DIODE LASER AND Er,Cr:YSGG LASER IN THE TREATMENT OF ORAL LEUKOPLAKIA –A COMPARATIVE STUDY

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In partial fulfillment for the Degree of

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ORAL MEDICINE AND RADIOLOGY

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CERTIFICATE

This is to certify that this dissertation titled **"DIODE LASER AND Er,Cr:YSGG LASER IN THE TREATMENT OF ORAL LEUKOPLAKIA – A COMPARATIVE STUDY"** is a bonafide record of work done by **Dr. Sonali Sarkar** under my guidance during her postgraduate study period **2010-2013.**

This dissertation is submitted to **THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY,** in partial fulfillment for the degree of **MASTER OF DENTAL SURGERY, BRANCH IX – Oral Medicine & Radiology.**

It has not been submitted (partial or full) for the award of any other degree or diploma.

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LIST OF ABBREVIATION

S.NO	ABBREVIATION	EXPANSION
1.	**AIDS**	Acquired Immunodeficiency Syndrome
2.	**CO_2**	Carbon dioxide
3.	**Cr**	Chromium
4.	**Er**	Erbium
5.	**Hz**	Hertz
6.	**J**	Joule
7.	**LASER**	Light amplification by stimulated emission of radiation
8.	**MZ**	Zirconium tip
9.	**nm**	Nanometer
10.	**OP**	Out- patient
11.	**USA**	United Sates of America
12.	**W**	Watts
13.	**YAG**	Yttrium- Aluminum- Garnet
14.	**YSGG**	Yttrium- Scandium- Gallium- Garnet

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ABSTRACT

Background: Soft tissue lasers and certain hard tissue laser have been used in the treatment of oral mucosal lesions. This study was an attempt to compare soft tissue laser and hard tissue laser in treating oral leukoplakia.

Aim & Objective: To compare the effectiveness of Diode Laser and Er,Cr:YSGG Laser in treating oral leukoplakia by assessing intraoperative pain and bleeding and postoperative pain on the following seven postoperative days as well as wound healing on the 7^{th}, 14^{th} and 21^{st} post-operative days.

Methodology: The study population included five patients, above the age of 18 years, provisionally diagnosed and histopathologically confirmed as having oral leukoplakia. In each patient part of the lesion was treated with Diode laser and the rest with Er,Cr:YSGG laser. Each patient was assessed individually during both laser procedures for intraoperative pain and bleeding during procedure, for postoperative pain on the following seven post-operative days and for wound healing on the 7^{th}, 14th and 21^{st} day after treatment. Pain was assessed using three different pain rating scales and wound healing using visual method.

Results: Using Diode laser caused minimal to no pain, excellent hemostasis and good wound healing with no postoperative complications and Er,Cr:YSGG laser caused minimal discomfort to patient, profuse bleeding during procedure and good healing outcome in treatment of oral leukoplakia.

Conclusion: While comparing both the lasers, in this present study it has been concluded that Diode laser (940nm) is superior to that of Er,Cr:YSGG laser (2780nm) in treating oral leukoplakia.

Key words: Diode laser, Er,Cr:YSGG laser, Oral leukoplakia.

Oral leukoplakia is a predominantly white lesion of the oral mucosa that cannot be characterized as any other definable lesion.[1] There is a dose – response relationship between tobacco usage and prevalence of oral leukoplakia.[2] It is the most common potentially malignant lesion. Oral leukoplakia have been treated by surgical excision, cryotherapy, retinoids and other drugs.[2] Laser therapy is a recent treatment modality which could be considered in the treatment of oral leukoplakia.[3]

