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The using of laser Er:YAG in teeth whitening operation

استخدم ليزرEr:YAG في عملية تبيض الأسنان

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Abstract

This study depends on the soluting of differential equation a ccomplished the following :- Calculating (time whitening , density with time , time with Temperature using laser Er:YAG wavelength (2940nm) . mathematical relation have been studied with the following (density , time whitening , time activation , Temperature) . The result of research showed that density increases with time whitening , through which we can notice obtain typical designs for this type of laser and study effects compartion with other type The laser Er:YAG beam is fully absorbed in the gel and does not penetrate to the hard tissue or the lip.

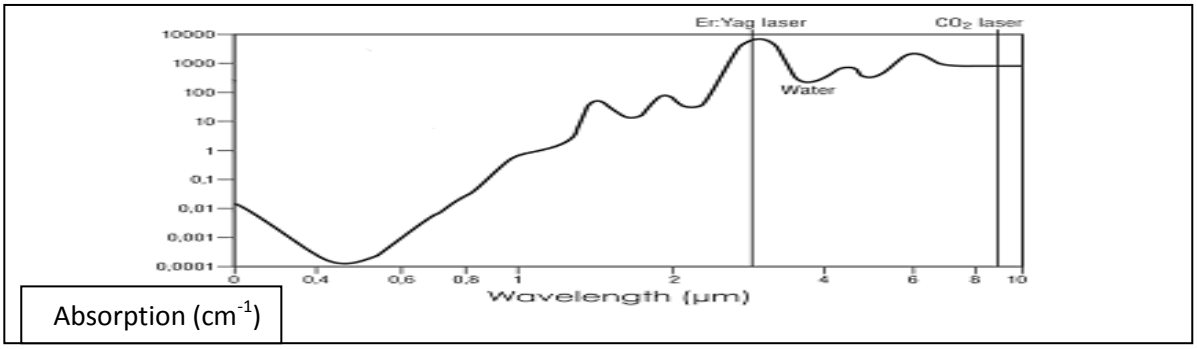
الملخص

اعتمد هذا البحث على حل المعادلات التفاضلية لانجاز مايلي :-
دراسة زمن التبيض والكثافة مع الزمن وأيضا زمن التبيض مع درجة الحرارة باستعمال ليزر Er:YAG بطول موجي (2940nm) ، ودرست علاقة المعلمات فيما بينها (الكثافة ، زمن التبيض ، زمن التنشيط ، درجة الحرارة) . حيث بينت النتائج أن الكثافة تزداد مع الزمن التنشيط والتي أمكن من خلالها الحصول على تصاميم مثالية لهذا النوع من الليزرات ودراسة تأثيره ومقارنته مع الأنواع الأخرى حيث أن شعاع ليزرEr: YAG يمتص من قبل الهلام بالكامل ولا يخترق إلى نسيج العصب أو اللب.

1-Introduction

White teeth have long been considered cosmetically describable for this reason , methods have been introduced to whiten teeth that are naturally off- white or have become stained by smoking or food intake [1,2]. Teeth whitening can be achieved in two ways firstly , with gels , pates or liquids (including tooth –pastes) that are mechanically agitated at the stained tooth surface in order to effect tooth stain removal through abrasive erosion of the stained acquired pellicle , second , with gels , pastes or liquids that accomplish the tooth bleaching effect by a chemical process while in contact with the stained tooth surface for a specified period of time [3]. The heat and light serve to increase the rate of bleaching of the hydrogen peroxide , providing a shorter period of time in which whitening of the teeth is achieved [4,5]. Instead , laser in the medium range of the Infrared electromagnetic spectrum have a close affinity with water and hdroxyaptite : laser Er:YAG (2940nm) . For this reason they are used on hard tissues (incision and vaporistion of the water content of the tissue) , but with less haemostatic effect , due to the lack of affinity for haemoglobin [6].

These laser , which are definitely the most versatile , are also those most in dictated in pediatric dentistry and traumatology. The Er:YAG laser wavelength is the water absorption peak in the vicinity of (3µm) see fig. (1)[7].



Fig(1)Absorption spectra of water .The absorption is highest at (3µm).

