بسم الله الرحمن الرحيم

Sudan University of Science and Technology

Collage of Graduate Studies

Comparative Evaluation The Effect of Diode laser(980nm) Versus Topical Desensitizing Tooth Paste in Cervical Dentine Hyper sensitivity

التقييم المقارن لتاثير ليزر الصمام الثنائى(980 nm)مقابل معجون الاسنان الموضعى المزيل للحساسيه على حساسيه الاسنان المفرطه لعاج عنق السن

A dissertation Submitted as Partial Fulfillment for the Requirements of Degree of Higher Diploma in Laser Application in medicine(Dentistry)

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DEDICATION

To my lovely parents

To my grand father

To my brothers and my sisters

To my friends and my colleagues who supported me.

Marwa

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Acknowledgement

I would like to express my deepest appreciation and gratitude my supervisor **Dr. DR Amna Mohamed Ahmed Elgrai**

whose contribution and encouragement helped me to achieve this work.

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MARWA

Abstract

Purpose: to compare the effectiveness of two desensitization therapies the diode laser (980nm) and topical desensitizing tooth paste containing potassium nitrate in patient with dentine hypersensitivity(DH) symptoms.

Method: A randomized clinical trial (RCT) using split mouth method 21 teeth of 1 patient who had been referred by periodontists in periodontic clinic of the faculty of dentistry, Karrary university, evaluation of pain due to dentine hypersensitivity had been confirmed by using visual analogue scale.

The diode laser (980nm) fiber glass tip with diameter of 600 nm was focused on cervical area of the tooth presented with sensitivity on non-contact method for 90 second at 1 wt. The scores were attributed before, immediately after and after (72 hours,1week desensitizing agent the reduction of pain immediately was 44.3%, after 1 week laser application the results showed that the pain was reduced in 38.7% compared to topical desensitizing agent the reduction of pain after 1 week was 17.3% so the laser was effective after 1week in compared to topical desensitizing agent

Conclusion: the laser and topical desensitizing agent containing sodium nitrate were effective to treat dentine hypersensitivity however the laser was more effective in long period of time.

) from time of laser application. **Result:** diode laser (980nm was found to be effective for treatment of dentine hypersensitivity, the results showed that the reduction of pain immediately after laser application was 38.7%, compared to topical .

ملخص الاطروحة

الغرض: مقارنة فعالية اثنين من علاجات إزالة التحسس ، وهما ليزر الصمام الثنائي (980 نانومتر) ومعجون الأسنان الموضعي لإزالة التحسس المحتوي على نترات البوتاسيوم في المريض المصاب بأعراض فرط الحساسية لعاج الأسنان .(DH)

الطريقة: تجربة سريرية عشوائية ((RCTباستخدام طريقة تقسيم الفم 21 سنًا لمريض واحد تم إحالته من قبل أطباء أمراض اللثة في عيادة اللثة في كلية طب الأسنان ، جامعة كرري ، تم تأكيد تقييم الألم الناتج عن فرط الحساسية لعاج الأسنان باستخدام مقياس النظير البصرى (VAS).

ركز طرف الألياف الزجاجية بليزر الصمام الثنائي (980 نانومتر) بقطر 600 نانومتر على منطقة عنق السن التي تتميز بحساسية على طريقة عدم التلامس لمدة 90 ثانية عند 1 بالوزن. نسبت النتائج قبل وبعد وبعد (72 ساعة ، 1 أسبوع) مباشرة من وقت تطبيق الليزر. **النتائج:** ليزر ديود (980 نانومتر وجد أنه فعال في علاج فرط الحساسية لعاج الأسنان ، وأظهرت النتائج أن تقليل الألم فورًا بعد تطبيق الليزر كان 38.7٪ ، مقارنة بمعجون الاسنان لاإزالة التحسس الموضعي ، كان تقليل الألم فورًا 44.3٪ ، بعد أسبوع واحد من تطبيق الليزر أظهرت النتائج أن الألم انخفض بنسبة 38.7٪ مقارنة بمعجون الاسنان لإزالة التحسس الموضعي ، كان تقليل الألم بعد أسبوع واحد 17.3٪ لذلك كان الليزر فعالاً بعد أسبوع مقارنة بعامل إزالة التحسس الموضعي.

الخلاصة: الليزر وعامل إزالة التحسس الموضعي المحتوي على نترات الصوديوم كانا فعالين في علاج فرط الحساسية لعاج الأسنان ولكن الليزر كان أكثر فاعلية ع فترة زمنيه طويله

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D.H Dentine hypersensitivity.

VAS Visual Analogue Scale.

Hz Hertz

Wt watt

Mw milliwatt

Min. minute

Sec. second

Yag yttrium aluminum garnet

Nd YAG Neodium yttrium Aluminum Garnet

Er:Yag Erbium yttrium Aluminum Garnet

Co2 Carbon dioxide

IR Infrared

Chapter 1

Introduction and Literature Review

1.1 Introduction

Dentin hypersensitivity is defined as “short, sharp pain arising from exposed dentin in response to stimuli typically thermal, evaporative, tactile, osmotic, or chemical (West, Seong et al. 2014)

This condition has been defined by an international workshop on DH as follows “Dentine hypersensitivity is characterized by short, sharp pain arising from exposed dentine in response to stimuli, typically thermal, evaporative, tactile, osmotic or chemical and which cannot be ascribed to any other dental defect or pathology”.

When the protective enamel/cementum is lost, the dentinal tubules will be exposed to external stimuli and result in hypersensitivity. Among many theories proposed regarding the mechanism of dentin hypersensitivity, Barnstorms hydrodynamic theory is the most widely accepted theory, which states that external stimuli cause fluid movement inside the dentinal tubules either in the inward or outward direction and promote mechanical deformation of nerve endings at the pulp/dentin. It will be transmitted as a painful sensation (Yilmaz HG Kurtulmus etal 2011). Based on the Brainstorms hydrodynamic theory, the two chief methods of treating dentin hypersensitivity are tubular occlusion and blockage nerve activity (Trushkowsky RD, Oquendo A .2011)

According to Brännström's theory (1966), the main strategy for the treatment of DH would consists of sealing the dentinal tubules, hence preventing fluid flow movement. Therefore, any treatment modality that can block or reduce the movement, blocks the pain transmission, or occludes the dentinal tubule and precipitates proteins can prove beneficial in the treatment of DH (Corona SA, Nascimento etal.2003).