Laser is an acronym for **Light Amplification by Stimulated Emission of Radiation** which completely describes the whole physics by process of the generation of light.[4] Dental lasers function by producing waves of photons (quanta of light) that are specific to each laser wavelength.[5] This photonic absorption within the target tissue results in an intracellular and/or intercellular change to produce the desired result.[6] Laser devices emit energy via chromatic radiation in either the visible, infrared or ultraviolet region of the spectrum. They produce in-phase waves and transmit heat and power when focused at close range.[7] The most important characteristic is the wavelength of laser used, as the wavelength determines how the laser light will interact with the target tissue (absorption in the appropriate tissue chromophores, penetration depth into the tissue etc.) Other characteristics which also need to be considered include maximum power available to the user as the available power determines the number of procedures which can be done and the speed

with which they can be done, the way the laser beam can be modulated such as continuous wave or pulsed mode and the mode of delivery of the laser beam.[8]

Dental lasers may be separated into two basic groups as soft lasers and hard lasers.[6] They can be used both for diagnosis as well as therapeutic purpose. The superiority of lasers to other modalities is that they provide a blood free surgical field by sealing the blood vessels thereby offering excellent visibility and reduced operative time and minimize post operative swelling by sealing the lymphatic vessels.[9] Lasers offer the ability to negotiate curves and fold in oral cavity and can vaporize, cut and coagulate tissue. With the use of lasers, the bacterial count is reduced, chances of mechanical trauma are minimal, scarring is negligible and pain is almost nil probably due to sealing of the nerve fibres.[9]

Among the various soft tissue lasers that appeared in the mid 1990s, **semiconductor Diode lasers** also made their debut. With several advantages including their small size, price range and versatility regarding the possible treatment applications, the Diode lasers represent a valuable addition to the dentist's repertoire. Diode lasers can be used for a multitude of dental treatments which are predominantly soft tissue procedures and include soft tissue surgery, periodontal pocket therapy, management of peri-implantitis, etc. Diode laser can also be used for certain applications involving hard tissue (eg) root canal disinfection and laser-assisted tooth whitening.[8] The available wavelength for dental use range from 800 nm to 980 nm. Each machine

delivers laser energy fibro optically in continuous wave and gated pulsed modes and is used in contact with soft tissue for surgery or out of contact for deeper coagulation. The Diode laser is an excellent soft tissue surgical laser and is indicated for cutting and coagulating oral mucosa.[10]

In 1997, **Erbium laser** which is a hard tissue laser was approved by FDI, for marketing in the United States. The Erbium laser has various uses, which can be divided into hard and soft tissue procedures for dentistry. Erbium lasers, by their sheer nature of being well absorbed by hydroxyapatite, were originally considered as primary hard tissue lasers. It must be remembered that the primary chromophore of the Erbium family of lasers is water in the target tissue, and the largest component of soft tissue is water. Laser physics and absorption curves of various tissues have shown that the Erbium family of lasers ablate soft tissue by the same mechanism as hard tissue. The laser energy from the infrared beam is converted into local thermal energy, and this energy creates a massive expansion in the target chromophore of water. The resulting microexplosions result in thin layers of tissue ablation. The erbium laser soft tissue removal process results in a ‘‘shaving’’ or ‘‘planing’’ of the tissue that clinically appears different than the deeper penetrating ablation process seen with dedicated soft tissue lasers.[11]

The Erbium family of dental lasers consist of two wavelengths with similar but not identical properties. The Erbium: Yttrium-Aluminium-Garnet (Er:YAG) laser produce a wavelength of 2940 nm and the Erbium, Chromium:

Yttrium-Scandium-Gallium-Garnet (Er,Cr:YSGG) laser produces a wavelength of 2780 nm.[12] **Er,Cr:YSGG laser** is a solid state laser that emits at 2780 nm in the mid-infrared region, in the strongest absorption peak of water. This leads to a superior evaporative efficiency and minimal thermal injury to adjacent tissue compared with any other laser ideal for the removal of superficial skin layers with maximum sparing of adjacent structures, a short healing process and minimal adverse effects.[13]

Very few studies are done in evaluating the effectiveness of Diode laser and Er,Cr:YSGG laser in oral mucosal lesions. Hence, a study was proposed to compare the effectiveness of Diode laser and Er,Cr:YSGG laser in the treatment of oral leukoplakia.