Among laser system ,Er:YAG laser seems to be promising . The Er:YAG laser is solid state laser and uses $Er=^{+3}$ ions suspended in complex crystalline matrix of Yttrium –Al uminium –Garnet (YAG) to provide electrons for excitation . In Er:YAG laser , lasing occurs at wavelength of (2.94µm) which falls in the middle infrared region of the electromagnetic spectrum . This emission wavelength is well absorbed by both water and hydro apatite resulting in effective ablation of enamel and dentine with minimal or no thermal damage to surrounding tissue [8,9]. The Er:YAG was proposed by many investigators to be a promising type of laser for cutting hared dental tissues with minimal pain and thermal damage . This was presumed assist wave length (2.94µm) coincides with the absorption peak of the hydroxyaptite crystals , collagen and water which are the major constituents of dentin [10,11,12].The wavelength of the Er:YAG laser modifies hard dental tissue once it acts on their properties , including permeability , microharness , and acid resistance [13]. The Er: YAG laser at low –energy setting can modify the dentin surface [14].It Er:YAG has a wavelength of (2940nm) (2.94 µm) in fig(2) , and very high absorption coefficients in water and hydroxyapatite compared with the diode and Nd:YAG laser . Because of its high rate of absorption in water , the Er:YAG laser ablates hard tissue through "microexplosions" rather than heating the tissue , resulting in minimal thermal side effect [15]. This desirable property Er:YAG laser:-

1-waveform:- free running –pulsed.
2-Delivery tip:- flexible fiber optic system or hollow wave guide ;surface cont required for must procedures.
3-soft tissue incision and ablation ; sub gingival (curettage and bacterial elimination , scaling of root surface , osteoplasty and ostectomy.
4- Tissue reaction :- Highly absorbed in both water and hydro apatite.
5- Color:- Infrared.
6- construction :- solid state .

Fig(2) The Laser Er:YAG (2940nm).

The degree of whitening provided by the gel , increase with the time of contact between the reactive species of peroxide and the tooth enamel surface . The activation of the gel consists of the oxidation of available peroxide (H_2O_2) and /or its reactive species (OH and O [2]. Due to its chemical structure , the peroxide must produce transient species , such as OH and O, before the final products, H_2O and O_2 are generated. The bleaching effect depends on the duration of the residence time and on the rate of activation , determined by the activation time Ta . In a simplified model , the gel activation process dynamics can be described by the following equation[2].

$$\frac{dP}{dt} = -\frac{P}{Ta} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where
P the density of the available still un-oxidized hydrogen peroxide.
Ta is the activation time.
The oxidation dynamics and the density of the available (still un –oxidized) hydrogen peroxide , P during a whitening process can be obtained by integrating Eq.(1)

$$P(t) = 1 - \int_0^t \frac{P}{Tadt} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Measured temperature dependence of the gel whitening time . The fitting line represented by the function

$T_w = 1.057*106/T^{2.164}$ …….(3)

Where
T is the gel temperature in deg. C.
Tw is the time whienting .
Under laser illumination the activation time Ta is not constant but gets shorter as the gel is heated up. Use the equation[2].
$T_a = T_w/3$ ……(4).

2- Measurement of the gel whitening dynamics under laser irradiation

Measurement were made of the bleaching time and temperature evolution during and after exposure of a tooth to irradiation by laser Er:YAG with wavelength (2940nm). The extracted human tooth was on the front surface covered by a freshly mixed gel and illuminated by a laser beam .For all wavelength the laser spot size on the tooth surface was 7mm . The tem. rise was measured with thermal camera (fig.(3)) [2].

