Sudan University of Science and Technology

Collage of Graduate Studies

Effectiveness of Diode Laser in the Treatment of Dentine Hypersensitivity in Comparison with Desensitizing 5% Potassium Nitrate Gel

فاعلية ليزرالديود في علاج حساسية الأسنان بالمقارنه مع جل نترات البوتاسيوم 5% المزيل للحساسية

A Dissertation of Graduation Project for Postgraduate Diploma in Laser Applications in (Dentistry)

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DEDICATION

This study is wholeheartedly dedicated to my beloved parents; I am extremely grateful to them, who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional, and financial support

To my brothers, sisters, relatives, mentor, and classmates who shared their words of advice and encouragement to finish this study,

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ABSTRACT

Background: The acute, non-spontaneous, short- or long-lasting nature of pain due to hypersensitivity that appears suddenly on stimulation warrants a therapeutic mode which would bring about a significantly greater, immediate reduction of dentinal hypersensitivity. Lasers may now provide reliable and reproducible treatment for this condition.

Objectives: the present study aimed to assess the immediate and long-term efficacy of diode laser in the treatment of dentinal hypersensitivity and to compare the efficacy of diode laser and 5% potassium nitrate gels in the treatment of dentinal hypersensitivity.

Subjects and methods: eighteen teeth diagnosed with dentine hypersensitivity were included in this split mouth study, and teeth were randomly divided equally into two groups: group A, which received treatment with GaAlAs (diode) laser, and group B, treated with desensitizer 5% potassium nitrate gel. DH was assessed by means of an air stimulus, and a visual analogue scale (VAS) was used to measure DH. The selected teeth in group A received laser therapy for one session. teeth subjected to diode-laser treatment were irradiated at 100 mW for 25 sec at 810 nm, with continuous-emission, noncontact mode, perpendicular to the surface, with scanning movements on the region of exposed root surfaces

Results: immediately. after the laser was applied, we observed an overall reduction in the response to air blast of 44.9% (mean 3.00, SD1.732) in group A, three times greater than that observed in the group B, which was 17.5% (mean 1.11, SD 0.928), after 10 days the reduction in VAS in the laser group was 58.3% (mean 3.89, SD1.616) which was more than the reduction in VAS observed in 5% potassium nitrate gel group which was 36.8%(mean 2.33, SD 1.871). both groups showed significant decrease between baseline and 10 days with pronouns effect on group A

Conclusions: A reduction of DH was recorded immediately and after 10 days in both groups (A and B), better results were noted in group A when compared to group B.

Keywords: dentin hypersensitivity, diode laser, potassium nitrate, visual analogue scale

المستخلص

الخلفية: تستدعي طبيعة الألم الحادة وغير العفوية والقصيرة أو طويلة الأمد بسبب فرط الحساسية التي تظهر فجأة عند التحفيز وضعًا علاجيًا من شأنه أن يؤدي إلى تقليل كبير وفوري لفرط حساسية الأسنان. قد يوفر الليزر الآن علاجًا موثوقًا وقابلًا للتكرار لهذه الحالة

الأهداف : هدفت الدراسة الحالية إلى تقييم الفعالية الفورية والطويلة الأمد لليزر الدايود في علاج فرط الحساسية للأسنان ومقارنة فعالية ليزر الصمام الثنائي وجل نترات البوتاسيوم في علاج فرط حساسية الأسنان

الطريقه:. تم تضمين 18سنًا تم تشخيصها بحساسية العاج في دراسة تقسيم الفم هذه ، وتم تقسيم الأسنان بشكل عشوائي بالتساوي إلى مجموعتين: المجموعة أ ، التي تلقت العلاج بليزر (الصمام الثنائي) ، والمجموعة ب، عولجت بهلام نترات البوتاسيوم. تم تقييم فرط حساسية العاج عن طريق منبه الهواء ، وتم استخدام مقياس تناظري بصري لقياس فرط حساسيه العاج. تلقت الأسنان المختارة في المجموعة أ العلاج بالليزر لجلسة واحدة. تم تشعيع الأسنان التي خضعت للمعالجة بليزر الصمام الثنائي عند100 ميغاواط لمدة 25 ثانية عند 810 نانومتر ، مع الانبعاث المستمر ، ووضع عدم الاتصال ، عموديًا على السطح ، مع حركات مسح على منطقة أسطح الجذر المكشوفة

النتائج: فورا. بعد تطبيق الليزر ، لاحظنا انخفاضًا إجماليًا في الاستجابة للانفجار الهوائي بنسبة 44.9٪ (متوسط 3.00 ، الانحراف المعياري 1.732) في المجموعة أ ، أكبر بثلاث مرات من ذلك الذي لوحظ في المجموعة ب ، والذي كان 17.5٪ (متوسط 1.11، الانحراف المعياري 0.928) ، بعد 10 أيام ، كان الانخفاض في المقياس التناظري البصري في مجموعة الليزر 58.3٪ (متوسط 3.89 ، الانحراف المعياري 1.616) وهو أكثر من الانخفاض في المقياس البصري التناظري الذي لوحظ في مجموعة هلام نترات البوتاسيوم بنسبة 5٪ والتي كانت 36.8٪ (متوسط 2.33 ، الانحراف المعياري 1.871)

الخلاصـــة: تم تســـجيل انخفاض في فرط حســـاســـيه العاج على الفور وبعد 10 أيام في كلا المجموعتين في (أ و ب) لوحظت نتائج أفضل في المجموعة أ بالمقارنه مع المجموعة ب.

كلمات البحث: فرط الحساسية للعاج ، ليزر ديود ، نترات البوتاسيوم ، مقياس بصري تناظري

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ABBREVIATIONS

DH	Dentine hypersensitivity
VAS	Visual Analogue Scale
SiO_2	Silicon Dioxide
P2O5	Phosphorus Pentoxide
CaO	Calcium oxide
Na_2O	Sodium oxide
Nd: YAG	Neodymium-doped yttrium aluminium garnet
Er: YAG	Erbium-doped yttrium aluminium garnet
GaAlAs	Galium-aluminium-arsenide
SEM	Scanning Electron Microscope
FDA	Food and Drug Administration
PPD	Periodontal Pocket Depth
CO2	Carbone Dioxide
KN	Potassium nitrate
DL	Diode Laser
He-Ne	Helium Neon
KTDH	Khartoum Teaching Dental Hospital
SMSB	Sudan Medical Specialization Board
NaF	Sodium Fluoride
GD	Gluma Desensitizer
SP	Seal&Protect
OG	Oxa-gel

F	Fluoride
LILT	Low Intensity Laser Therapy
Er: Cr: YSGG	Erbium, chromium-doped yttrium, scandium, gallium and garnet
SPSS	Statistical Package for Social Sciences

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Teeth are mineralized organs composed of three unique hard tissues, enamel, dentin, and cementum, and supported by the surrounding alveolar bone (Foster, Nociti and Somerman, 2014)

Throughout lifetime, the teeth are continuously exposed to numerous chemical and physical impacts, leading to wear of the dental hard tissues and to alterations in tooth histology and anatomy (Palareti *et al.*, 2016)