At date, several strategies such as therapeutic toothpaste containing fluorides and nitrates, desensitizing topical agents (fluoride salts, potassium nitrate (KNO3), oxalate, calcium phosphate, and arginine), iontophoresis, adhesives, resins, and lasers have been tried to mitigate symptoms (Gerschman JA, etal 1994)Potassium nitrate (KNO3) for topical use is one of the most popular precipitating substances used for blocking dentinal tubes. The mechanism of action of potassium nitrate is largely unknown, although an oxidizing effect or blocking of tubules by crystallization has been proposed (Reddy, G. V., et al. 2017) Other authors posit that Potassium ion tends to accumulate in dentinal tubules leading to depolarization of cellular membrane of terminal nerve endings thus greatly reducing sensitivity (Shen, S.-Y., et al. 2009). In addition, topical application therapy of Potassium nitrate is considered a technique of easy application, optimal manipulation and low costs. However, the main disadvantage related to this kind of treatment is the patient constancy along treatment, since immediate effects are not seen, and, in many cases, there is a recurrence of hypersensitivity upon the withdrawal of the product (Mittal, R., et al. 2014).

On the other hand, laser technology has been studied widely for treating DH since the mid-1980s though results were divergent (Orchardson, R., et al. 1994).The neodymium-doped: yttrium, aluminum and garnet (Nd:YAG), CO2 and yttrium, aluminum and garnet (Er:YAG) lasers , have been the most widely used, because of their property of causing melting and resolidification of superficial dentin, its thermos mechanical ablation mechanism and the high absorption of its wavelength by water (Sicilia, A., et al. 2009).

More recently, especially over the last decade, a new tendency in laser therapy termed Low-level lasers, mostly oriented upon the therapeutic, rather than the surgical applications, has been developed. Low-level laser therapy (LLLT) provides cold thermal low energy wavelengths (400–900 nm) triggering a non-thermal bio activation at the periphery of the target tissues with bio- stimulatory and bio -modulatory effects (West, N., et al. 2014). LLLT as an alternative for the management of hypersensitivity has proven to produce an immediate analgesic effect, due to a photo-bio modulation on the dental pulp which increases and regulates the metabolic and the cellular activity (Aranha, A. C. C. etal 2012)

1.2 Justification:

Dentin hypersensitivity is one of the most common painful conditions affecting oral comfort and function. (Addy, M. etal 1992). It may affect up to 85% of the population. (Aranha, A. C. C 2012). The disease is common in patients age 20 to 50, but becomes more prevalent in patients from age 30 to 40, particularly women. (Asnaashari, M etal 2013) Among periodontal patients, the occurrence of cervical dentin sensitivity ranges between 72% to 98%(Brugnera Jr, A etal 2003) This condition occurs most frequently in canines and premolars, and often involves buccal surfaces (Duran, I. and A. Sengun 2004)

Management can involve either in-office or at-home therapy (or a combination), and these options fall under two main categories: nerve stabilization/desensitization or occlusion, other treatment option include laser therapy, The effect of dental lasers for treating dentin hypersensitivity might be between 5% to 100%, depending on the type of laser and beneficial parameters, such as the laser's length of beam, treatment time, and laser intensity. (West, N., et al. (2014)

In this study we try to know the effect of laser in treatment of dentine hypersensitivity.

1.3 General objective:

To compare between the effect of diode laser with wave length 910nm and the effect of topical desensitizing agent of the tooth paste in the treatment of dentine hypersensitivity.

1.4 Specific objective:

To assess the immediate effect of diode laser and topical desensitizing toothpaste containing potassium nitrate (Sensodyne) in reducing dentine hypersensitivity

2.To assess the effect of diode laser and topical desensitizing toothpaste containing potassium nitrate (Sensodyne) in reducing dentine hypersensitivity after two weeks.

3.To evaluate the duration of the treatment by Diode laser with wave length 910 nm.

1.5 LITERATURE REVIEW

1.5.1 dentin structure and components:

Dentine is the main supporting structure of the tooth and is the second hardest tissue in the body after enamel, It is 70% mineral and acellular, as hydroxyapatite crystals, and 30% organic as water, collagen and mucopolysaccharide. The main structure is the dentinal tubule, which extends from the external surface to the pulp. There are approximately 30,000 - 40,000 tubules per square millimeter, which can transmit pain to the pulp if the dentine is exposed.

There are three main types of dentine

Primary dentine forms before tooth eruption, Secondary dentine forms after eruption, as the tooth develops with age. It develops from the odontoblasts living within the pulp and is laid down in layers within the pulp cavity and reparative or tertiary dentine forms as a result of trauma to the odontoblasts; this can be thermal, chemical, bacterial or mechanical. Tertiary dentine has few tubules and is darker in colour and very dense in structure.

1.5.2 Definition of dentine hypersensitivity:

According to the Canadian consensus document DH(Shen, Tsai et al. 2009) has been defined as "pain derived from exposed dentin in response to chemical, thermal tactile or osmotic stimuli which cannot be explained as arising from any other dental defect or disease".

Although DH is a prevalent disorder and one of the most annoying diseases, the treatments which have been suggested for it are not sufficient and very successful (Addy and Urquhart 1992)This can lead to both physical and psychological problems for the patient. Furthermore, it can have a negative effect on the quality of a person's life, especially with regards to dietary selection, maintaining optimal dental hygiene, and beauty aspects.

1.5.3 Prevalence and epidemiology:

The prevalence distribution and appearance of the disease have been reported differently in different studies. These differences are due to the differences in populations, habits, dietaries, and methods of investigation (Brugnera Jr, A., et al. (2003)

The disease is prevalent in the patient with the age range of 20-50 years. However, it is more prevalent in the patient with the age range of 30-40 and more prevalent in female individuals that would probably be related to their dental hygiene and dietary (Kimura, Y., et al. 2000).