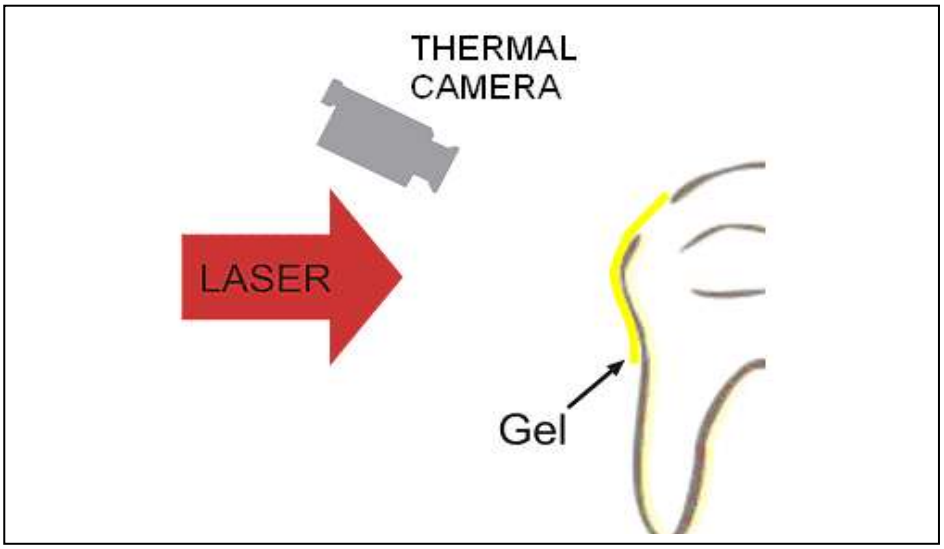


Fig (3) Experimental set-up for measuring get temperature dynamtics during laser –assisted tooth whitening [2].

3- Laser Tissue Effect and Biological effect

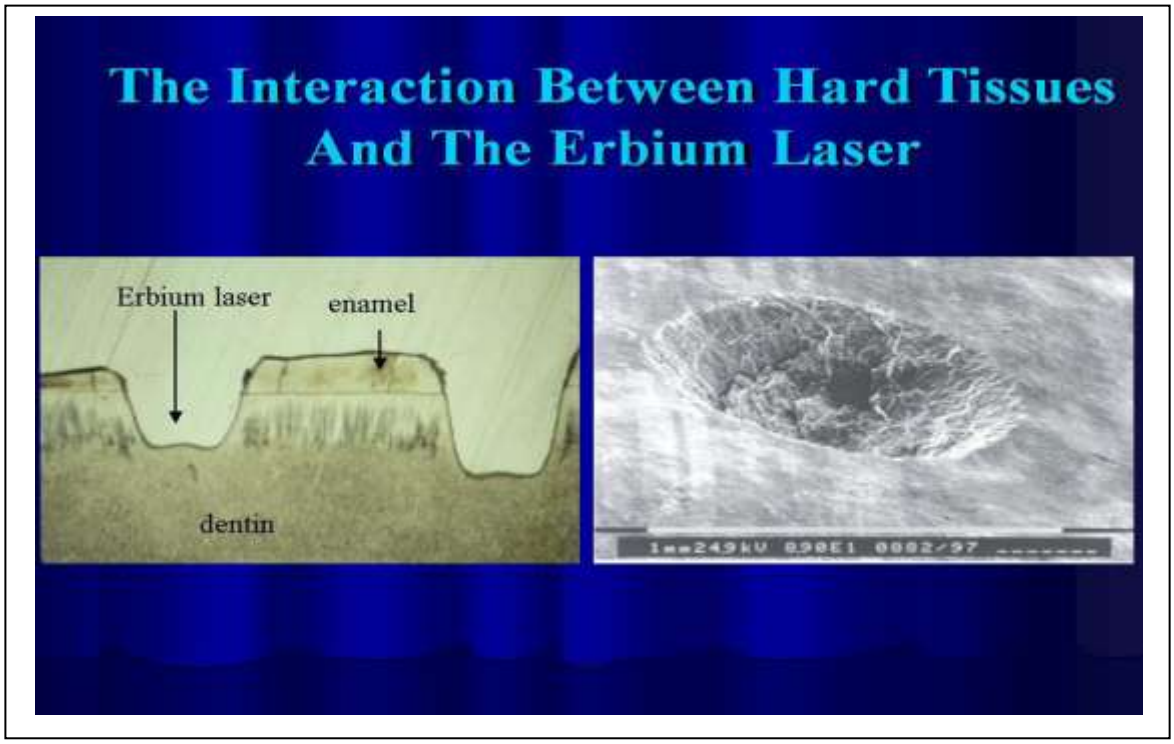
Once a laser beam is produced it is aimed at tissue to perform a specific task . As the energy reaches the biological , one of four interactions will occur in fig.(4,5).

1- Absorption :- specific molecules in the tissue know as chromospheres absorb the photons. The light energy is then converted into other forms of energy to perform work.