AIM OF THE STUDY:

To compare the effectiveness of Diode Laser and Er,Cr:YSGG Laser in treating oral leukoplakia.

OBJECTIVES OF THE STUDY:

1. To compare the effectiveness of Diode Laser and Er,Cr:YSGG Laser in treating oral leukoplakia.
2. To assess bleeding during the Diode and Er,Cr:YSGG laser treatment.
3. To assess pain using Behavioral Observation Pain Scale during the laser treatment.
4. To assess pain using Visual Analogue Scale and "Faces" Pain Rating Scale immediately after the procedure and 7 days post- operatively.
5. To observe the outcome of healing on the 7^{th}, 14^{th} and 21^{st} post-operative days after the treatment.

The present study is to Compare the effectiveness of Diode Laser and Er,Cr:YSGG Laser in the treatment of oral leukoplakia. To obtain a meaningful study and result, a proper and detailed review of the literature is of utmost importance. The present literature review is about the various aspects of Lasers, Diode laser, Er,Cr:YSGG laser and comparison between diode and Er,Cr:YSGG laser in Oral leukoplakia.

Diode Lasers: [9,14,15]

Diode lasers have a solid active medium, manufactured from semiconductor crystals using some combination of Aluminum, Gallium and Arsenide to change electric energy into light energy. The available wavelengths for dental use range from about 800 to 980nm placing them at the beginning of the near-infrared invisible nonionizing part of the spectrum. Each machine delivers laser energy fiber optically in continous mode and gated-pulse modes, used ordinarily in contact with the tissue. The optic fiber needs to be cleaved and prepared before initial use and occasionally during long procedures to ensure the efficient operation of the laser.[14]

All of the diode wavelengths are very well absorbed by pigmented tissue, although hemostasis is not quite as rapid as with the Argon laser. These lasers are relatively poorly absorbed by tooth structure so that soft tissue surgery can be performed safely in close proximity to enamel, dentin and cementum. The diode is an excellent soft tissue surgical laser indicated for

cutting and coagulating gingiva and mucosa and for soft tissue curettage or sulcular debridement.[15]

Care must be taken when using the continuous emission mode because of the rapid thermal increase in the target tissue. The chief advantage of the diode lasers is use of a smaller size instrument. The units are portable and compact and are easily moved with minimum setup time.[9]

Basic design of Diode Laser:

One of the advantages of diode lasers in comparison to other laser systems, which is immediately apparent to the naked eye, is their size. The development of micro-structure diode cells which are capable of emitting laser light has drastically reduced the bulk of laser systems. The latest dental diode lasers have been designed to have dimensions similar to a standard phone. Only solid material active media (e.g. GaAlAs –Gallium Aluminium Arsenide) is used in diode lasers. Because of the crystalline nature of the active medium, the ends of the crystal can be selectively polished relative to internal refractive indices to produce totally and partially reflective surfaces thus serving the same function as the optical resonators of larger laser systems. The discharge of current across the active medium releases photons from the active medium, finally resulting in the generation of laser light of a specific wavelength, which is determined by the active medium used. At the present, each diode "chip" produces relatively low-energy output. Some low power

diode lasers, operating in milliwatt range, are usually being used for low level laser therapy (LLLT). In order to achieve the power necessary for various dental procedures (e.g. soft tissue surgery), today's dental diode lasers employ banks of individual diode chips in parallel to achieve the appropriate power levels (several watts).[8]

Laser light emission modes:

Lasers are said to be running in either continuous wave (CW) or pulsed mode. This relates to the rate of emission of laser light with time and the prime benefit of a pulsed mode will be the capacity of the target tissue to cool between successive pulses. The CW mode is generally the fastest way to ablate tissues but heat can build up and cause collateral damage to the target and adjacent tissues. Modern dental diode lasers can operate in both CW and pulsed mode. The factors that determine the average power when the diode laser is operating in pulsed mode are the current power setting and the duty cycle setting. Duty cycle is a periodic phenomenon defined as the ratio of the duration of the phenomenon (pulse width) in a given period to the period (reciprocal value of the current frequency setting - number of pulses per second).[8]

It is important to familiarize oneself with the various average and peak powers that can be achieved when using different emission mode settings of

the laser system in order to achieve an optimal transfer of the energy from the laser beam to the target tissue, resulting in a desired therapeutic effect.[8]

Laser light Delivery to the Target Tissue:

Most dental diode lasers employ a flexible optic fibre (usually inserted into an appropriate handpiece for comfortable handling) to deliver the treatment beam to the desired area. Using a smaller diameter fibre will increase the power density at the fibre tip. As a result, the power setting must be decreased. Increasing the power may be required when using a larger diameter fibre. As a rule of thumb, in order to achieve the same rate of work after changing fibre diameters, a smaller diameter fibre will require less power and conversely, a larger diameter will require more power. Another thing to keep in mind is the speed of movement of the fibre tip during treatment. Tissue charring is an undesirable side effect of too much power and/or the tip moving too slowly. Least amount of power is necessary to complete the procedure and move the fibre tip using short 1-2 mm "paint brush" type strokes and move quickly when working on soft tissue. The condition of the optical fibre must be checked regularly. The tip should be cleaved regularly after it becomes blackened (2-4 mm from the tip), because tissue debris accumulate on the tip during surgery and this causes the fibre tip to retain extreme heat and begins to act as a "branding iron". This can lead to unwanted tissue heating and can lead to rapid tip deterioration and subsequent breakage. It is also important to properly cleave the fibre so that no shard is present on

the fibre tip, as it may act as a miniature scalpel and damage the small blood vessels, thus interfering with hemostasis and coagulation.[8]

Applications:

The removal of fibroma, labial and lingual frenectomies, small hemangiomata, mucocele, denture granulomata, treatment of nonerosive lichen planus, aphthae, herpes lesions, premalignant lesions like leukoplakia.[8]

Erbium family Lasers (Er,Cr:YSGG and Er:YAG):

There are two distinct wavelengths with similar properties that use Erbium. Firstly, Er,Cr:YSGG (2790nm) has an active medium of a solid crystal of Yttrium-Scandium-Gallium-Garnet that is doped with Erbium and Chromium and Er:YAG (2940nm) has an active medium of a solid crystal of Yttrium-Aluminum-Garnet that is doped with Erbium. Both of these wavelengths are near the boundary of the near-infrared and mid-infrared, invisible, and nonionizing portion of the spectrum. Both of these lasers are delivered fiber optically in the free-running pulsed mode. At the end of the fiber, a hand piece and small-diameter glass tips concentrate the laser energy down to a convenient surgical size, approximately 0.5nm. These two wavelengths have the highest absorption in water of any dental wavelength and have a high affinity for hydroxyapatite.[9,14,15]

Er,Cr:YSGG laser emits energy at a wavelength of 2780 nm and delivers photons into air-water spray matrix producing microexplosive forces on water droplets. It is a hydrokinetic system laser with a frequency of 20 Hz, pulse energy between 0 and 300 mJ, a focal distance of approximately 1.5 mm from the tissue and has FDA approval for several soft tissue procedures. The water droplets of the water spray are energized by laser energy 1.5 mm from the end of the tip; thus, the most focused distance while working with this laser is 1.5 mm from the tissue so that less thermal damage occurs. It is a very precise ablation instrument that offers certain advantages. It is strongly absorbed by water and causes minimal damage to the adjacent tissues, especially the underlying muscle layers. Due to minimal trauma to the adjacent tissues, postoperative healing was favorable, with very little scar formation. Post operative bleeding is minimal.[9,14,15]

Review of Laser:

Townes et al (1958)[16] examined the Maser principles, which were eventually used for the conversion of light energy using light from visible and infrared portions of electromagnetic spectrum. This examination introduced the principles of light amplification by the stimulated emission radiation or laser.