There are two common methods to determine the intensity of DH. One of them is through asking some questions from the patient and the other is through clinical examination. The prevalence distribution of DH in the first method is usually estimated higher than that of the second method (Markowitz, K. etal 1990).

4.1.1 pathogenesis of dentine hypersensitivity:

Dentin is considered as a vital tissue and has the capacity to respond to physiologic and pathologic stimuli (Matsumoto, K. 1985). dentin is covered by enamel in the crown surface and by a thin layer of cementum in the root surface of the tooth. Dentin is sensitive to stimuli due to the lesion extension of odontoblastic process and formation of dentin-pulp complex (McCarthy, D., et al. 1997). Dentin and pulp are histologically different. However, they have the same embryonic origin; ectomesenchymal origin. The formation of dentin-pulp causes dentin to be affected by pulp and vice versa. Dentin has very minute tubules which are filled with odontoblastic process. The processes are also surrounded by dentinal fluid which forms about 22% of the total volume of dentin. The fluid is completely filtrated and originates from the blood vessels of the pulp (Miglani, S., et al. 2010). Dentin's sensitivity to stimuli does not lead to any problem while it is covered with protective tissues; enamel and cementum

Based on the studies, DH is developed in two phases (Orchardson, R., et al. (1994).

1.Lesion localization

2.Lesion initiation

In the first phase, dentinal tubules, due to loss of enamels, are exposed by attrition, abrasion, erosion, and abfraction. However, dentinal exposure mostly occurs due to gingival recession along with the loss of cementum on the root surface of canines and premolars in the buccal surface. It is worth noticing that not all the exposed dentins are sensitive. However, their calcified smear layer, as compared to non-sensitive dentin, is thin and this leads to an increase in the fluid movement and consequently the pain response (Reddy, G. V., et al. 2017) In the second phase, for the exposed dentin to be sensitized, the tubular plugs and the smear layer are removed and consequently, dentinal tubular and pulp are exposed to the external environment (Orchardson, R., et al. 1994). Dentin's sensitivity to stimuli does not lead to any problem while it is covered with protective tissues; enamel and cementum.

Plug and smear layer on the surface of exposed dentine are composed of elements of protein and sediments which are derived from salivary calcium phosphates and seal the dentinal tubules inconsistently and transiently.

The findings of laboratory research indicate that both mechanical and chemical factors are effective in removing the smear layer from the dentinal tubules, the mechanical factors are not the only key factors in removal of the smear layer and when they are accompanied with acidic foods or drinks they lead to the removal of smear layer (Shen, S.-Y., et al. 2009)

5.1.1 Mechanism of dentine hypersensitivity:

Three main mechanisms of dentin sensitivity are:(Duran, I. and A. Sengun (2004).

1-Direct Innervation (DI) Theory:

Regarding the first theory; DI, it has been reported that the nerve's endings enters dentin through pulp and extends to DEJ and the mechanical stimuli directly transmit the pain.

2-Odontoblast Receptor (OR) Theory:

In the OR theory, odontoblasts act as receptors of pain and transmit signals to the pulpal nerves

3. Fluid Movement/Hydrodynamic Theory

Hydrodynamic Theory for sensitive dentine was first proposed by Brannstorm (Wargantiwar, A. A., et al. (2021) . This theory is the most widely accepted theory for DH. The theory has been proposed based on the movement of the fluid inside the dentinal tubules. The theory claims that tubules are open between dentine surface which is exposed to the environment and pulp (West, N., et al. 2014).

6.1.1. -Clinical treatment of dentin hypersensitivity and Diagnosis:

the accurate diagnosis of dentin hypersensitivity before receiving treatment is critical for successful treatment.

The diagnosis of the disease starts through investigating the medical history of the patient and examination. In investigating the medical history some questions are asked about the time of the start of DH, the intensity of the pain, the stability of the pain and the factors that reduce or increase the intensification of the disease. In examination, some techniques such as pure air, pure water, and sounds are used in order to reconstruct the stimulating factors and to determine the degree of pain of the patient, All of the teeth with pain should be examined and the degree of pain should be described through qualitative parameters such as slight, medium, and severe pain or through using quantitative parameters such as visual analogue scale (Aghayan, S., et al. (2021).

There are various treatment modalities available which can be divided into in-office (i.e., applied by a dentist or dental therapist), or treatments which can be carried out at home, available over-the-counter or by prescription.

Various desensitizing agents have been used depending on the mechanism of action, they act by either occluding the dentinal tubules or blocking the neural transmission to reduce DH such as dentin adhesive sealers (fluoride varnishes, dentin-bonding agents) (Duran and Sengun 2004), agents forming protein precipitates (silver nitrate)(Markowitz and Kim 1990), agents plugging dentinal tubules (sodium fluoride, stannous fluoride, and bioactive glass) (Miglani, Aggarwal et al. 2010), and nerve-desensitizing agents (potassium nitrate and strontium nitrate) (Mittal, Singla et al. 2014).

Recently laser-assisted treatment of dentine hypersensitivity shown a good method to solve immediate and long-term pain. Compared to conventional desensitizing topical agents. Laser treatment, although more expensive, leads to rapid results with less application time and more quickly for the patient (Sicilia, Cuesta-Frechoso et al. 2009).

7.1.1. Mechanism of Laser Treatment

Laser therapy was first introduced as a potential method for treating dentinal hypersensitivity in 1985 (Matsumoto 1985). Since then, many studies have been done on laser applications for dentine hypersensitivity treatment and a lot of information has been gathered.

Laser interaction with the tissue, causes different tissue reactions, according to its active medium, wavelength and power density and to the optical properties of the target tissue (Ladalardo, Pinheiro et al. 2004). Laser treatment reduces sensitivity by coagulation of protein without altering the surface of the dentin (Trushkowsky and Oquendo 2011). Pashley suggests that it may occur through coagulation and protein precipitation of the plasma in the dentinal fluid or by alteration of the nerve fiber activity (Orchardson, Gangarosa Sr et al. 1994). The study by McCarthy et al. indicates that the reduction in DH could be the result of alteration of the root dentinal surface, physically occluding the dentinal tubules (McCarthy, Gillam et al. 1997).

According by Myers & McDaniel's study laser energy interferes with the sodium pump mechanism, changes the cell membrane permeability and/or temporarily alters the endings of the sensory axons (Kimura, Wilder-Smith et al. 2000).