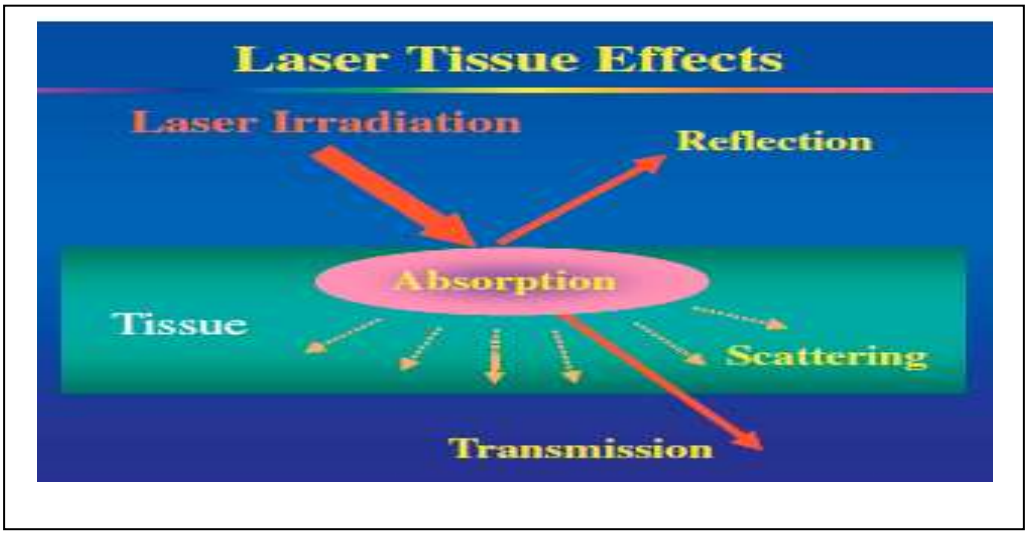
2-Reflection :- The laser beam bounces off the surface with no penetration or interaction at all reflection is usually an undesired effect , but a useful example of reflection is found when Erbium laser reflect off titanium allowing for safe trimming of gingival around implant butments.

3- Transmissions :- The laser energy can pass through superficial tissues to interact with deeper areas. Retinal surgery is an example the laser passé s through the lens to treat the retina .

4-Scattering :- Once the laser energy enters the target tissue it will scatter in various directions . This phenomenon is usually not helpful , but can help with certain wavelength biostimulative properties.



The fig.(4) The interaction between hard tissue and the erbium laser



The fig. (5) Laser tissue effect

4- The different laser and non – laser whitening system

The role of laser in teeth whitening is to accelerate the activation of hydrogen peroxide (H_2O_2) in whitening gels which typically contain 30% to 35% H_2O concentration .

In reaction to the absorption of photon , the hydrogen peroxide breaks down into particle of water and radical oxygen chemically reduces larger organic – pigmented molecules (the chromospheres') in the enamel matrix into smaller , less pigmented constituents by rapid oxidation .These compounds that originally have double bonds and long carbon chains and hydroxyl groups , which eliminate discoloration . Before laser , several other lights such as xenon Lamp , halogen light , plasma arc lamp light etc. was used to replace the role of light . But due to an inefficient light power output , limited effective lifetime and regular light consumed high electric power , researches kept trying to find new ways to accentuate the activation of H_2O_2 . These light use acting percentage

of the polychromatic light energy and the rest is wasted as heat and light which is absorbed by adjacent tissue. The properties of laser which include coherent , monochromatic and collimated can reduced the amount of light absorbed by a adjacent tissue. Figure (6) shows the comparison of effect of using laser as opposed to non – laser system.

