chamber and irradiated by laser light (Figure 4).

Figure 2: A metal flask of brass that used in water bath technique

Figure 3: Fibre glass flask that used in laser technique

Figure 4: Irradiation chamber of specimens by diode laser (1064 nm)

Transverse Strength Test

Following preparing (40) acrylic samples with (8x0.8x0.3) cm. dimensions, (20) samples by water bath technique with log cycle (overnight curing) 74 Celsius for 8 hours and the other (20) samples via laser technique, smoothing and finishing have been carried out via utilizing silicon carbide grit papers. Initially, grit 120 has been utilized, after that finally via grit 600, after that samples have been polished with soar and polishing cloth based on ADA Spe.

Carefully into five pieces (utilizing band saw); each measuring (8x0.8x0.3) cm.

The total amount of the samples for the transverse strength is (40):
(20) acrylic samples are cured via a traditional water bath, whereas the other (20) acrylic samples have been cured via laser approach.

Then, all samples have been stored in distilled water at a temperature of 37 Celsius via using incubator (CoKG + Memmert GmbH), the samples have been measured via 3-point bending test which is closely resembling service conditions (Figure 5). The sample has been supported at every one of the ends via roller with a diameter of 3.2mm and 59 mm distance between 2 rollers.

Figure 5: Transverse strength. The load has been measured via compression machine (inc. model cn 472, Evanston, ill–U.S.) at a 0.5cm cross head speed for each minute

Transverse strength (T.S.) has been evaluated via the following formula (Aoki et al., 2008).

\[ T.S. = \frac{3 \times W \times L}{2bd} \]

\( L \) representing the distance between the supports (50mm)
\( W \) representing the maximal load at mid-point of a sample (Kg)
\( b \) representing the sample’s width (8 mm)
\( d \) representing the sample’s thickness (3 mm)

Porosity Test

There are 20 acrylic samples with dimensions (8x0.8x0.3) cm were processed by Heat – Cured activation (long polymerization cycle involves constant temperature water bath at 74°C for 8 hours technique using brass flask and other (20) acrylic samples with identical dimensions have been processed via laser method, such acrylic samples have been polished and finished utilizing a process indicated in the earlier test, such acrylic samples are examined and arranged under the light microscope (Olympus, Japan) utilizing 20x and 40x magnification degrees (Figure 6).

RESULTS

Concerning transverse strength test, the student t-test has been carried out (Table 1) and indicated that there was no considerable difference (p more than 0.050) in the transverse strength which is related to samples that have been cured via water bath technique, when we used laser technique we can see a significant difference (p> 1) with respect with increasing duration time, also when we exam the sample under a microscope we can saw a decreasing in the pores inside the acrylic material that gives more solidness to the denture materials, give it an excellent quality to the material, so laser technique proved that it was a best for enhancing denture material quality.

The results of the presented work showing that there isn’t porosity in all the acrylic samples are cured via laser. Yet, in a traditional water bath approach, there were pores founded in the material when we examine the samples under a microscope (Table 2).

It has been indicated that there isn’t a risk related to porosities in the thick samples (thickness over 3mm) cured via laser irradiation. In the presented work, the thickness related to acrylic sample is 3 mm, low wattage (80 watts) as well as long curing cycle (25mins, 15 mins for each per side, succeeded via 2500 watts and 2 1/2 minutes) is utilized for laser curing approach, such curing cycle improved exothermal heat for being quickly dissipated to surrounding investing stone; also the low value of the wattage is chosen to cure and facilitate the spreading regarding the heat in a gradual way; thus the monomer's boiling point that is 100 °C isn’t reached. Furthermore, this is a potential explanation indicating that sample which has been cured via laser method in the presented work is considered to be free of porosities, while the results of this work are under other researches.
Table 1: Transverse strength testing

| Curing Technique | Number | Mean ±SD (Kg.cm⁻²) | df | Significance |
|------------------|--------|--------------------|----|--------------|
| Water Bath       | 20     | 1871.877 ±2432.123 | 25 | 0.343*       |
| LASER            | 20     | 2671.969 ±3318.976 | 25 |              |

* S.D. stands for Standard deviation; df stands for Degree of freedom. * No significant differences at p > 0.05

Table 2: Test of Porosity

| Curing Technique | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| Water Bath       | n | n | n | n | n | n | n | n | n | N  | n  | n  | n  | n  | n  | n  | n  | n  | n  | n  |
| LASER            | 12| 12| 12| 12| 12| 13.3|13.3|13.3|13.3|13.3|13.3|14  |14  |14  |14  |16  |16  |16  |16  |16  |

*n: Negligible amount of porosity

**DISCUSSION**

Transverse strength test has been majorly utilized to evaluate the quality related to acrylic denture base materials as a test condition which is approximate to the service conditions as closely as possible (Aoki et al., 2008). Throughout mastication, a load applied via the denture force teeth the base against mouth’s hard tissues. Differences in compressibility related to soft tissue lying between denture and bone were in a way that dentures might bend about their midpoint (Mohamed et al., 2008).

Concerning dentistry, the transverse strength test was typically conducted on acrylic samples with a thickness of 3 mm, supported across distance (6x0.8x0.3) cm, and such dimensions are representing the mean value of the thickness and premo-lar to the molar distance and width in the den-tures (Craig, 1997). Besides, results of this work exhibited that there was not a considerable difference in transverse acrylic samples’ strength, which have been cured via the two curing methods. The use of Iraqi FRP flask provides suitable polymerizations of the acrylic samples through laser irradiation resisting the mechanical failure comparable the acrylic samples cured via traditional water bath method, such results were per the results indicated via other researches.

**CONCLUSION**

Laser technique proved that it’s the best method in the enhancement of the denture quality in decreasing the pores and increasing the strength of it (Iraqi FRP flask) created via new metal mould might be efficiently utilized for curing related to acrylic den-ture base materials through laser irradiation with the physical characteristics (i.e. the porosity, transverse strength) more than comparable to the one which has been cured via traditional water bath method.

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**Conflict of interest**
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