The immediate analgesic effect in the treatment of dentine hypersensitivity with diode laser was reported by Brugnera Júnior et al. Based on this study the laser interaction with the dental pulp causes a photobiomodulating effect, increasing the cellular metabolic activity of the odontoblasts and obliterating the dentinal tubules with the intensification of tertiary dentine production (Brugnera Jr, Garrini et al. 2003).

8.1.1Effectiveness of Various Laser Types in The Treatment of DH

Laser's radiation used for the treatment of dentine hypersensitivity are divided into two groups:

1- Low output power (low-level) lasers [(He- Ne) helium-neon and (GaAlAs) gallium-aluminum arsenide (diode) lasers]

2- Middle output power (Carbon Dioxide Laser (CO_2), neodymium- or erbium-doped yttrium aluminum garnet (Nd: YAG, Er: YAG lasers) and erbium, chromium doped: yttrium, scandium, gallium and garnet (Er: Cr: YSGG) lasers) (Asnaashari and Moeini 2013).

Desensitization procedure depend mostly on the type of laser therapy adopted (Aranha and de Paula Eduardo 2012).

In case of low output power lasers, a small fraction of the laser's energy is transmitted through enamel or dentin to reach the pulp tissue. Low-power laser therapy is an appropriate treatment strategy to promote bio modulatory effects, minimize pain and reduce inflammatory processes. Its use has been widely accepted and approved due to satisfactory results reported in the literature. In contrast, the effects of high-power lasers, such as the carbon dioxide, Nd: YAG, Er: YAG and Er:Cr:YSSG lasers, are related to an increase in surface temperature which can result in the complete closure of dentinal tubules after recrystallization of the dentinal surface (Aranha and de Paula Eduardo 2012).

Many studies were conducted to compare and evaluate the efficacy of desensitizing agents and laser assisted therapy of dentine hypersensitivity.

evaluate and compare the clinical efficacy of diode laser in combination with topical Potassium nitrate (KNO_3) gel, Iontophoresis and KNO_3 topical gel alone in the treatment of dentinal Hypersensitivity. They enrolled in this study 30 systemically healthy patients, they were allocated into 3groups: Group I was treated with diode laser and KNO_3 gel; Group II with Iontophoresis using Sodium Fluoride (NaF) gel and Group III was treated with KNO_3 topical gel alone. Sensitivity was recorded using the verbal rating scale before treatment, 10 min after treatment and 7-, 15- and 21-days post therapy. All groups showed significant reduction in Dentinal Hypersensitivity. However, the use of diode laser with KNO_3 gel showed statistically significant reduction in sensitivity when compared to Iontophoresis and KNO_3 topical gel alone (Wargantiwar, Moolya et al. 2021).

GV Reddy *et al* (2017) evaluated the efficacy of diode laser (980 nm) alone and in combination with desensitizing toothpastes in occluding dentinal tubules (both partially occluded and completely occluded tubules) by scanning electron microscope (SEM). Fifty human teeth were extracted, cervical cavities were prepared and etched with 17% ethylene diamine tetra acetic acid, and smear layer was removed to expose the tubules. The teeth were divided into five groups: Group I – Application of NovaMin-formulated toothpaste, Group II – Application of Pro-Argin™-formulated toothpaste, Group III – Application of diode laser in noncontact mode, Group IV – NovaMin-formulated toothpaste followed by laser irradiation, and Group V – Pro-Argin formulated toothpaste followed by laser irradiation. After treatment, quantitative analysis of occluded dentinal tubules was done by SEM analysis. There results showed that the mean values of percentages of total occlusion of dentinal tubules in Groups I, II, III, IV, and V were 92.73% ± 1.38, 90.67% ± 1.86, 96.57% ± 0.64, 97.3% ± 0.68, and 96.9% ± 6.08, respectively. Addition of diode laser (Groups III, IV, and V) yielded a significant occlusion of the dentinal tubules when compared to desensitizing toothpastes alone (Groups I and II), they concluded that Diode laser (Group III) has shown more efficacy in occluding dentinal tubules when compared with desensitizing toothpastes. Among the five groups NovaMin and diode laser (Group IV) showed the highest percentage of occluded dentinal tubules (Reddy, Akula et al. 2017).

Oscar Tocarruncho *et al* (2018) compared the effectiveness of two dental desensitization therapies, 940nm laser diode and potassium nitrate, in patients with dental hypersensitivity (DH) symptoms. They're randomized clinical trial included 30 patients who initially underwent basic periodontal therapy and presented gingival recessions Class I and II (Miller 1985) with symptoms of DH. Subjects were randomly assigned into two groups. The first group (n = 15) received laser 940 nm application for 90 seconds on the surface of the recession and were given a tube of glycerin to be applied daily in order to avoid generating bias. Patients in the second group (n = 15) were exposed to inactive laser simulating the actual application of the laser, and they were given a desensitizing gel containing 0.5 g of potassium nitrate to be applied twice daily during 14 days. Control participants were carried out at 15 minutes, 8 days, 15 days, and 4 weeks. There results showed that all patients involve in the study experienced reduction in DH, indicating Laser and nitrate therapies were effective to manage DH after basic periodontal therapy. However, a significant higher sensitivity reduction was observed in laser therapy group (Tocarruncho, Robayo et al. 2018).

Shabnam Aghayan *et al* (2021) assessed and compared the efficacy of the 980 nm diode, Nd: YAG and Er: YAG lasers accompanied by fluoride in dentinal tubule obstruction. They analyzed twenty sound single-rooted human teeth. Forty dentinal discs were prepared of the roots and etched with 6% citric acid. One layer of fluoride varnish was applied over their surface. The sections were randomly allocated into 4 groups. The control group received no laser irradiation. Group 2 underwent 980 nm diode laser irradiation with 0.5 W power. Group 3 underwent Nd: YAG laser irradiation with 0.5 W power and group 4 underwent Er: YAG laser irradiation with 0.5 W power. All samples were then inspected under a scanning electron microscope, and the number of obstructed dentinal tubules and the diameter of open dentinal tubules in the field were determined. All three laser types decreased the number of open dentinal tubules significantly compared to the control group. The diameter of open tubules in the three laser groups did not show a significant difference from that in the control group. Concluding that all three types of lasers evaluated in this study can effectively obstruct the dentinal tubules (Aghayan, Fallah et al. 2021).