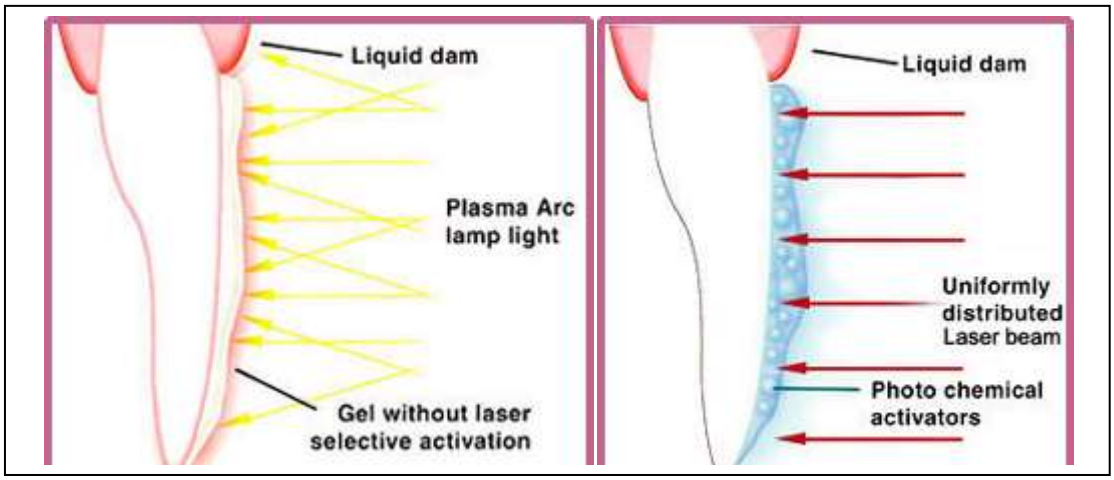


Fig.(6) comparison of effect using laser and non laser system .

5- Laser teeth cleaning

Teeth whitening systems today consist of an hour – long laser treatment that can bright a smile and get rid of unattractive stains such as coffee . cigarettes , and win from teeth instantly . The laser treatment is quite awesome and once was only accessible to the very rich . but the prices are becoming more economical so that the public can also enjoy a white smile . one of the many benefits of the laser teeth whitening system is there no discomfort . This treatment does not cause pain and is a easy process . Avery nice benefit to the laser whitening is it is normally a one – time treatment . laser Er:YAG use in teeth cleanings fig.(7,8) . Now before the laser cleaning begins , your teeth will have to be cleaned physically by the hygienist first so as to make way for the laser instrument . This isn't a full dental cleaning , but instead is designed to quickly remove obvious plaque and tartar build – up so the laser can get to your actual surface . Teeth whitening does not affect the color of artificial teeth , crowns , veneers of filling . The process safe the research and clinical studies indicate the whitening teeth with peroxide and hydrogen peroxide . The effects of whitening normally last for many year , although this will vary from person to person . Inevitably with time the teeth will start to darken a gain due to drinks and food (and more rapidly if you are a smoker) Most people like to maintain their whitening effect by using the gel one or two nights every three to six month Teeth whitening can only lighten the existing color of your natural teeth . It will not work on any types of" false" teeth such as crowns . Teeth whitening is a highly effective way of lightening the natural color of your teeth without removing any of the tooth surface . whitening tooth pastes do not affect the natural color of your teeth .The fig(9,10) shows the comparison using laser Er:YAG non – laser Er:YAG.

Fig(7) Er:YAG used to thoroughly remove calculus from the root surface

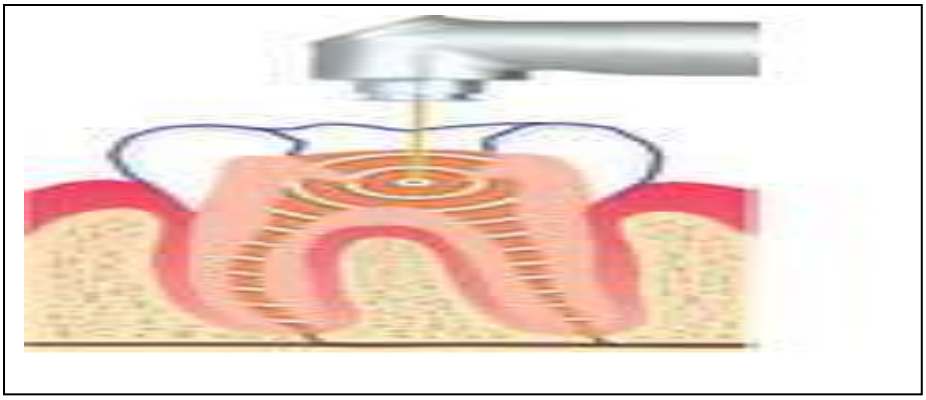


Fig (8)Er:YAG used to thoroughly remove calculus from the root surface

Fig.(9) before use laser Er:YAG

Fig.(10) after use laser Er:YAG

Results

The use matlab language of the solution equation (1,2,3,4) version (6).