As a consequence, the appearance of teeth changes as age increases, and older individuals have greater number of teeth with cracks, stains, defects, wear, and gingival recession Gingival recession is the main causal factor of root caries and dentine hypersensitivity(DH) .(Palareti *et al.*, 2016) Gingival recession and periodontal treatment such as scaling, root planing, and also improper tooth brushing can expose root surfaces and may provoke DH.(Yilmaz, Kurtulmus-Yilmaz and Cengiz, 2011)

Dentine hypersensitivity (DH) is defined as an exaggerated response to sensory stimuli that usually causes no response in a normal, healthy tooth(Wakwak, 2020) however DH is a common painful clinical problem arising from exposed dentine, which cannot be attributed to any other dental pathology. Under normal conditions, dentine is covered by enamel or cementum and is not affected by direct stimulation.(Yilmaz, *et al.*, 2011)

Dentine hypersensitivity (DH) is characterised as a short, sharp pain, usually arising in response to thermal, evaporative, tactile, osmotic, or chemical stimuli, which cannot be ascribed to any other dental pathology (Moraschini, *et al.*, 2018).

Physiological and morphological studies have shown that DH in non-carious cervical lesions is caused by exposed dentinal tubules at the dentin surface. Traditionally, dentin exposure in the cervical region is caused by three distinct factors: abrasion, erosion, and abfraction (Moraschini, da Costa and dos Santos, 2018).

Prevalence studies of dentine hypersensitivity reported in literature have resulted in unpredictable data, ranging from 1.3% to 92.1%. This heterogeneity has been associated to the population screened, recruitment process, study setting, and the different diagnostic criteria used to collect data (Favaro Zeola, Soares and Cunha-Cruz, 2019)

Dentin hypersensitivity (DH) is a frequently chronic finding and a challenging condition to treat in dental clinical practice (Favaro Zeola, Soares and Cunha-Cruz, 2019). . This condition impacts oral health-related quality of life, producing significant impairment on patients' daily life such as speaking, eating, drinking and toothbrushing.(Favaro Zeola, Soares and Cunha-Cruz, 2019)

The most widely accepted pain theory is the hydrodynamic theory, first proposed by Gysi and later proven by Brännström (West, Seong and Davies, 2014). This supports the theory that sensitive dentine is based on the stimulus-induced fluid flow in the dentinal tubules and consequent nociceptor activation in the pulp/dentine border area (West, Seong and Davies, 2014) Therefore, it seems appropriate to suppose that any materials or technique that reduces dentinal fluid movement should decrease DH.(Yilmaz, *et al.*, 2011)

Two other theories that have been proposed to account for the pain of dentine hypersensitivity, the neural theory and the odontoblast transducer theory, are now receiving renewed attention(West, Seong and Davies, 2014)

Based on hydrodynamic theory, several techniques and materials such as dentine adhesives, restorative materials, dentifrices, varnishes, and mouthwashes have been tried to reduce DH (Yilmaz, Kurtulmus-Yilmaz and Cengiz, 2011).

Difficulties in treating cervical DH gave rise to a large number of techniques and therapeutic procedures which are currently used for pain alleviation in DH(Gojkov-Vukelic *et al.*, 2016).Therapy uses various impregnating agents in the form of solutions or gels and, in more recent times, laser (Gojkov-Vukelic *et al.*, 2016).

In recent decades, classic treatments with desensitizing agents have been supplemented by the use of laser. Using lasers to treat DH dates back to the 80s with the advent of erbium lasers. Even though the initial results were quite disappointing, the improvement of technology and scientific knowledge over time has led to the development of new lasers with wavelengths suitable for therapeutic treatment (Gojkov-Vukelic *et al.*, 2016).

1.2. RESEARCH PROBLEM

Dentin hypersensitivity is one of the most common problem in dentistry, the management of dentin hypersensitivity always presented a challenge for clinicians. The most common age of onset is between 30 and 40 but women experience a higher incidence of dentin hypersensitivity at a younger age than men (Wakwak, 2020) it is also apparent that the sensitivity of any exposed dentine can vary considerably from patient to patient or even tooth by tooth within the same patient (STOWE, 1955)

Dentine hypersensitivity represent a major complain for patient with recession resulting from abusive brushing of teeth, it affects approximately half of the population and the pain associated with this condition can limit oral functions such as eating and tooth brushing, which negatively affect individual oral health related quality of life (Alessandro, 2011a).

For that reason, management of pain become a challenge, desensitizing agents offer a temporary relieve from the pain but still remain major problem that affects the life quality of the patients. Treatment by laser may offer better result; relieve the pain immediately after the visit, offer permanent control of the pain and no side effect on hard and soft tissues

1.3. PREVIOUS STUDIES

Diode laser has been used in combination with potassium nitrate or potassium oxalate gel. The authors found that DL and NK10% gel proven to be effective in the treatment of DH. A significantly greater immediate response was observed with DL (Sicilia *et al.*, 2009) these results were agreed with other study that treatment modalities under study (GaAlAs laser, potassium oxalate gel, and placebo gel) provided statistically significant reductions in dentinal hypersensitivity immediately and after 3 months after treatment (Vieira *et al.*, 2009)

Aranha et al. compared different types of products. Teeth were randomly assigned to five groups (n = 20): G1: Gluma Desensitizer (GD); G2: Seal & Protect (SP); G3: Oxa-gel (OG); G4: Fluoride (F); G5: Low intensity laser-LILT (660 nm/3.8 J/cm²/15 mW) Although all these protocols have led to a hypersensitivity reduction, laser therapy has very long term desensitizing effects(Aranha, Freire Pimenta and Marchi, 2009)

In 2012, Romeo et al. compared the effectiveness of GaAlAs diode laser alone and with topical sodium fluoride gel (NaF) and concluded that the GaAlAs laser showed a very high capability to improve immediately the DH-related pain, both alone and even better in combination with NaF gel (Romeo *et al.*, 2012)

Umana et al. conducted an in vitro study, focuses on both the sealing ability and the potential danger of laser at the expanse of dental pulp have used different laser powers (0,8 - 1 - 1,6 - 2 W) on 24 extracted teeth and concluded that 810 and 980nm diode laser irradiation (0.8–1 W, continuous mode, irradiation speed: 1 mm/sec for 10 sec, laser fibre diameter: 200 μm) can lead to dentinal melting and to the narrowing of dentinal tubules.(Umana *et al.*, 2013) Higher energy densities (1.6–2 W) produce an important destruction of the dentinal surface and hence damage the dental pulp (Umana *et al.*, 2013).

In study conducted by Raichur PS et al, they divided the subjects into three groups; Group A, subjects treated with DL; Group B, subjects treated with 0.4% stannous fluoride gel; and Group C, subjects treated with 5% potassium nitrate gel. Each group was evaluated at baseline; at weekly intervals for 2 consecutive weeks; and at 1, 3, and 6 months. All 3 groups showed decreases in the DH scores between baseline and 6 months This was more pronounced in Group A at all time intervals (Raichur, Setty and Thakur, 2013).

