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Hardness Enhancement of Amalgam Teeth Fillings Using Diode Laser (675 nm)

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Abstract

This work aimed to enhance the hardness of human teeth filler material (Amalgam), in a short possible time via irradiation by low level laser. Hardening tests were carried out on different amalgam mixtures subjected to irradiation for two minutes by diode laser with wavelength of 675 nm and power of 15 mW. The samples were left for different time intervals and for each time interval hardening test was carried out using Brinell hardness test. Other samples were prepared for the same test with the same procedure but without irradiation, i.e. control group.

The irradiated samples showed a considerable increasing in their hardness compared with samples without irradiation. The samples irradiated by laser need only 6 hours to reach the same value of hardness that the control group reached after 30 hours.

In Conclusion, the irradiation of amalgam by this type of laser with the above parameters believed to be recrystalizing the material so it become harder with shorter time compared with the amalgam without irradiation.

Key words: laser matter interaction, laser hardening of amalgam, laser in dentistry

Introduction

Many materials used in dentistry are not homogenous solids but consist of two or more essentially insoluble phases. There may be one continuous phase and one or more dispersed phases, or there may be two or more continuous phases with each of these phases, these materials are called composites[1].

The property of hardness is a property of major importance in the comparison of restorative materials. Hardness may be broadly defined as the resistance to permanent surfaces indentation or penetration.

Formulating, a more rigorous definition of hardness, is difficult because any test method will, at a microscopic level, involve complex surface morphologies and stresses in the test material, thereby involving a variety of qualities in any single hardness test. Despite this condition, the most common concept of hard and soft substances is therefore a measure of the resistance to plastic deformation and is measured as force per unit area of indentation [2].

Hardness is indicative of the ease of finishing of a structure and its resistance to in service scratching. Finishing or polishing a structure is important for esthetic purposes and scratches can compromise fatigue strength and lead to primitive failure. Hardness of dental fillings is very important because it determines the life time of the filling material and its ability to do the required function.

The most common methods of testing the hardness of restorative materials are: Brinell, Knoop and Vickers test where, each of these tests differs slightly from the other [3].

For over 150 years, silver amalgam has been used to fill the cavities made by dentists during the removal of dental decay from teeth. When pure silver is mixed with mercury, it produce a paste of slowly forming intermetallic compounds, when this is packed into the cavity at body temperature (37 ^{0}C), the intermetallic compounds interlock and the amalgam hardens. However, setting is accompanied by a considerable expansion, and 100 year ago, it was discovered that this can be controlled by adding tin to the silver. Unfortunately, this produces corrodible tin-mercury intermetallic phases, and their loss can cause break down of the filling. By adding copper, the tin mercury phase is eliminated and modern dental amalgams are made by mixing silver-tin-copper alloy powder with mercury. This will lead to fillings that resist both the chemical and mechanical effects, especially if the hardness is high enough [4]. Ages amalgam materials have been the mostly used as a controversial restorative material in dentistry. However, the main concern surrounding its use is the fact that it contains mercury, which is known to be toxic. Posterior resin–based composites (RBCs) restorative techniques are now used as viable alternative to amalgam state. The following points can be the reasons of use: their efficiency, more importantly their safety for use in humans, improvements in the physical properties of the materials, their positive clinical performances encourage. Amalgam is high stable in fluids, especially in saliva, where its degradation rate is very low, compared with RBCs; this is due to the fact that stability depends on the chemical nature of the monomers, amounts of dimers and oligomers and the degree of cross linking in the polymerized matrix. Usually the material reaches the maximum hardness at 24 hours after mixing.

Recently lasers showed significant contribution in material hardening. Lasers can be used for surface hardening and for copolymerization which lead to increase material hardening. With the interaction of high power laser light and its movement over the surface, very rapid heating of metal workpiece can be achieved and subsequently rapid cooling down or quenching. The cooling rate, which in conventional hardening defines quenching, has to ensure martensitic phase transformation. In laser hardening the martensitic transformation is achieved by self-cooling, which means that after the laser light interaction the heat has to be very quickly conducted into the workpiece interior. The amount of the disposable energy of the interacting laser beam is strongly dependent on the metal absorptivity [5].

Low power lasers can be used for Polymerization which denotes a chain reaction (chain polymerization), and consequently photopolymerization refers to the synthesis of polymers by chain reactions that are initiated upon the absorption of light by a polymerizable system. Notably, laser light serves only as an initiating tool. This is mainly due to capability of laser to be tuned to a specific wavelength, therefore exciting a particular bond and hence the polymerization chain reaction starts [6].

The use of laser to initiate polymerization of vinyl monomers has attracted attention and several reports have been published in this field.

This work aimed to enhance the hardness of human teeth filler material (Amalgam), in a short possible time via irradiation by low level laser. The materials were subjected to diode laser with wavelength of 675nm and 15mW power for two minutes. Hence the hardness was investigated at 2, 6, 10, 18, 24 and 30 hours after irradiation. The results were compared with a control group (without irradiation).

Materials and Methods

Materials

Different equipments and materials were used to increase the amalgam hardness by diode laser and to measure the hardness at different time intervals after irradiation.

The diode laser

Diode laser supplied from Omega laser system - UK was used in this work; it is a diode laser with two probes of different wavelengths: 675 and 820 nm with 30 and 200 mW output power, respectively. The first probe was used in this work to irradiate the samples. A beam splitter was used to reduce the laser power to 15 mW.