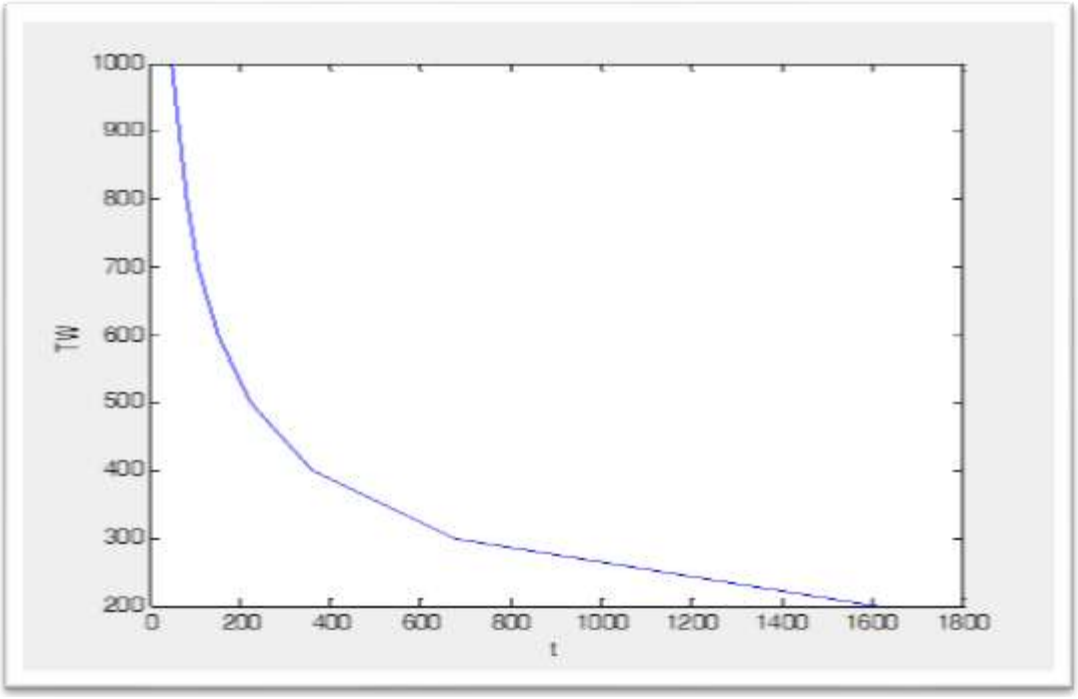
1- The fig.(1) relation Time whitening (T_W) and Time (t) is the time whitening change with time (t) we saw TW high value at low (t). the optimum value at 0.200s.

2-The figure(2) show Temperature dependence of the gel whitening time. The measured dependence of the gel whitening time , T_w on the gel temperature. The temperature of the gel is raised from (30^0C) to (70^0C) the whitening time becomes approximately times shorter . measured temperature dependence of the gel whitening time.

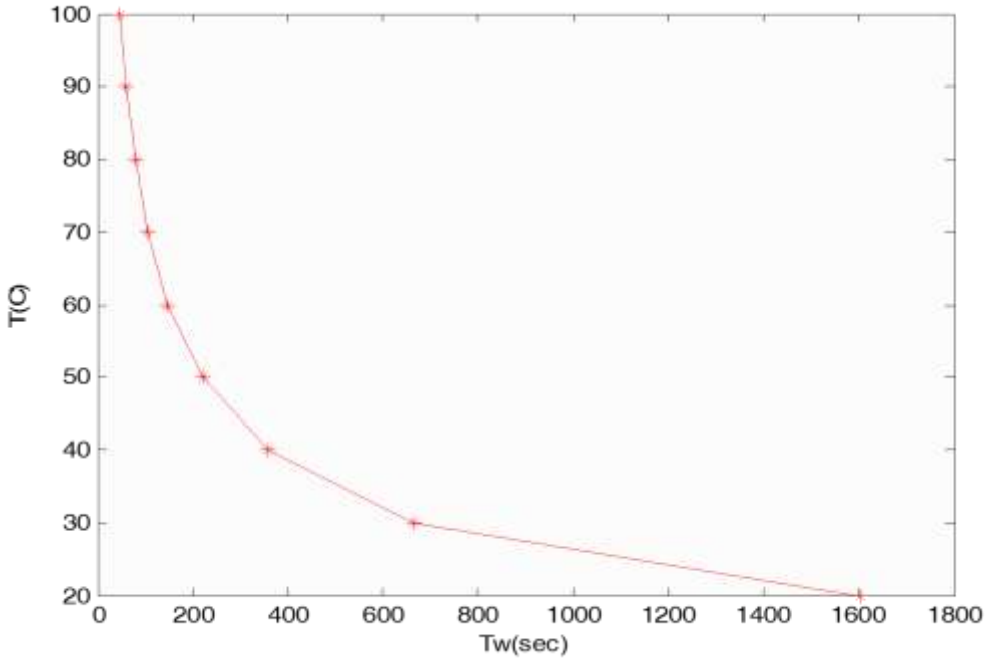
3- The figure(3relation Time activation (Ta) and Temperature (T) where Ta is not constant but gels shorter as the gel is heated up. Using the relation $T_a=T_w/3$ where the temperature dependence of the gel activation time.