Chapter two

Basic Concepts of Laser

Definition of laser

Laser is an acronym for light amplification by stimulated emission of radiation. Laser is device that emits electromagnetic radiation through a process of optical amplification based on the stimulated emission of photons (Ladalardo, T. C. C. G. P, et al. 2004)

2.1 Development of Laser

Albert Einstein (1917) describes the theory of stimulated emission (stimulated emission is process by which an incoming photon of specific frequency can interact with an excited atomic electron causing it to drop to a low level energy). C.H.Townes and CO-Worker (1954) developed a microwave amplifier based on stimulated emission radiation it was called a maser (Tocarruncho, O., et al. (2018).

2.2 Laser Light Properties

Light produced from the lasers have several valuable characteristics not shown by light obtained from other conventional light sources, which make them suitable for a variety of scientific and technological applications .

- Monochromaticity (one color) the color of the light is determined by the length of its waves represent by Greek word called (lambda), each type of lasers has single wavelength.
- Directionality (collimated) the laser light travel in single direction within a narrow cone of divergence.
- Coherence is the term used to describe the in – phase property of laser beam, all waves are in step or in phase with one another at every point.

Intensity (Brightness) the number of photons emitted per unit surface area per unit solid angle. Each laser type has its own intensity ((Tocarruncho, O., et al. (2018).

2.3 Classification of Laser

According to gain medium (active medium)

- Gas
- Solid
- Semiconductor
- Liquid

According to their nature of emission -
Continuous wave (C W)

- Pulsed Wave (P W)

According to their wavelength

- Visible Region
- Ultraviolet Region (UV)
- Infrared Region (IR)

According to frequency

- Fixed
- Tunable

According to power

- High power
- Low power

According to excitation mechanism

- Electrical
- Chemical

According to their site of action

- Soft Tissue

- Hard Tissue (Ladalardo, T. C. C. G. P, et al. 2004)

2.4 Emission Mode of Lasers

2.4.1 Continuous- Wave Mode (CW)

Lasers depend on a beam whose output power is constant over time and steady when averaged over any longer time periods, with the very high frequency. The power variations had little or no impact in the intended application. Such a laser is known as continuous wave.

2.4.2 Pulsed Mode

There are periodic alterations of laser energy, this mode is achieved by the opening and closing of mechanical shutter in front of the beam path of a continuous- wave emission.

2.5 Component of Laser Unit

2.5.1 Active Medium

Active medium is material support the population inversion. Such as Gas (Co2, Argon, Krypton) , Solid (Ruby, Nd: YAG, Er : YAG) , Liquid (fluorescent dyes such as Rhodamine 6G) and Semiconductor (Diode) .

2.5.2 Laser Resonator

Active medium is contained within optical enclosure, create high radiation density (eg: mirrors). Mixture of gain medium with mirrors is called optical cavity or optical resonator.

2.5.3 Pumping Source

Active medium needs to be changed to release photons. The external source of energy may be electrical, chemical, or flash lamp. The gain medium is pumped by an external energy source. The gain medium then emits photon, which bounce back and forth between the reflectors. Part of the radiation is allowed to exit through an aperture in one of the reflectors, resulting in the laser beam ((Tocarruncho, O., et al. 2018).

2.6 Laser Tissue Interaction

Laser light has either four different interactions with the target tissue, depending on the optical properties of that tissue. Laser tissue interaction such as absorption, transmission, reflection and scattering .

2.6.1 Absorption

Laser light is converted into effective thermal energy. The amount of energy that is absorbed by the tissue depends on the tissue characteristics, such as pigmentation and water content, on the laser wavelength and emission mode.

2.6.2 Transmission

Light energy passes freely through the tissue, without interaction of any kind and has little or no effect. It is an inverse of absorption.

2.6.3 Reflection

Light energy reflects off tissue surface with little or no absorption and consequently has no effect on tissue. The laser beam generally becomes more divergent as the distance from the head piece increases, which become dangerous because the energy is directed to an unintentional target such as eye.

2.6.4 Scattering

Light energy is re-emitted in a random direction and ultimately absorbed over a grater surface area which produces less intense and less precisely distributed thermal effect. Laser beam travels in straight line until it hits something that reflects or refracts it or until it hits something that stops it and absorbs it energy.

2.7 Tissue Changes by Laser

There are five important types of biological effects that can occur once the photons enter the tissue such as fluorescence, photothermal, photochemical, photo disruptive and Photobiomodulation.

2.7.1 Fluorescence

Fluorescence happens when actively carious tooth structure is exposed to the 655 nm visible wavelength and the amount of fluorescence is related to the size of the lesion, and is useful in diagnosing incipient carious lesion. e.g. Diagnodent.

2.7.2 Photothermal

Photothermal effects occur when the chromophores absorb the laser energy and heat is generated. This heat is used to perform work such as incising tissue or coagulating blood. Photothermal interactions predominate when most soft tissue procedures are performed with dental lasers.

2.7.3 Photodisruptive

Hard tissues are removed through a process known as photo disruptive ablation. The pulsed Erbium laser ablation efficiency seems to result from these micro explosions of overheated tissue water in which their laser energy is predominantly absorbed.

2.7.4 Photochemical

Photochemical reactions occur when photon energy causes a chemical reaction. These reactions are implicated in some of the beneficial effects found in bio stimulation. Eg, Photodynamic therapy.

2.7.5 Biostimulation (Photobiomodulation)

Biostimulation refers to lasers ability to speed healing, increase circulation, reduce edema, and minimize pain. The exact mechanism of these effects is not clear, but it is theorized they occur mostly through photochemical and photobiological interactions within the cellular matrix and mitochondria.

Biostimulation is used dentally to reduce postoperative discomfort and to treat maladies such as recurrent herpes and Aphthus stomatitis.