Hashim et al. carried out an in vivo study on 14 teeth of five different patients using a diode laser (0,5 W). Moreover, subjects have been divided into two groups based on laser exposure (30 and 60 seconds) and checked 15 minutes and seven days after. Authors demonstrated that the 60 seconds exposure is the most effective (Hashim *et al.*, 2014)

A preliminary in vitro study determined the use of the Nd: YAG laser to be effective in occluding dentin tubules without harming the tooth and suggested its use in future treatments. Middle-output lasers, such as Nd: YAG, CO_2 and Er: YAG, work by occluding dentinal tubules. and lower level output lasers, such as He-Ne and GaAlAs, affect nerve activity (Clark and Levin, 2016).

A study conducted in 184 patients revealed that diode laser 980 nm coupled to the application of graphite paste, provides a statistically significant decrease in the sensation of pain immediately after one treatment and within a 6-month follow up period. The irradiation condition used in vivo for DH treatment can be considered as safe on pulpal tissue (Mobadder *et al.*, 2019).

1.4. OBJECTIVES

1.4.1 GENERAL OBJECTIVE

-To compare the effect of diode laser in treatment of dentine hypersensitivity to desensitizing gel containing 5% potassium nitrate.

1.4.2.SPECIFIC OBJECTIVES

-To assess the immediate and long-term efficacy of diode laser in the treatment of dentinal hypersensitivity

-To assess the effect of diode laser on dentine hypersensitivity at 25 seconds exposure time and I watt power.

-To assess the effects of 5% potassium nitrate gel in the treatment of dentinal hypersensitivity immediately and after 10 days from baseline.

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CHAPTER TWO

BASIC CONCEPTS

2.1 LASER

The acronym LASER means: Light Amplification by Stimulated Emission of Radiation. It developed to laser = device for generation of coherent electromagnetic waves by stimulated emission of radiation (Renk, 2012).

2.1.1 PROPERITIS OF LASER

Laser energy is distinguished from ordinary light by two properties. One is monochromaticity which means the generated light wave is a single specific colour. Secondly, each wave has coherency, identical in physical size and shape along its axis, producing a specific form of electromagnetic energy(Coluzzi and Parker, 2017)

The final laser beam begins in collimated form and can be emitted over a long distance in that fashion. However, beams emanating from optical fibres usually diverge at the tip. By using lenses, all the beams can be precisely focused, and this monochromatic, coherent beam of light energy can accomplish the treatment objective (Coluzzi and Parker, 2017).

Laser light is highly directional. Due to the way laser light is generated, beams of laser light are very small, narrow, and bright. Photons in a laser beam are traveling almost exactly parallel to each other, in the same direction. In comparison, the photons in ordinary light diverge because they are emitted in all directions away from the generating source (Junior and Namour, 2018).

2.1.2 ELEMENTS OF LASER

Identifying the components of a laser instrument is useful in understanding how the energy is produced. For dentistry, there are two basic types of lasers: (1) one that operates as a semiconductor and is compact in size and (2) one that has distinct components that, when assembled, occupy a larger footprint (Coluzzi and Parker, 2017).

The first type is generally known as a diode laser; the second type encompasses all other lasers. Both of these types share common features an active medium, a pumping mechanism, and a resonator. In addition, a cooling system, controls, and a delivery system complete the laser device(Coluzzi and Parker, 2017)

The active medium consists of a set of atoms or molecules that can be excited or, in other words, that can change from their ground state to an excited state. The active medium can be in any of the four states of matter: solid, liquid, gas or plasma(Junior and Namour, 2018).

The pump system is the external source that transfers energy to the active medium of a laser. The pump system is indispensable in the formation of a laser beam.(Junior and Namour, 2018)

There are different pumping systems and can be divided into the following:

Optical pumping (e. g. ruby laser), in which the light source is an arc lamp or a flashlamp made of xenon or another laser that generally has a shorter wavelength (Junior and Namour, 2018).

Electrical pumping, in which electrical current passes through the active material that usually is a gas (e. g. helium-neon laser) or through the P-N junction of a semiconductor (e. g. arsenium-gallium laser) (Junior and Namour, 2018).

Chemical pumping, in which the energy is obtained by the forming and breaking of chemical bonds (e. g. hydrogen fluoride laser) (Junior and Namour, 2018).

The resonator, sometimes known as the optical cavity or optical resonator is the laser component surrounding the active medium. In most lasers, there are two mirrors one at each end of the optical cavity, placed parallel to each other, or in the case of a semiconductor, either a cleaved and polished surface exists at the end of the wafer or there is reflection within the wafer (Coluzzi and Parker, 2017).

In all cases, these mirrored surfaces then produce constructive interference of the waves: that is, the incident wave and the reflected wave can superimpose on each other producing an increase in their combined amplitude (Coluzzi and Parker, 2017).

A cooling system is necessary for all lasers, and higher output power requires increasing dissipation of the heat produced by pumping and stimulated emission. Air circulation around the active medium can control the heat, especially with diode lasers; the sold state crystal lasers and some gaseous lasers require additional circulating water cooling (Coluzzi and Parker, 2017).

Laser energy is produced because the active medium is energized by the pumping mechanism. That energy in the form of photons is absorbed into the active medium, raising its atomic electrons to higher orbital levels. As the electrons return to their stable ground state, photons are emitted while other entering photons can produce stimulated emission.

The resonator allows more numbers of these photonic interactions and will continue the amplification process (Coluzzi and Parker, 2017).

2.1.3 LASER TYPES

Lasers may be classified according to the type of active medium, excitation mechanism, and region of emitted wavelength or mode of operation. According to the active medium, lasers are classified to: solid, gas, liquid and semiconductor lasers. According to the spectral region of the emitted laser, the classification is: UV, visible and I.R. lasers. Based on the mode of operation lasers are classified to : continuous wave (CW), chopped, pulsed and ultra-short pulsed lasers (Silfvast, 2004).

Every laser produces only one predominant wavelength of photons. The laser is usually identified by its active medium and host material. The active medium is a material that can absorb photons of energy and then release them when stimulated further by more photons. Many different materials have been shown to produce this unique «stimulated emission (Coluzzi and Parker, 2017).

Lasers are designated therefore as solid state, gas, semiconductor, and liquid, based on the material used.

Solid-state lasers are most commonly trivalent rare earth ions such as neodymium (Nd) and erbium (Er). The host material suspends the active ions and comprises the majority of the laser crystal. They are most commonly grown crystal structures such as yttrium aluminum garnet abbreviated as YAG. This combination of elements accounts for the naming convention of Er:YAG, Nd:YAG, etc (Coluzzi and Parker, 2017).

Gas lasers consist of a combination of gases. Carbon dioxide lasers are actually a mixture of approximately one-part carbon dioxide combined with four parts nitrogen as the active medium distributed in approximately five parts helium as the host material (Coluzzi and Parker, 2017).