Theodore Maimen (1960)[10] successfully stimulated ruby crystals to produce red light with a wavelength of 0.69 nm, thus first laser was developed.

Within a year the ophthalmologist used this device for photocoagulation. **Snitzer (1961)[10]** developed the second laser which was Neodymium laser**.**

Ralph H Stern et al (1964)[10] started research on dental laser at the University of California at Los Angeles, School of Dentistry and reported the development of cratering and glasslike fusion of enamel and the penetration and charring of dentin following a single millisecond pulse of ruby laser at 500 to 2000 J/cm^2.

Townes, Basov and Prokhrov (1964)[17] were awarded the Nobel Prize for the development of laser. **Bridges (1964)[18]** and **Geusic (1964)[18]** developed continuous wave Argon laser and Nd:YAG laser respectively. This continuous wave 488 nm (blue-green) gas laser was easy to control and its high absorption by haemoglobin made it well suited to retinal surgery; clinical systems for treatment of retinal diseases were soon available.

Taylor et al (1965)[18] were first to report the histologic effects of the ruby laser on the dental pulp. They observed extensive hemorrhagic necrosis and disruption of odontoblastic layer in the incisors of laboratory animals, which have been exposed to a 3-millisecond pulse of a ruby laser ranging 35 to 55J. Damage to adjacent teeth and surrounding structures were also reported as a result of scattering of laser beam.

Dr Leon Goldman (1965)[15] a dermatologist was first to report the use of laser on a vital human tooth. While experimenting with tattoo removal

using ruby laser he focused two pulses of red light on a tooth of his dentist brother which resulted in painless crazing of the enamel. Thus, the first laser dentist was a physician and the first laser patient was a dentist.

Polanyi (1965)[16] was first to perform a surgical procedure by carbon dioxide laser. **Yahr and Scully (1966)**[16] identified and documented specific cutting and hemostatic properties of continuously operating carbon dioxide laser beam.

Adrian (1971)[9] confirmed extensive pulpal injury and destruction with ruby laser even at greatly reduced power levels.

Stern (1974)[9] observed that under specific parameters of exposure to the ruby laser there occurred an increased resistance to the acid penetration into enamel, suggesting a possible role for the laser in caries prevention.

Yamamoto et al (1974)[9] from Tohoku University School of Dentistry was first to report the dental application of Neodymium laser to vital oral tissue in experimental animals. In a series of experiments, they determined that Nd:YAG laser was an effective tool for inhibiting the formation of an incipient caries both in vitro and in vivo.

Shafir (1977)[16] a plastic and reconstructive surgeon became first one to apply laser in oral maxillofacial surgery by excising buccal hemangioma in an 8 year old boy.

In the early 1980s, smaller but more powerful lasers became available. Most of these systems were CO_2 lasers used for cutting and vaporizing tissue and argon lasers for ophthalmic use. These 'second generation' lasers were all continuous wave systems which tend to cause non-selective heat injury, and proper use required a long 'learning curve' and experienced laser surgeons.

Dr Terry Myers and Dr. William (1980's)[9] an ophthalmologist conducted experiments to remove incipient caries. Soon after this the development of true dental laser begun. D-lase 300 was the first true dental laser system designed specifically for dental application.

Melcer et al (1984)[9] actively involved in the clinical application of the carbon dioxide laser for the vaporization of caries, reported the successful treatment of over 1,000 patients in clinical trials of caries removal.

Frame and Fisher (1984)[19] of England presented several papers on treatment of benign and premalignant oral lesions using carbon dioxide laser.