2.8 Advantages of Using Lasers in The Periodontal Therapy

- Less pain
- Less need for anesthetics (advantage for medically compromised patients)
- No risk for bacteremia.
- Excellent wound healing (no scar tissue formation) .
- Bleeding control.
- Usually no need for suture.
- Ability to remove both soft and hard tissues.
- Use a fewer inusuroments and material.
- Can be used in combination with scalpels

2.9 Disadvantages of Using Lasers in The Periodontal Therapy

- Relatively high cost of the devices
- A need for additional education
- Every wavelength has different proprieties
- The need for implantation of safety measures (i.e. Goggle use, etc.) .

2.10 Diode Laser

Diode laser (DL) is semiconductor laser type .the wavelength of diode laser 610 nm (visible in red region) and 980nm (near IR). The most widely used lasers in this family are Gallium-Aluminum-Arsenide (GaAlAs) laser (810 nm) and Indium-Gallium-Arsenide (InGaAs) laser (980nm). Diode lasers operate in continues and pulsed modes and very effective for soft tissue applications, offering excellent incision, hemostasis and coagulation.

Diode lasers (DL) enable the effective removal of bacteria and toxins. In addition to bactericidal and detoxification effects, a diode laser can accelerate wound healing, facilitate collagen synthesis. Diode lasers are extremely effective in removing the epithelium with a thermal mechanism.

Another advantage of Diode lasers is their small size and low cost. Deepethelialization with diode lasers requires less anesthesia and is associated with less postoperative discomfort than compared with hand inusuroments.

During irradiation a part of diode laser energy scatters and penetrates into periodontal pockets, stimulating the cell surrounding tissues. This result in reduction of the inflammatory conditions, increased in cell proliferation, improving the periodontal tissue attachment and marked reduction in postoperative pain.

2.11 Low Level Laser Therapy (LLLT)

Amongst recent advances, low –level laser therapy (LLLT) is highly recommended for its pain reducing, wound healing promoter and anti-inflammatory effects.

Low level laser therapy uses photonic energy to provide biological therapeutic advantages and is considered a non-invasive and painless process. The bio stimulatory and inhibitory effects of lasers are based on Arndt- Schultz Law, which indicates that weak stimuli will increase physiological processes and strong stimuli will inhibit physiological activity**.**

Low level laser light its absorption parameter is in sub cellular photo receptors, electron transfer in the respiratory chain of mitochondria membrane capable of penetrating into tissues in depth of 3-15mm . In vivo and in vitro experiments it has been shown that low level laser is capable of speeding up repair process

Chapter 3

Material and Methods

3.1 Study Design

A randomized clinical trial (RCT) using split mouth method.

3.2 study area and study population

Patients with dentine hypersensitivity attending Dental clinics of the faculty of dentistry; University of Karrary and military dental hospital during the study period were enrolled in the study.

3.3 study duration

The study period was from November 2021 to January 2022.

3.4 Methodology

Subjects satisfying the eligibility criteria were asked to participate in the study after reviewing and signing the informed written consent as follows:

3.4.1 Inclusion Criteria:

1.Patients complaining of sensitivity due to mechanical stimuli (Tooth brushing), thermal (Warm, cold) or chemical (Sweet or sour food).

2. Patients with two or more teeth with dentinal hypersensitivity.

3. Patients with non- carious lesions not requiring restoration, like attrition, dental erosion and pathologic dental abrasion.

4. Early non-carious lesions.

5. Patients in the age group of 18-70.

6. Patients ready to sign the consent form and ready to come for follow-ups.

3.4.2Exclusion Criteria:

1. Teeth with cervical caries.

2. Teeth with non-carious lesions with pulpal involvement.

3. Patients under any medications.

4. Patients having any systemic diseases.

5. Patients already taking any hypersensitivity treatment or had taken within last three months.

6. Teeth with advanced periodontal disease.

7. Crazed or hypo plastic teeth.

8. Patient with any psychological diseases and senso-neurological disease (trigeminal neuralgia, sensory processing disorder

9. Pregnant lady.

10. Patient with orthodontic appliance.

11. Patient with history of bleaching.

3.5 SAMPLE SIZE AND SAMPLING TECHNIQUE

Convenient sampling technique was adopted where one subject was recruited from dental hospitals.

The sample population were categorized randomly into two groups:

Group 1- desensitizing paste, Sensodyne tooth paste for sensitive teeth.

Group 2- Diode laser with 980 nm wave length.

3.6:DATA COLLECTION METHODS:

In this split mouth study, All subjects who met the inclusion criteria and signed the informed consent form (1 patient patients complaining of 21teeth sensitive teeth) received a baseline

1. Tactile hypersensitivity evaluation with the help of dental explorer and

2. An air blast hypersensitivity evaluation.

The quadrants were randomly assigned into two groups with a randomized matching method. Group A was treated with 980-nm diode laser, Group B, treated with desensitizing toothpaste.

For tactile stimuli, a sharp tip of the dental explorer was stroked perpendicular to the hypersensitive tooth surface with slight pressure.

For air blast, each hypersensitive tooth was isolated by placing the cotton rolls, then air was delivered from a standard dental unit air syringe at 60psi and environmental temperature. The air was directed at the exposed surface of the hypersensitive tooth for 1 second from a distance of approximately 1 cm.

Both the stimuli were recorded on the visual analogue scale (VAS Scale) of 10, along with the hard and soft tissue evaluation(Shen, Tsai et al. 2009).

VAS is a linear scale marked from 0 to 10 to describe the pain experienced. The values on the scale are assigned as:

0- no pain.

1 to 3- mild pain.

4 to 6- moderate pain.

7 to 9- severe pain.

10- Unbearable pain.

Patient was instructed to point out the level of sensitivity he felt during tactile and air stimulation on this VAS scale and thus the scores were self-rated by the patients. The test was repeated 3 times and average final score was recorded.

The treatments were rendered at one visit and by the same operator. The patient was asked to brush twice per day by a very soft toothbrush and toothpaste and not use any desensitizing or fluoride agent following therapy.