Liquid or, so-called, dye lasers use fluorescein, malachite green, coumarin, or rhodamine as the active medium suspended in water, alcohol, or glycol as a host material. They have the great advantage of being «tunable» from approximately 365 nm to 1000 nm and, because of the inherent cooling provided by the liquid medium, can produce as much as 20 watts of continuous wave output and 1.4 kilowatts of pulsed output. Unfortunately, they are bulky, complex, and expensive and are not currently used in dental applications (Coluzzi and Parker, 2017).

Finally, semiconductor lasers, represented by the diode laser, are the most common laser available in dentistry today. They are small, simple, and relatively inexpensive making them very attractive. Those fabricated from gallium arsenide and its derivatives typically lase at wavelengths between 660 and 900 nm while those utilizing indium phosphide-based compounds produce wavelengths between 1300 and 1550 nm. Recent advances in technology allow laser emission at wavelengths ranging from as little as 370 nm to an amazing 15,000 nm. Only a few of these have practical application in dentistry and are limited to approximately 808 nm to 1064 nm (Coluzzi and Parker, 2017).

2.1.4 Laser- Tissue Interaction

When laser light strikes a tissue surface, it can be reflected, refracted, transmitted, scattered, or absorbed. The fractional intensity that goes into these different processes depends on the optical properties of the tissue, such as its reflectivity, scattering and absorption coefficients, the particle size, as well as on the laser parameters such as the wavelength, the energy per pulse or the power, the pulse duration, and the operation mode (Junior and Namour, 2018).

Absorption is the most important interaction. Each wavelength has specific chromophores that absorb their energy. This absorbed energy is converted into thermal and and/or mechanical energy that is used to develop the desired effects(Junior and Namour, 2018)There are five important types of biological effects that can occur once the laser photons enter the tissue. These effects are fluorescence, photothermal, photodisruptive, photochemical, and photobiomodulation (Junior and Namour, 2018).

The most common effects of laser-matter interaction include; photothermal, photochemical, photomechanical and photoelectric effects. Most of the high-power lasers used in dentistry are infrared, except for Argon and Nd: YAG-KTP lasers that emit visible light. All these lasers develop photothermal effect, however, all the previously mentioned effects occur to a greater or lesser extent. Lasers may allow different types of laser-tissue interaction such as photocoagulation, photothermal ablation, photochemical ablation, photodisruption and photochemical interactions (non-ablative interactions) (Junior and Namour, 2018).

Photobiomodulation or biostimulation refers to lasers' ability to speed healing, increase circulation, reduce edema, and minimize pain. Many studies have exhibited effects such as increased collagen synthesis, fibroblast proliferation, increased osteogenesis, enhanced leukocyte phagocytosis, and the like with various wavelengths. 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 aphthous stomatitis. Low Level Laser Therapy (LLLT) is another term used to describe this phenomenon (Junior and Namour, 2018).

2.2 DENTIN HYPERSENSITIVITY

2.2.1. CHARACTERISTICS OF DENTIN HYPERSENSITIVITY

Dentine hypersensitivity is diagnosed after other possible conditions have been eliminated. Alternative causes of pain include chipped or fractured teeth, cracked cusps, carious lesions, leaky restorations and palate-gingival grooves.(Bedoya and Park, 2014)

The most common aetiology of dentin exposure is gingival recession. When the gingival margin recedes past the cemento–enamel junction it reveals cementum. This thin cementum covering is easily lost, as a result of which dentinal tubules become exposed to the external environment. This exposure is thought to be influenced by aggressive toothbrushing, abrasive toothpastes, poor plaque control, facial piercings, periodontal disease, anatomical predisposition and orthodontic treatment(Clark and Levin, 2016) . Normal toothbrushing will not remove enamel, but it has been cited in the aetiology of gingival recession**.**(Bedoya and Park, 2014)

Aggressive toothbrushing is considered to be the use of excessive force with a hard-bristled toothbrush. A study published in 2013 indicated that most cases of dentinal hypersensitivity studied involved patients who were currently using a hard toothbrush. However, it has also been argued that although aggressive toothbrushing may play a role in the abrasion of soft tissue, other factors, such as anatomical predisposition and toothpaste abrasiveness, should also be evaluated as potential co-contributors to tooth hypersensitivity(Clark and Levin, 2016)

Periodontal disease can be considered as a risk factor or a cause of dentinal hypersensitivity as it involves gingival recession and therefore is associated with dentin exposure (Clark and Levin, 2016). A study performed on an adult and elderly population in Brazil stated that a reduction in the prevalence of tooth sensitivity may be accomplished by periodontal health improvements(Clark and Levin, 2016). A systematic review published in 2013 examined whether periodontal therapy impacted tooth hypersensitivity. It concluded that there was insufficient research to establish whether scaling and root planing procedures had any impact on tooth hypersensitivity and, as a result, more research needs to be performed before making recommendations specific to the correlation of periodontal disease and dentinal hypersensitivity (Clark and Levin, 2016)

Anatomy of the tooth and dentin-pulp complex. Dentin is considered as a vital tissue and has the capacity to respond to physiologic and pathologic stimuli (Ataei and Assarzadeh, 2013).

As it is known, 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 (Ataei and Assarzadeh, 2013).

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 (Ataei and Assarzadeh, 2013). 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 (Ataei and Assarzadeh, 2013).

Mechanisms of sensitivity. Dentin is naturally sensitive owing to its close structural and functional relationship with the dental pulp. This inherent sensitivity usually is not a problem while the dentine is covered by protective tissues enamel and cementum. Microscopic examination reveals that patent dentinal tubules are more numerous and wider in hypersensitive dentin than in non-sensitive dentin (Bedoya and Park, 2014).

The results of scanning electron microscope (SEM) indicate that the number of tubules in sensitive dentin is eight times more than the number of tubules in non-sensitive dentin (Ataei and Assarzadeh, 2013). Furthermore, tubules of sensitive dentin are thicker than those in non-sensitive dentin (Ataei and Assarzadeh, 2013)

The rate of dentinal fluid flow depends on the fourth power of tubule's radius and the difference is an important factor in the establishment of DH in the clinical conditions.(Ataei and Assarzadeh, 2013).

These observations are consistent with the hypothesis that dentinal pain is mediated by a hydrodynamic mechanism. In the hydrodynamic sequence, a pain-provoking stimulus applied to dentin increases the flow of dentinal tubular fluid. This results in a pressure change across the dentin which activates intra-dental nerve fibres via a mechano- receptor response, to cause pain. In addition, the fluid movement in the tubules can cause an electrical discharge, known as "streaming potential," which may contribute by electrically stimulating a nerve response (Alessandro, 2011b).

In turn, this mechanically activates the nerves situated at the inner ends of the tubules or in the outer layers of the pulp. Cooling, drying, evaporation and hypertonic chemical stimuli that stimulate fluid to flow away from the pulp more effectively activate intra-dental nerves than do stimuli such as heating or probing that cause fluid to flow toward the pulp.(Bedoya and Park, 2014) heat causes a relatively slow retreat of dentin fluid, and the resultant pressure changes activate the nerve fibres in a less dramatic fashion, consistent with the fact that heat is generally a less problematic stimulus than cold.(Alessandro, 2011b) The observation that about 75 percent of patients with DH complain of pain on receiving cold stimuli supports this hypothesis.(Bedoya and Park, 2014).