Frame, Pecaro and Pick (1985)[15] were first to use carbon dioxide laser to oral soft tissue lesions and periodontal procedures. **Melcer et al (1987)**[15] further concluded that carbon dioxide laser could induce secondary dentin formation and sterilization of dentin and exposed pulp.

The **Food and Drug Administration (1987)**[17,20] gave the marketing approval for laser use in oral surgery to Pfizer Laser Company for 10W

portable carbon dioxide laser system. In 1989, after the market clearances were approved by the Medical Device Division of Food and Drug Administration in United States, groups of laser dentists joined together to form local study clubs, societies and diverse organizations for the purpose of gathering and sharing information related to their use. Another major advancement was the introduction of scanning devices in the early 1990s, enabling precision computerized control of laser beams. Scanned, pulsed lasers revolutionized the practice of plastic and cosmetic surgery by making safe, consistent laser re-surfacing possible, as well as increasing public awareness of laser medicine and surgery**.**

Laser used in the treatment of Oral leukoplakia:

Fausto Chiesa et al (1986)[21] treated 92 leukoplakias by CO_2 laser surgery the results concluded that minimal damage, immediate hemostasis and good wound healing was seen.

Felix WK Chu et al (1988)[22] used CO_2 laser to treat 29 leukoplakia patients and follow up was done for 3-10 years. The results supported CO_2 laser over conventional modes of treatment in relation to precision of tissue removal, minimal damage to adjacent tissue, immediate hemostatic effect, excellent wound healing and effective destruction of abnormal mucosal tissue minimizing recurrences.

Roodenberg JLN et al (1991)[23] treated a total of 70 patients with 103 leukoplakias with CO_2 laser evaporation. They concluded that there was an excellent wound healing with virtually no scarring. The patients were followed up during a period of upto 12 years (mean 5.3 years) showing a cure rate of 90%.

Gooris et al (1999)[24] conducted a retrospective study to evaluate the treatment results of CO_2 laser evaporation for 27 cases of leukoplakia of the lip. It was concluded that selective removal of affected epithelium with minimal damage to surrounding structures is possible using CO_2 laser evaporation, followed by excellent wound healing and good functional result. Treatment can be performed under local anaesthesia on an outpatient basis and the recurrence rate is low compared with the recurrence rate after surgical excision.

PS van der Hem et al (2005)[25] treated 200 patients of oral leukoplakia by CO_2 laser evaporation from 1976-2004. In a follow up period of 1–219 months, 89% treated leukoplakia did not show a recurrence. Thus the study with a long follow up showed that laser is a good prophylactic treatment for oral leukoplakia.

Vasavi Krishnamurthy et al (2009),[26] **Tousif Farid Sayed et al (2009)**[53] in the treatment of oral leukoplakia which have shown excellent

wound healing, immediate hemostatic effect and minimal tissue damage with minimal recurrence rate.

Review of Diode laser in Soft tissue lesions:

George Romanos et al (1999)[27] in their study examined the wound healing of soft tissue after the application of a diode laser (980 nm) in oral surgical procedures in 22 patients which comprised of removal of soft tissue tumors, frenectomies, excision of gingival hyperplasias, vestibuloplasties, hemangioma removal, and peri implant soft tissue surgery. The laser was used in both pulsed and continuous modes, with and without contact to the tissue. It was concluded that diode laser resulted in sufficient hemostasis and precise incision margin with all of the surgical procedures. The coagulation properties, were beneficial in vascular lesions. The postoperative advantages, i.e., lack of swelling, bleeding, pain or scar tissue formation and good wound healing were observed in all the applications and depended on the laser physical parameters.

Goharkhay et al (1999)[28] used diode laser with 810 nm wavelength on soft tissue lesions which resulted in excellent coagulation ability.