The effectiveness of the therapy was assessed by VAS Scale of 10, Scores were recorded in an analogous visual scale: score 10 (unbearable pain); 7 to 9 (strong and bearable pain), 4 to 6 (moderate pain), 1 to 3 (light pain) and 0 (no pain)(Hashim *et al.*, 2014) along with the hard and soft tissue evaluation, at 3 examination periods: 1) immediately after the application of the diode laser ,the toothpaste 2) after 72days and3) after 1week Furthermore, the patient was requested to avoid the use of analgesics as much as possible, but if he perceived severe pain, he should take paracetamol 500 mg and record the number and frequency of consumption.

3.7 MATERIALS NEEDED FOR DATA COLLECTION:

1. Face mask and a pair of examination gloves were used for each participant and discarded after use for infection control,
2. Sterile WHO examination set (mouth mirror, a probe – explorer, and tweezers) was used.
3. Dispensaries: sterile cotton.

3.8 STATISTICAL ANALYSIS:

Statistical Package for the Social Sciences (SPSS) computer software version 23.0.0.0 was used for analysis of the data obtained.

3.9 ETHICAL CONSIDERATIONS

Ethical clearance was taken before the start of the study from the Ethics Committee and informed written consent was obtained at the clinic of Laser Institute, Sudan University of Science and Technology. all patients who are eligible and have accepted the invitation to participate, the objective of the study was explained to them, and then all participants asked to sign a written consent in Arabic form explaining the goals and procedure of the study. Moreover, for those were illiterate, the form was read to them. periodontal treatment was done to the participant when needed

The data was collected coded and locked in a password-protected computer at the principal investigator office to ensure the confidentiality and privacy of patient data.

Chapter 4

Results and Discussion

4.1. Introduction:

This chapter deals with results of this work, discussion, conclusion and recommendation**.**

4.2. Results:

The total number of patients attending the laser clinic of institute of laser, Sudan university of science and technology was 1 patient with 21(cases) teeth, for treatment of dentine hypersensitivity, the numbers of teeth treated by laser were12 (57.1%)and the number of teeth treated by desensitizing agent were 9 (42.9%) the results of analysis of this patient was as follow:

Table 1 show the mean, minimum and maximum standard deviations for VAS (before treatment, immediately after treatment, after 72hours after treatment and after 1 week) for teeth treated by laser.

Table 2 show the mean, minimum and maximum standard deviations for VAS (before treatment, immediately after treatment, after 72hours after treatment and after 1 week) for teeth treated by application of topical desensitizing agent.

Table 3 show the mean values of overall reduction in VAS by laser, reduction immediately after treatment was 38.7%, reduction in VAS after 72hours after treatment was 38.7% and after1 week was 38.7%.

Table 4 show the mean values of overall reduction in VAS by application of desensitizing agent, immediately after treatment the overall reduction was 44.3%, after 72 hours the reduction was 44.3%while after 1week the overall reduction was 17.3%.

From above tables we realized that diode laser 980nm and topical desensitizing agent were effective in the treatment of dentine hypersensitivity.

The therapeutic late effects of the diode laser 980 nm (90 Sc exposure time,1wt power) was greater than the therapeutic late effect of topical desensitizing agent.

The therapeutic immediate effect of topical desensitizing agent was greater than the effect of laser.

Table 1-3 showed general frequency tables

Intervention Laser/toothpaste

	Frequency	Percent
Desensitizing gel	9	42.9
Laser	12	57.1
Total	21	100.0

Table 2-3 showed the mean, minimum and maximum standard deviations for VAS scores for teeth treated by laser

	VAS before treatment	VAS immediately	VAS after 72hours	VAS after 1 week
Mean	6.25	3.83	3.83	3.83
Std. Deviation	2.598	2.406	2.480	2.368
Minimum	3	0	0	0
Maximum	10	8	7	8

Table3-3 showed the mean, minimum and maximum standard deviations for VAS scores for teeth treated by application of topical desensitizing agent

	VAS before treatment	VAS immediately	VAS after 72hours	VAS after 1 week
Mean	5.78	3.22	3.22	2.56
Std. Deviation	3.308	1.986	1.716	2.242
Minimum	2	1	1	0
Maximum	10	6	6	6

Table 3-4 showed the mean values of overall reduction in VAS by laser,

	VAS before treatment (baseline)	VAS immediately	Reduction immediately from treatment	VAS after 72hours	Reduction after 72 h from baseline	VAS after 1 week	Reduction after 1 week from baseline
Mean	6.25	3.83	2.42(38.7%)	3.83	2.42(38.7%)	3.83	2.42(38.7%)

Table 3-5 showed the mean values of overall reduction in VAS by application of desensitizing agent.

	VAS before treatment (baseline)	VAS immediately	Reduction immediately from treatment	VAS after 72hours	Reduction after 72 h from baseline	VAS after 1 week	Reduction after 1 week from baseline
Mean	5.78	3.22	2.56(44.3%)	3.22	2.56(44.3%)	2.56	3.22(17.3%)