Other theories for dentinal hypersensitivity: I. odontoblastic transduction theory: According to this theory, odontoblastic processes are exposed on the dentine surface and can be excited by a variety of chemical and mechanical stimuli. As result of such stimulation neurotransmitters are released and impulses are transmitted towards the nerve endings. To date no neurotransmitters, have been found to be produced or released by odontoblastic processes.(Tsukada, 1987) this theory has been rejected since the cellular matrix of odontoblasts is not capable of exciting and producing neural impulses. Furthermore, no synopsis has been found between odontoblasts and pulpal nerves(Ataei and Assarzadeh, 2013).

II.Neural theory: As an extension of the odontoblastic theory, this concept advocates that thermal, or mechanical stimuli, directly affect nerve endings within the dentinal tubules through direct communication with pulpal nerve fibers While this theory has been supported by the observation of the presence of unmyelinated nerve fibers in the outer layer of root dentine and the presence of putative neurogenic polypeptides (McGrath, 1986).

However, there is little evidence to prove this theory; firstly, because there is little evidence that can support the existence of nerve in the superficial dentin; where dentin has the most sensitivity; and secondly because the plexus of Rashkov do not become mature until complete tooth eruption. However, the newly developed teeth can be sensitive too (Ataei and Assarzadeh, 2013).

It has been proposed that DH develops in two phases' lesion localization and 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 (Ataei and Assarzadeh, 2013).

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 (Ataei and Assarzadeh, 2013)

In the second phase**;** lesion initiation. The localized DH lesion has to be initiated. This occurs when the smear layer or tubular plugs are removed, which opens the outer ends of the dentinal tubules. Abrasion and erosion maybe implicated here, but acid erosion seems to be the predominant factor(Ataei and Assarzadeh, 2013).

Plaque is not a significant factor in DH; patients with DH tend to have good plaque control DH is more frequently encountered in patients with periodontitis, and transient hypersensitivity may occur after periodontal procedures such as deep scaling, root planing or gingival surgery. Hypersensitivity also may occur after tooth whitening and restorative procedures(Ataei and Assarzadeh, 2013).

2.2.2 CLINICAL MANAGEMENT OF DENTIN HYPERSENSITIVITY

In stark contrast to caries and periodontal disease, the management of which are based upon decades of research and well established, evidence-based prevention and treatment measures, dentin hypersensitivity has been managed on an empirical basis. Furthermore, approaches to dentin hypersensitivity management have focused heavily upon treatment, with little emphasis, to date, on prevention.(Alessandro, 2011)

concept advocates that thermal, or mechanical stimuli, directly affect nerve endings within the dentinal tubules through direct communication with pulpal nerve fibers.

While this theory has been supported by the observation of the presence of unmyelinated nerve fibers in the outer layer of root dentine and the presence of putative neurogenic polypeptides, this theory is still considered theoretical with little solid evidence to support it. contributing factors should be performed. An attempt to reduce or eliminate the contributing factors might be a helpful non-invasive and easy stage of treatment of tooth hypersensitivity. Upon elimination of these risk factors, the prevalence of tooth sensitivity and future sensitivity may be reduced.(Clark and Levin, 2016).

Management strategies have been proposed which include:1) correct diagnosis, compatible with the clinical description of dentin hypersensitivity, based upon history and examination; 2) differential diagnosis, to exclude other conditions which might give rise to similar pain; 3) treatment of all secondary conditions that induce symptoms similar to dentin hypersensitivity; 4) identification of etiologic and predisposing factors, particularly dietary and oral hygiene habits pertinent to erosion and abrasion; 5) removal or minimization of etiologic and predisposing factors through dietary advice and oral hygiene instruction; and 6) recommendation or provision of treatment based upon individual need (Alessandro, 2011).

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. Some other diagnostic tests are as follows: palpitation for diagnosing pulpitis or periodontal involvement, pushing a wood stick or transillumination for diagnosing a fracture or cracked tooth (D. G. Gillam and Orchardson, 2006).

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 (Prorto and Andrade, 2011)

2.2.3 CLASSIFICATION OF DESENSITIZING AGENTS

I. Mode of administration; At home desensitizing agents, In-office treatment

II. On the basis of mechanism of action; Nerve desensitization (Potassium nitrate), Protein precipitation; (Gluteraldehyde, Silver nitrate, Zinc chloride, Strontium chloride hexahydrate), Plugging dentinal tubules; (Sodium fluoride, Stannous fluoride, Strontium chloride, Potassium oxalate, Calcium phosphate, Calcium carbonate, Bio active glasses (SiO_2–P_2O_5–CaO–Na_2O) Dentine adhesive sealers; (Fluoride varnishes, Oxalic acid and resin, Glass ionomer cements, Composites, Dentin bonding agents), Lasers; Neodymium:yttrium aluminum garnet (Nd-YAG) laser, GaAlAs (galium-aluminium-arsenide laser), Erbium-YAG laser. Homeopathic medication;Propolis (Miglani, Aggarwal and Ahuja, 2010).

The principle of interrupting the neural response to pain stimuli has primarily been applied to the development and validation of desensitizing toothpaste. Today, desensitizing toothpastes represent 8–10% of the global toothpaste market. The vast majority of these products contain a potassium salt to “numb” the pain of dentin hypersensitivity. Most potassium-based toothpastes also contain fluoride for cavity protection; some contain other ingredients to provide additional benefits, such as tartar control and whitening(Ataei and Assarzadeh, 2013).

management strategy, i.e., the treatment of dentin hypersensitivity based upon individual needs. A first step is to recommend use of a desensitizing toothpaste, because this typically results in improvement for the majority of individuals. When use of a desensitizing toothpaste is insufficient, home-use prescription fluoride products can offer additional benefits to sensitivity relief toothpaste, and so may be a useful second step; professionally applied products may be suitable for patients with additional treatment needs (Alessandro, 2011b).

The United States Food and Drug Administration (FDA) has reviewed clinical data on the efficacy of 5% potassium nitrate toothpaste and, on the basis of its safety and proven efficacy in reducing dentin hypersensitivity, has classified potassium nitrate toothpaste as a safe and effective tooth desensitizer in the tentative final monograph. Potassium nitrate (5%), potassium chloride (3.75%), and potassium citrate (5.5%) are used interchangeably in desensitizing toothpaste in many countries, as each of these salts provides 2% potassium ion which is the desensitizing active ingredient (Sharma, Shetty and Uppoor, 2012).

Some studies have found that potassium nitrate does not improve the symptoms of dentine hypersensitivity. Other studies demonstrate that patients experiencing sensitivity have a reduction in their symptoms after a 2-week use of potassium nitrate-containing dentifrice (Clark and Levin, 2016).

With the advent of laser technology and its growing utilization in dentistry, an additional therapeutic option is available for the treatment of dentinal pain. The laser, by interacting 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 *et al.*, 2004).