4- The figure(4) relation density (P) between time (T_a) get high at time activation , the produces (Ta) reduces at very low power (10J). Due the whitening depends of the energy of the laser .

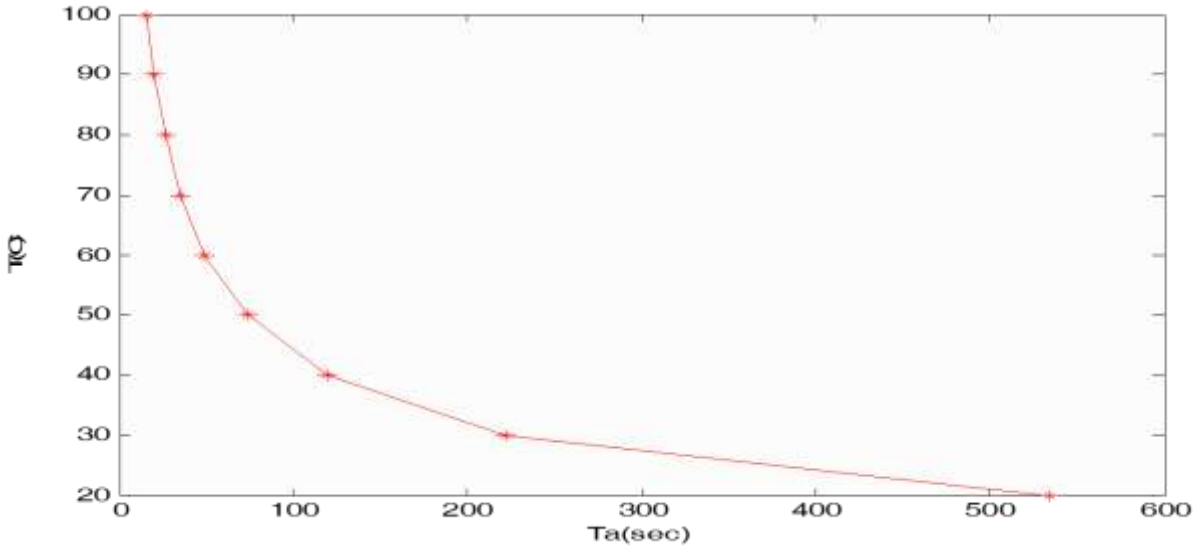
5- The figure(5) relation time whitening (T_W) between time (t) there is optimum value (t) to set the best Whitening time (T_W).