Figure 3-1 showed the effect of desensitizing agent

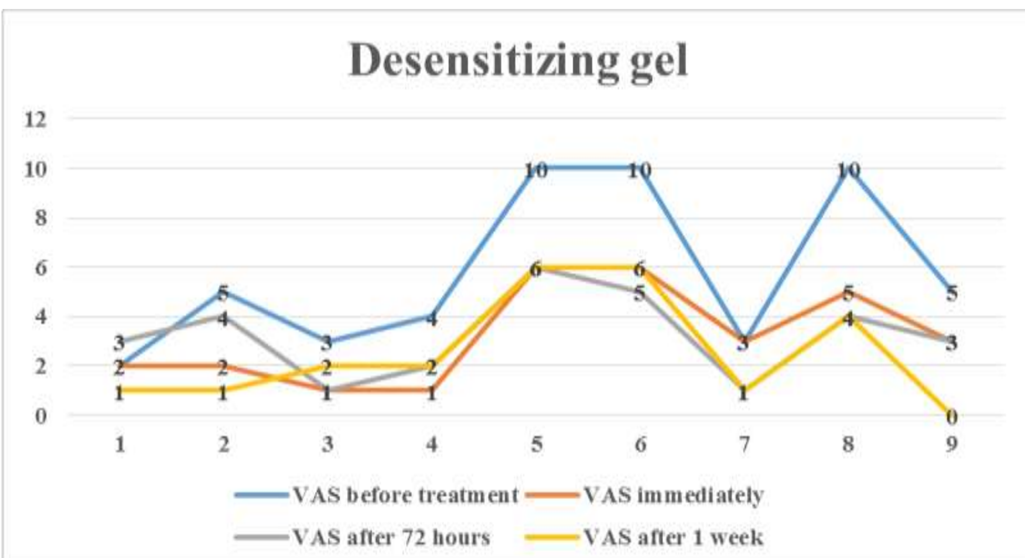
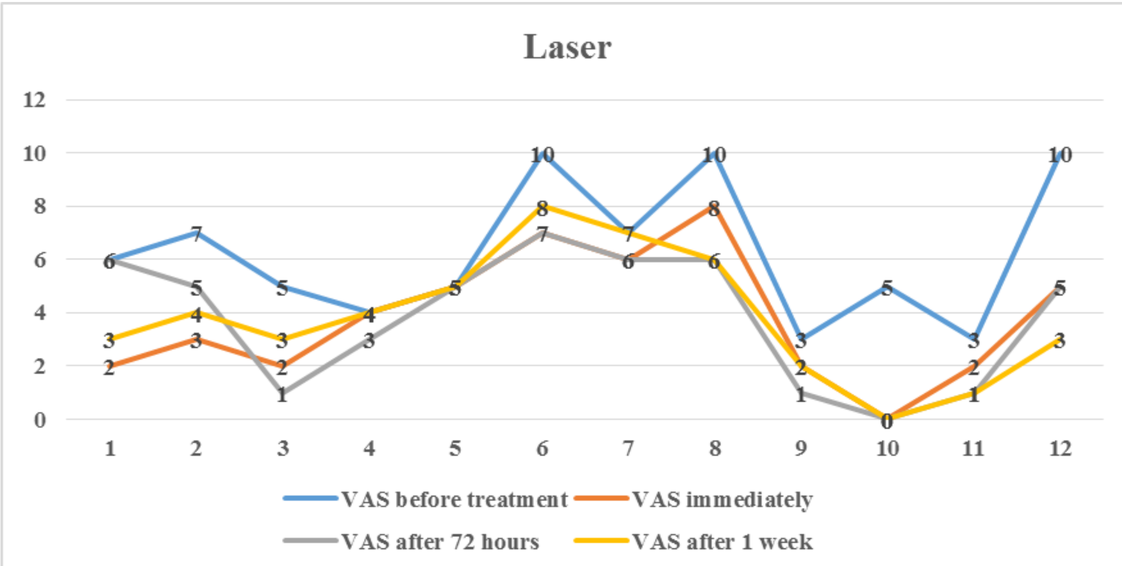


Figure 3-2 showed the effect of laser application



4.3. Conclusion:

1- This study indicated that diode laser 980nm and topical desensitizing agent were effective in the treatment of dentine hypersensitivity.

2- The therapeutic late effects of the diode laser 980 nm (90 Sc exposure time,1wt power) was greater than the therapeutic late effect of topical desensitizing agent.

3- The therapeutic immediate effect of topical desensitizing agent was greater than the effect of laser.

4.4. Recommendations

I recommend the following for the treatment of dentine hypersensitivity:

1- Increase the sample size with different variety in age and gender.
2- Follow up of the patients for long period of time.
3- Use of other types of laser.
4- Change the power and time exposure of the laser.

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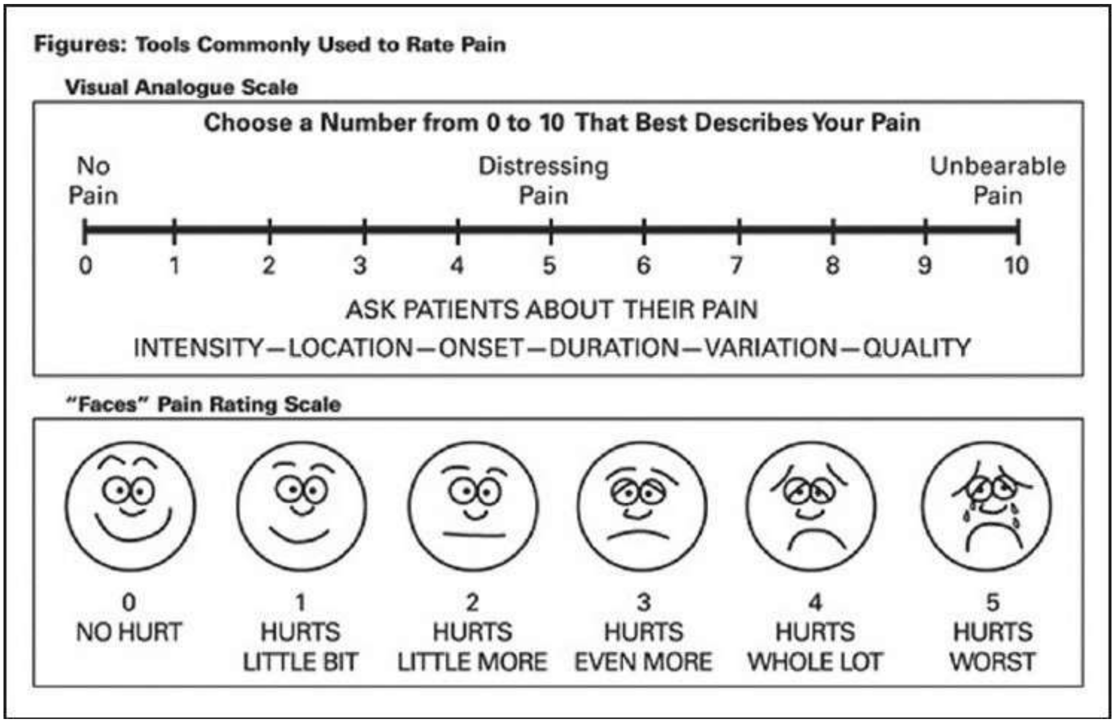
APPENDICES

Appendix 1

Visual Analogue Scale(VAS)



APPENDIX 2

Sheet of data collection

Date	Pt name	Tooth number	VAS before treatment	Intervention Laser/toothpaste	VAS immediately after	VAS after 72 hours	VAS after 1week