Most of the studies conducted with various types of lasers, at different wavelengths and application times, reveal the effectiveness of this treatment, both immediately and during follow-up after approximately 6 months from the first treatment. As a result, the pain is reduced and in many cases it even disappears. Often the laser therapy is integrated with the use of desensitizing agents based on fluorine or newly discovered substances, and this can lead to an improvement in results(Asnaashari M, 2010; Bamise and Esan, 2011).

The laser photobiomodulating action in the dental pulp was reported by Villa et al. with histological studies of dental pulp of mice after irradiation with laser, in teeth previously eroded with high rotation in order to expose the dentine. The profiling of the odontoblasts was observed, showing evidence of a large quantity of tertiary dentine production, causing the physiological obliteration of the dentinal tubules. The non-irradiated control teeth showed intense inflammatory process that, in some cases, evolved to necrosis (Ladalardo *et al.*, 2004).

Referring to the course of action, it was shown how the low-power lasers, including the GaAlAs diode laser with a wavelength between 780 and 900 nm, acts on the nervous level, thus eliminating the sensitivity. The medium-power lasers, including Nd:YAG, CO2 and Er:YAG laser, desensitize causing narrowing and occlusion of dentinal tubules (Biagi, 2015).

In the last years, the diode laser (DL) has been the most used by dental hygienists during daily work. The literature contains a good amount of studies about this type of laser, particularly its effectiveness against dentinal hypersensitivity (Biagi, 2015).

The effectiveness of dentine hypersensitivity treatment with diode laser, with different wavelengths, has been reported in various clinical studies. Matsumoto et al. found 85% improvement indexes in teeth treated with laser; Aun et al. reported successful treatment in laser irradiated teeth in 98% of the cases; Yamaguchi et al. reported effective improvement index of 60% in the group treated with laser and only 22.2% in the control group (Ladalardo *et al.*, 2004).

Kumazaki et al. showed an improvement of 69.2% in the group treated with laser compared to 20% in the placebo group; Gerschman et al. , in a double-blind study, found significant values in the treated group in relation to the placebo group: sensitivity to thermal stimuli was reduced by 67%, whereas the placebo group had a reduction of 17%, sensitivity to tactile stimuli was reduced by 65%, while the placebo group showed a reduction of 21% (Ladalardo *et al.*, 2004).

The immediate analgesic effect in the treatment of dentine hypersensitivity with diode laser was reported by Brugnera Júnior et al. with an improvement index of 91.29% in 1102 treated teeth, operating in different bands of wavelength, 780 nm and 830 nm, and different power densities of 40 mW and 50 mW, but maintaining the same energy density deposited per dental element of 4 J/cm^2 (Ladalardo *et al.*, 2004).

According to the consulted literature, both red and infrared wavelength lasers have been effective in the treatment of dentine hypersensitivity. They are physical methods which, even operating at different bands of wavelength, cause the dentine-pulp complex to respond to the irradiation with the obliteration of the dentinal tubules by the means of specific biological mechanism (Ladalardo *et al.*, 2004)

CHAPTER THREE

SUBJECTS AND METHODS

3.1. STUDY DESIGN

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

3.2. STUDY AREA

The study was conducted at Amna Specialized Dental Clinics

3.3. STUDY DURATION

From October 2021 to March 2022

3.4. METHODOLOGY (ELIGIBILITY CRITERIA OF PARTICIPANTS)

3.4.1. inclusion criteria

I. Patient with dentine hypersensitivity and willing to participate.

II. Adult patient.

III. Patient with good oral hygiene.

3.4.2. Exclusion criteria

I. Patients with teeth showing evidence of irreversible pulpitis or necrosis, carious lesions in selected or neighboring teeth, defective restoration, cracked enamel.

II. Patient with orthodontic appliance.

III. Patient with history of bleaching.

IV. Patient with hypersensitivity treatment within the previous 3 months.

V. Patient using daily doses of medications, under sedatives, tranquilizers, analgesic, anticonvulsants, and anti-inflammatory medication within 72 hours

VI. Patient with any psychological diseases.

VII. Patient with senso-neurological disease (trigeminal neuralgia, sensory processing disorder)

VIII. Pregnant lady.

3.4.3 SAMPLE SIZE

Eighteen sensitive teeth with visual analogue scale (vas) score being ≥2

3.4.4 SAMPLING TECHNIQUE

Convenience sampling technique to choose the Patients.

Simple random sampling technique to create two groups

3.5. DATA COLLECTION METHODS

In this split mouth study, 18 sensitive teeth with visual analogue scale (VAS) score being ≥2 were selected. The sample were divided into two groups of 9 teeth for each group. Group A was treated with 810-nm diode laser, Diode lasers provide an abundance of available wavelengths in the visible and infrared spectrum. Near infrared (NIR) lasers are characterized by a high absorption in chromophore found in soft tissue.810 and 980nm wavelengths, the most commonly used wavelengths in dentistry, especially in endodontics and periodontics.(Umana *et al.*, 2013)

Group B, treated with desensitising gel containing 5% potassium nitrate (Sensodyne ® gel). One trained operator applied all stimuli, with the patient seated in the same dental chair, with the same equipment

Sensitivity assessment

The degree of sensitivity was determined for each tooth in response to air blast stimuli. The air blast was performed with an air syringe for 1 sec at a distance of 1 cm from the tooth surface. The teeth were dried and isolated with cotton rolls before the assessment

Dentinal hypersensitivity was assessed by patient's indication of the amount of pain related to each tooth immediately after each stimulus, according to a visual analogue scale (VAS) This scale utilises a straight line, conventionally 10 cm long, whose extreme limits are marked by perpendicular lines. The ends of the scale carry a verbal description of each extreme of the symptom to be evaluated, and the patient is asked to mark the line at a position between the two extremes which represents the level of pain. (Downie et al., 1978). The patient was instructed to mark a point on this scale according to the degree of perceived discomfort.

Treatment strategies

After measuring DH, the jaw quadrant was assigned to one of the two treatment groups of 9 teeth for each group. Group A (the diode laser exposure group) and group B (the 5% potassium nitrate gel application group).

All the teeth in the selected quadrant were treated in the same manner, but follow-up assessments were performed on the tooth with the highest sensitivity at baseline. The treatments applied in the study groups were as follows:

Group A: The patients in this group underwent low-level laser therapy, The applied laser device was Diode Laser (Oralia Company – Germany)emitting an infrared light at wavelength of 810 nm , The cone tip (beam converging) was used as close as possible with the tooth surface without contact(I mm from the dentine surface) and in continuous wave modes which was employed because it is easier for the operator to scan the whole dentin surface in this way(Umana *et al.*, 2013) , perpendicular to the tooth surface with a sweeping motion for 25 seconds with an average power output of 1Watt received by each tooth.

Group B: group B received topical desensitising gel containing 5% KNO_3 (Sensodyne ® gel) treatment. Following tooth drying and isolation with cotton rolls, the desensitizing gel (Sensodyne ® gel) was applied by ultra-fine micro brush (for three minutes) and washed by water jet

Sensodyne gel used in the present study containing a desensitizing agent [5% potassium nitrate], an anticaries agent [0.315% sodium fluoride], currently marketed in Sudan.