Mona Soliman et al (2005)[29] treated 25 patients suffering from persistent oral lichen planus with diode laser (980 nm) at the affected areas of oral mucous membrane with defocused mode until blanching of the treated area. No serious complications were recorded, apart from slight edema and pain. Complete healing occurred after the second week. Diode laser provides a

marked clinical improvement without the need for neither local nor systemic treatment.

Deppe, H. and H.H. Horch (2007)[3] reviewed the use of diode laser systems for the treatment of oral and maxillofacial diseases as an application in removal of premalignant lesions of the oral mucosa concluded its use did not cause discomfort to the patient, minimal bleeding and excellent wound healing.

Jawahar R et al (2009)[30] used diode laser to treat trismus in oral submucous fibrosis patients. They concluded that Diode laser is a less expensive and alternative method in group III and group IVA cases in whom bilateral temporalis myotomy and coronoidectomy are considered to be the only solution. Also this technique had less morbidity and was suitable for Asian population as it required less hospital stay and less follow up as compared to other surgical methods.

Apollonia Desiate et al (2009)[31] evaluated the safety and efficacy of a 980nm diode laser for the treatment of benign facial pigmented and vascular lesions in 20 patients which resulted in healing within 10 days. The melanoses healed completely within four weeks. All the vascular lesions healed after 15 days without any residual scarring thus concluding that patient undergoing treatment with diode laser have good acceptance without compromising the health of the patient.

Akmam H. AI-Mahdi (2010)[32] evaluated the efficiency of diode Laser 810 ± 20nm in treatment of oral lesions in 6 patients (2 females and 4 males) different oral lesions were treated in the hospital of specialized surgeries by the use of diode laser 810 nm, the lesions were: Apthous, Lichen planus, Pyogenic granuloma, Second stage of implant. The results showed that there was no pain, no bleeding, and no infection while the edema and necrosis at the operation site were present. They concluded that Diode laser can be used to perform haemostatic surgery, decrease rate of infection and reduce post operative discomfort.

Pedron IG et al (2010)[17] used diode laser in excision of mucocele which resulted in no post operative problems.

Prajwalit Kende et al (2011)[33] in their case report concluded diode laser as a promising aid in performing excisional biopsies of oral premalignant lesions in patients who need to be treated with a technique where reduction of the operative and postoperative blood loss, postoperative discomfort is important with minimal problems in the histopathological evaluation.

Nilesh Ravel et al (2011)[34] conducted a clinical study on post operative recovery, depth control and wound healing of diode laser on white lesions using the visual analogue scale for pain. Out of 10 patients, (20%) complained of moderate pain during first three days following laser irradiation, while rest of the patient complained mild pain (80%). The pain

disappeared in the end of third week post operatively. Complete wound healing and depth control was seen using Diode laser.

Review of Er,Cr:YSGG laser in Oral soft tissue lesions:

Rizolu et al (1996)[35] conducted a study on 12 mucocutaneous soft tissues using Er,Cr:YSGG laser which resulted in minimal edge coagulation artifact, minimal hemorrhage, good re-epithelisation.

Lee SC (1998)[36] in their study concluded that hemostatic ability is limited with the use of Er,Cr:YSGG laser because only the water on the surface of the blood in the surgical site is vaporized. There is neither deep penetration nor sustained heat to provide rapid vessel shrinkage.

Boj et al (2007)[20] used Er,Cr:YSGG laser on squamous cell papilloma concluded that there was no pain medication required after surgery,wound healing was excellent and rapidly achieved with no recurrence.

Kirti chawla et al (2011)[37] treated a 22 year old patient, diagnosed with lip mucocele with Er,Cr:YSGG laser which showed healing, which was uneventful, no analgesic required, no suture requires and no relapse was observed upto one year after surgery.

Chaudhary et al (2012)[38] in their study concluded that Er,Cr:YSGG Laser can be used effectively in the treatment of Oral Submucous fibrosis

which resulted in better mouth opening and no scar formation, with minimal discomfort to the patient.