Brinell hardness tester

The Brinell hardness test is among the oldest methods used to test hardness of metals and alloys used in dentistry. The method depends on the resistance to the penetration of small steel or tungsten carbide ball, typically 1.6 mm in diameter, when subjected to a weight of 123 N. The resulting hardness value, known as a Brinell Hardness Number (BHN), is computed as a ratio of the load applied to the area of the indentation produced. Smaller area of indentation means larger BHN value [7].

The Brinell hardness tester used in this work was model EQOTIP made in Switzerland.

Amalgam material

Dental Amalgam is produced by mixing liquid mercury with solid particles of an alloy of silver, tin, copper. This combination of solid metals is known as the Amalgam alloy.

Fixed artificial tooth

Fixed artificial tooth was used in this work to housing the amalgam and accomplish the hardness measurement.

Optical Elements:

A concave lens, (+20) focal length, was used to focus the laser beam on the samples.

Also a beam splitter was used to transmit only 50% of the laser power, i.e. 15 mW, to the sample surface.

Methods

The diode laser probe (675nm) was held in a right position to the sample; the lens was situated at 2 cm in front of the diode laser where a beam splitter was positioned at 45^0 a head of the lens. The composite material was prepared from Amalgam and mercury and then subjected to laser irradiation for two minutes during and after mixing. After that, the material was filled in the artificial tooth ready for hardness testing.

The hardness test was carried out for the samples in different time intervals (2, 6, 10, 18, 24 and 30 hours) after irradiation. Additional samples were further prepared without irradiation process, as control groups, and their hardness were tested at the same time intervals in order to compare the hardness of the two groups.

Results and Discussion

The hardness of the filling amalgam without irradiation and of that irradiated by diode laser, 675nm wavelength and 15mW power, are listed in table (1).

A comparison between the hardness of the control group and the irradiated group, at different time periods after samples irradiation, is shown in figure (1) below.

Table 1. Hardness values of samples without radiation and samples irradiated by diode laser measured at different time periods.

Time (hr)	Hardness without irradiation (Kg/mm^2)	Hardness after irradiation by diode laser (Kg/mm^2)
2	**46.2**	**56.8**
6	**47.6**	**57**
10	**49.5**	**58.6**
18	**52.5**	**62.8**
24	**53.8**	**64.9**
30	**54.1**	**66.9**

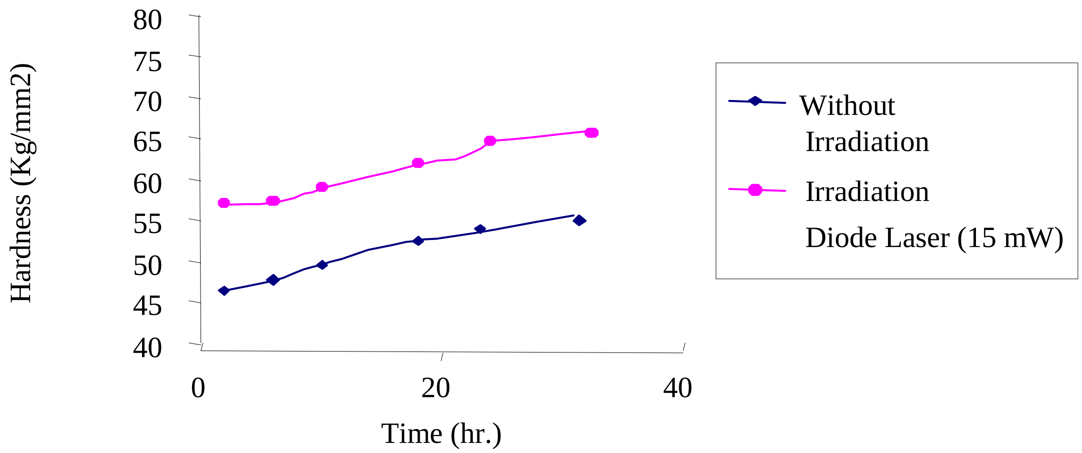

Fig. 1 The hardness of samples without irradiation and of that irradiated by diode laser after different time intervals.

As can be seen from the figure, the hardness of the irradiated samples exceeds the hardness of the samples without irradiation by about 23% just two hours after filling preparation. The samples irradiated by diode laser took 6 hours only to achieve a hardness equal (57 Kg/mm^2), where the samples without irradiation took 30 hours to reach its maximum hardness value, (54.1 Kg/mm^2). After 30 hours the irradiated samples have hardness exceed that for nonirradiated samples by about 24%.

Table (2) lists the percentage of hardness enhancement for the irradiated samples.

Table 2. The percentage of hardness enhancement for irradiated samples.

Time (hrs)	Percentage of hardness enhancement for the irradiated samples (Kg/mm^2)%
2	**22.9**
6	**19.7**
10	**18.3**
18	**19.5**
24	**20.6**
30	**23.6**

We believed that the hardness increased after irradiation due to the laser photons which increases the polymerization rate of the amalgam. The polymerization process can be affected photo-chemically by the coherent laser photons [8, 9].

The diode laser initiate the process and the polymerization become faster which leads to enhance the hardness in shorter time.

Conclusions

From the obtained results, one can concludes that:

- The irradiation by diode laser (675 nm) is effective in hardening amalgam teeth filling materials. The hardness of amalgam can be enhanced significantly (to about 24%) after laser irradiation.
- The time required for hardening amalgam irradiated by diode laser is much less than that for nonirradiated amalgam.

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