Potassium nitrate is the active ingredient in Sensodyne toothpaste, Potassium containing toothpastes (Sensodyne Freshmint, Colgate Sensitive Maximum Strength, etc.) are able to reduce Visual Analogue Scale (VAS) measurements of pain in clinical studies by raising the pain threshold of pulpal nerves to stimuli(Wang *et al.*, 2010)

The treatments were rendered at one visit and by the same operator. The patients were 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 2 examination periods: 1) immediately after the application of the diode laser and the desensitising gel 2) after 10 days.

Furthermore, the patients were requested to avoid the use of analgesics as much as possible

3.6.MATERIALS NEEDED FOR DATA COLLECTION:

I. Face mask and a pair of examination gloves were used for each participant and discarded after use for infection control,

II. Sterile WHO examination set (mouth mirror, a probe – explorer, and tweezers) was used.

III. Dispensaries: sterile cotton

IV. low-level GaAlAs diode laser device (Oralia Company – Germany)

V. (Sensodyne ® gel) containing a desensitizing agent [5% potassium nitrate], an anticaries agent [0.315% sodium fluoride],

VI. Ultra-fine micro brush for the application of desensitising gel

VII. Protective eye wear

3.7. STATISTICAL ANALYSIS:

Descriptive statistics, including mean and standard deviation, were calculated for each group using statistical package for the social sciences (SPSS) version 28 program.
tests were chosen because the data were distributed normally. The relation between the treatment type and the reduction of DH, measured using VAS, was analysed using the Student's t-test when normality of variables and homogeneity of variances could not be ruled out. The intra-group response to a specific treatment (before/after) was evaluated using paired Student's t-test

The significance level adopted was <5% ($p < 0.05$) for all tests.

3.8. ETHICAL CONSIDERATIONS

Ethical clearance was taken before the start of the study from the Ethics Committee. the objective of the study was explained to the patients, 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 FOUR

RESULTS AND DISCUSSION

4.1. RESULTS

This split mouth study was conducted to assess the immediate and long-term efficacy of diode laser in the treatment of dentinal hypersensitivity and to compare the efficacy of diode laser and potassium nitrate gels in the treatment of dentinal hypersensitivity.

No complications such as detrimental pulpal effects or allergic reactions were observed.

The mean and standard deviation of VAS index for DH obtained from air-blast stimuli for the two groups are presented in (Table 4.1 and Table 4. 2)

Paired Samples t. test was used to compare the effect of each treatment among both group at different times. the intergroup comparisons revealed that the differences immediately and 10 days after treatment were statistically significant in both active treatment groups compared to the baseline score.

There was a significant decrease in the VAS scores immediately and after 10 days at group A (GaAlAs laser) (Table 4.3) and group B (*5%* potassium nitrate gel) (Table 4.4)

In group A, there was 40%, 0%, 20%, 65%, 55.6%, 60%, 60%, 57.1%, 40% reductions in VAS immediately in the upper left canine, upper left first molar, upper left second molar, lower right second molar, lower right second premolar, lower right first premolar, lower right central incisor, lower left canine, lower left second premolar respectively (Table 4. 5)

Table 4.5 also revealed a 40%, 16.7%, 60%, 62.5%, 66.7% , 80% , 80%, 71.4%, 50% reductions in VAS after 10 days in the upper left canine, upper left first molar, upper left second molar, lower right second molar, lower right second premolar, lower right first premolar, lower right central incisor, lower left canine, lower left second premolar respectively

In group B there was a 3.3%, 40%, 0%, 25%, 20%, 0%, 20%, 25%, 0% reduction of VAS immediately in upper right first molar, upper left lateral incisor, upper left second premolar, lower right first molar, lower right canine, lower right lateral incisor, lower left lateral incisor, lower left first premolar, lower left first molar respectively (Table 4.6)

The reductions in VAS after 10 days from baseline among group B were 66.7%, 40%, 16.7%, 50%, 20%, -25%, 40%. 37.5%, 50% in upper right first molar, upper left lateral incisor, upper left second premolar, lower right first molar, lower right canine, lower right lateral incisor, lower left lateral incisor, lower left first premolar, lower left first molar respectively (Table 4.6)

However, immediately. after the laser was applied, we observed an overall reduction in the response to air blast of 44.9% (mean 3.00, SD1.732) in group A, three times greater than that observed in the group B, which was 17.5% (mean 1.11, SD 0.928), after 10 days the reduction in VAS in the laser group was 58.3% (mean 3.89, SD1.616) which was more than the reduction in VAS observed in 5% potassium nitrate gel group which was 36.8%(mean 2.33, SD 1.871) (Table 4.7 and 4.8)

Table 4.1: The mean and standard deviation of VAS index for DH obtained from air-blast stimuli for group A

Statistics					
	VAS at baseline	VAS immediately after	Reduction immediately from baseline	VAS after 10 days	Reduction after 10 days from baseline
Mean	6.67	3.67	3.00	2.78	3.89
Std. Deviation	1.936	1.500	1.732	1.481	1.616
Minimum	5	2	0	1	1
Maximum	10	6	5	5	6

Table 4.2: The mean and standard deviation of VAS index for DH obtained from air-blast stimuli for group B

	VAS at baseline	VAS immediately after	Reduction immediately from baseline	VAS after 10 days	Reduction after 10 days from baseline
Mean	6.33	5.22	1.11	4.00	2.33

Std. Deviation	1.936	2.108	.928	1.118	1.871
Minimum	4	3	0	2	-1
Maximum	10	10	2	5	5

Table 4.3: A significant decrease in the VAS scores immediately and after 10 days at group A (GaAlAs laser)

Paired Samples Test										
		Paired Differences					t	df	Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	VAS at baseline - VAS immediately after	3.000	1.732	.577	1.669	4.331	5.196	8	<.001	<.001*
Pair 2	VAS at baseline - VAS after 10 days	3.889	1.616	.539	2.647	5.131	7.220	8	<.001	<.001*

*P value significant

Table 4.4: A significant decrease in the VAS scores immediately and after 10 days at group B (*5%* potassium nitrate gel)

Paired Samples Test										
		Paired Differences					t	df	Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				One-Sided p	Two-Sided p
					Lower	Upper				
Pair 1	VAS at baseline VAS immediately after	1.111	.928	.309	.398	1.824	3.592	8	.004	.007*
Pair 2	VAS at baseline VAS after 10 days	2.333	1.871	.624	.895	3.771	3.742	8	.003	.006*

*P value significant

Table 4.5: Percentage of reductions in VAS immediately and after 10 days in group A

Tooth	baseline	immediately	Reduction immediately from baseline	after 10 days	Reduction after 10 days from baseline
Upper left canine	5	3	2(40%)	3	2(40%)
Upper left first molar	6	6	0(0%)	5	1(16.7%)
Upper left second molar	5	4	1(20%)	2	3(60%)
Lower right second molar	8	3	5(65%)	3	5(62.5%)
Lower right second premolar	9	4	5(55.6%)	3	6(66.7%)
Lower right first premolar	5	2	3(60%)	1	4(80%)
Lower right central incisor	5	2	3(60%)	1	4(80%)
Lower left canine	7	3	4(57.1%)	2	5(71.4%)
Lower left second premolar	10	6	4(40%)	5	5(50%)