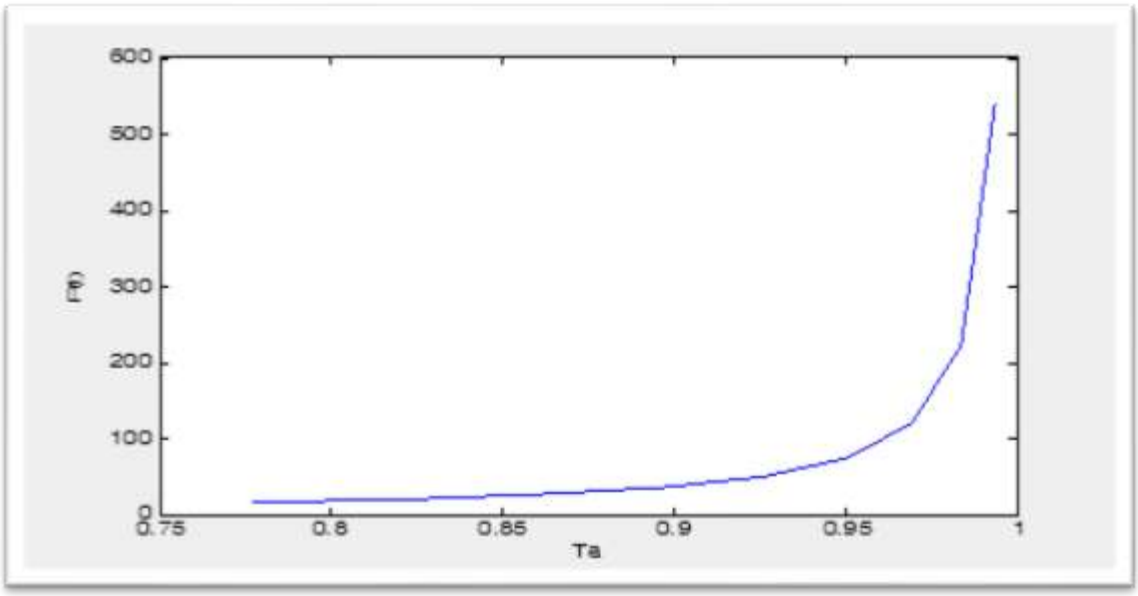
The fig. (1) relation between [TW(sec) and Time activation (t(sec)]



The fig. (2) relation between [Time whitening (T_w) and Tem.(^{0}C)]



The fig.(3) relation between [Temperature(T) and Time activation (T_a)].



The fig.(4) relation between [density (P) and Time activation (T_a)].

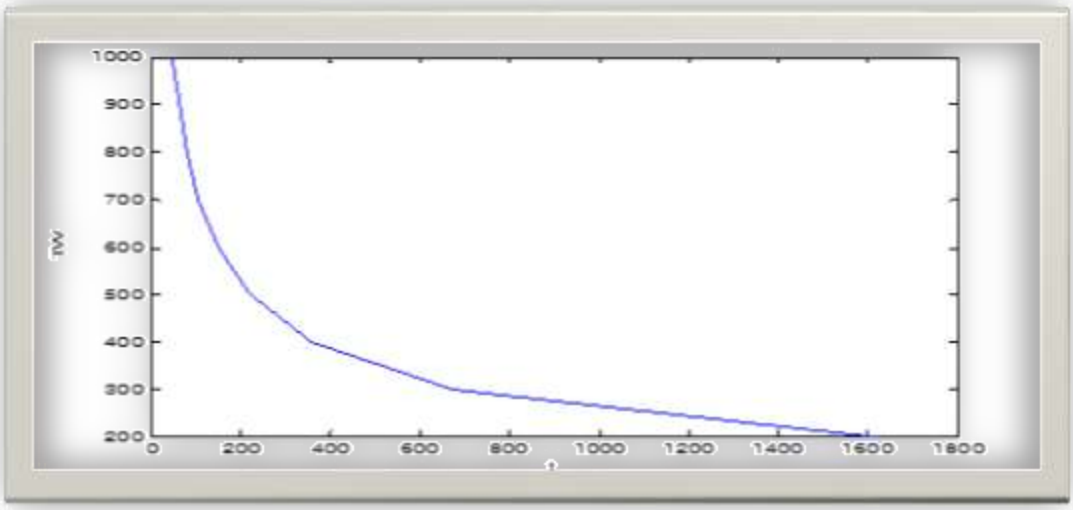


fig.(5) the relation between [Time (t) and Time whitening (T_w)].

Conclusion

The whitening treatment times can be safely shortened to (1-2 minutes) , down from (10-15 minutes) when no laser activation is applied. The method is effective and safe. The aim the whitening process uses laser Er:YAG wavelength (2940µm) riddance barbica and color produce the use coffee , tea , smoking . The obtain best result in the processing whitening use laser Er:YAG with compartion xenon lamp. The laser Er:YAG ability high of the absorption to give beat in the shorter time is not affect any types of false teeth such as crowns , veneers and dentures.

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