Table 4.6: Percentage of reductions in VAS immediately and after 10 days from baseline in group B

Tooth number	baseline	immediately	Reduction immediately from baseline	after 10 days	Reduction after 10 days from baseline
Upper right first molar	6	4	2(3.3%)	2	4(66.7%)

Upper left lateral incisor	5	3	2(40%)	3	2(40%)
Upper left second premolar	6	6	0(0%)	5	1(16.7%)
lower right first molar	8	6	2(25%)	4	4(50%)
Lower right canine	5	4	1(20%)	4	1(20%)
Lower right lateral incisor	4	4	0(0%)	5	-1(-25%)
Lower left lateral incisor	5	4	1(20%)	3	2(40%)
Lower left first premolar	8	6	2(25%)	5	3(37.5%)
Lower left first molar	10	10	0(0%)	5	5(50%)

Table 4.7: overall percentage of reduction in VAS immediately from baseline and after 10 days from baseline in group A

	VAS at baseline	VAS immediately after	Reduction immediately from baseline	VAS after 10 days	Reduction after 10 days from baseline
Mean	6.67	3.67	3 (44.9%)	2.78	3.89(58.3%)

Table 4.8: overall percentage of reduction in VAS immediately from baseline and after 10 days from baseline in group B

	VAS at baseline	VAS immediately after	Reduction immediately from baseline	VAS after 10 days	Reduction after 10 days from baseline
Mean	6.33	5.22	1.11(17.5%)	4.00	2.33(36.8%)

4.2. DISCUSSION

Traditional DH treatment is based on the application of desensitizing substances, which reduce or eliminate pain and are capable of stimulating the formation of dentine, which obliterates the dentinal tubules exposed to the oral environment(Sicilia *et al.*, 2009)

A dentifrice-containing potassium nitrate, in combination with fluoride, a copolymer, and anti-calculus[tartar] ingredients, has also been successfully formulated to reduce DH(Gillam and Orchardson, 2006)

Most dentifrice products on the market now contain potassium salts (nitrate, chloride, or citrate) with fluoride and an anti-plaque ingredient such as triclosan, although there has been concern raised over possible interactions of some of these ingredients with the desensitizing activity(Gillam and Orchardson, 2006)

According to literature conventional treatment with potassium salts has demonstrated a significant reduction of DH in weeks, However, because the elicitation of pain in DH patients is acute, the availability of a treatment that reduces or eliminates DH within a period of 24–48 h, or even earlier, would be ideal(Sicilia *et al.*, 2009)

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(Tocarruncho *et al.*, 2018)

On the other hand It is postulated that the diode laser mediated an analgesic effect related to depressed nerve transmission(Kimura *et al.*, 2000) Meanwhile, the sensitive area, that is, irradiation by diode laser, changes the nerve fibre membrane permeability to potassium and sodium, increases peripheral nerve action potentials, and stimulates the formation of neural axon endorphins, which cause an analgesic effect(Hu *et al.*, 2019) Moreover, laser effects on endorphin release could be the reason for the immediate pain relief in patients(Tocarruncho *et al.*, 2018)

In addition , diode laser can also produce secondary reaction ,which stimulates the dentin cells and induces them to produce secondary dentin(Hu *et al.*, 2019).

In the present study when the values obtained by each of the therapies were individually observed, it was evident that there was a statistically significant difference in the reductions of response to air blast among different periods of times for each group. However, the diode GaAlAs laser had a better desensitizing effect on DH than 5% potassium nitrate gel in immediate and long term. In addition, the present study concluded that the 25 seconds application of diode laser is statistically effective in reducing the DH with output power of 1 watt.

The faster desensitizing effect of laser therapy observed in the conducted research may be attributed to depressed nerve transmission. According to physiological experiments using the GaAlAs laser at 830 nm, this effect is caused by blocking the depolarization of C-fiber afferents(Asnaashari M, 2010)

Moreover, besides the immediate analgesic effect, the laser therapy if used within the correct parameters may stimulate the normal physiological cellular functions. Therefore, at subsequent appointments, the pulpal tissue would be less injured and inflamed and the laser would stimulate the production of sclerotic dentin, thus promoting the internal obliteration of dentinal tubules(Asnaashari M, 2010)

The results of the present study were concurrent with the results of the similar study conducted by Sicilia et al who evaluated the immediate efficacy of diode laser (810 nm) and potassium nitrate bioadhesive gel (10%) in the reduction of DH. A significant immediate response was observed in the laser group.(Sicilia *et al.*, 2009)

The present study was also in agree with Raichur et al who examined the efficacy of diode laser versus stannous fluoride and potassium nitrate gels in the treatment of DH. They found that there was a statistically significant decrease in all groups but the greatest difference in the DH scores was reported in the laser group which showed immediate relief as compared to the other methods(Raichur, Setty and Thakur, 2013)

The results attained in the present study are in consistent with Tocarruncho *et al.*whose study aim to compare the effectiveness of two dental desensitization therapies, 940nm laser diode and potassium nitrate, in patients with dental hypersensitivity (DH) symptoms and concluded that : Laser and nitrate therapies were effective to manage DH after basic periodontal therapy.

However, a statistically significant higher sensitivity reduction was observed in laser therapy group(Tocarruncho *et al.*, 2018)

In addition, a significant effect of combined desensitiser toothpaste and diode laser therapy occurs in the treatment of desensitization of teeth with gingival recession. Desensitizer toothpaste appears to have therapeutic potential to alleviate DH. Conversely, diode laser can be used to reduce DH.(Dilsiz, Aydn and Emrem, 2010).

However, the present study is disagrees with Pandey *et al*.(Pandey *et al.*, 2017) who concluded that KNO_3 did not give any beneficial results but the results of the present study are in accordance to studies results of Hodosh 1974, Green *et al*. 1977, Tarbet *et al*. 1982, Blong *et al*. 1985, Reinhert *et al*. 1990, Echeverria *et al*. 1991, etc., which demonstrated that KNO_3 is effective in reducing DH(Pandey *et al.*, 2017)

4.3. Summary and Conclusion

-From the present study, the following conclusions can be drawn:

The 810 nm with 25 seconds exposure time diode laser brought about a statistically significant reduction of dentinal hypersensitivity immediately, and at 10 days from baseline

-5% potassium nitrate gel was effective in reducing DH immediately and after 10 days from baseline

-Both treatment modalities provide a significant reduction on DH with better results obtained by diode lasers

4.4. Limitation of the study

the present study was only a short- term study, with a small study sample size which limits the generalizability of the study's conclusions.

4.5. Recommendations of the study

-Further studies are needed to evaluate the long-term stability of the obtained positive results Since DH has been touted as a recurrent phenomenon

-Further studies are necessary to evaluate the morphological changes of the dental hard tissues under SEM after GaAlAs diode laser irradiation for DH treatment.

-It would be recommendable to perform an additional therapeutic option a combination of laser irradiation with the application of specific products for the treatment of DH, with the intention of achieving an accumulation of effects from both treatments.

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