Comparative studies using Diode laser and Er,Cr:YSGG laser:

Stabholz A et al (2003)[39] in their study compared Diode and Er,Cr:YSGG laser and found that homeostasis is better achieved by the use of diode laser when compared to Er:Cr,YSGG Laser because diode lasers are very well absorbed in melanin and hemoglobin. There wavelengths (810-980 nm) will pass through water and penetrate much deeper into the soft tissue unlike the Erbium laser were they are not well absorbed by these chromophores. They concluded that the Erbium family lasers is not ideal wavelength for soft tissue surgeries in which ideal homeostasis is desired.

Carcadillo- Ibarquren et al (2010)[40] conducted an vitro study on porcine oral mucosa with CO_2, Diode and Er,Cr:YSGG Laser to determine the thermal effect. The concluded that charring of tissue was minimal with Er,Cr:YSGG laser when compared to CO_2 laser, whereas charring was more with Diode laser when compared to Er,Cr:YSGG laser. It was concluded that to minimize thermal effect on tissues, power density, continuous or pulse mode, the duration of pulse and pause interval must be adequate.

Jin et al (2010)[41] conducted a comparative study to assess healing of buccal mucosa in 24 guines pig with stainless steel scalpel, Diode laser and Er,Cr:YSGG laser. It was found that Diode laser showed increased TGF beta 1

which determined at Diode laser has better effect on wound healing when compared to Er,Cr:YSGG laser.

Comparative studies using laser in treatment of leukoplakia:

White et al (1998)[42] compared CO_2 with Nd:YAG laser in the management of oral mucosal lesion in an out- patient clinic treated over 80 years period. The study included 64 patients with a variety of benign oral soft tissue lesions which were treated by laser excision.34 patients were treated by Nd:YAG contact laser and 29 patients by continous free- beam CO_2 non contact laser. The largest group of lesion treated was leukoplakia which comprised 39 cases. The study concluded that both CO_2 and Nd:YAG lasers are successful laser surgical options used for treatment of benign mucosal lesions and showed minimal post operative pain, conservative site specific invasive procedure and good wound healing.

Lim et al (2010)[43] conducted a retrospective study in 35 patients diagnosed as leukoplakia to compare CO_2 laser and Potassium – Titanyl phosphate to determine recurrence rate. The recurrence rate of lesion between 2 groups were compared and they concluded that KTP laser resulted in lower recurrence rate than CO_2 laser in treatment of leukoplakia.

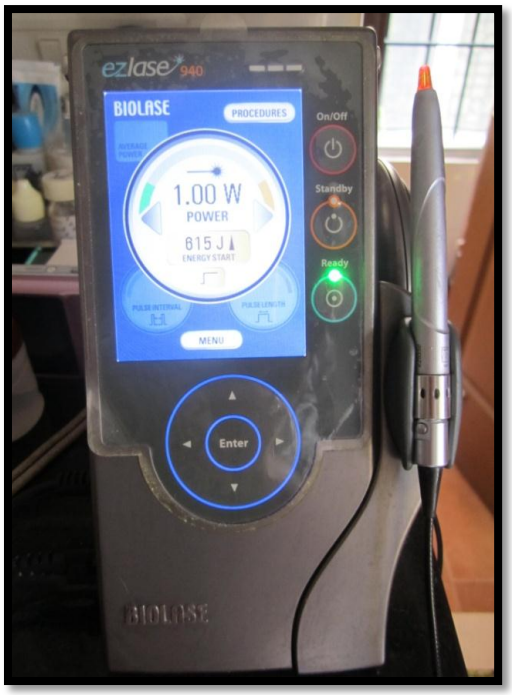


Fig.4: Diode laser equipment

Fig.5: Er,Cr:YSGG laser equipment

Fig.6: Patient visiting OP

Fig.7: White lesion present in the right buccal mucosa provisionally diagnosed as oral leukoplakia

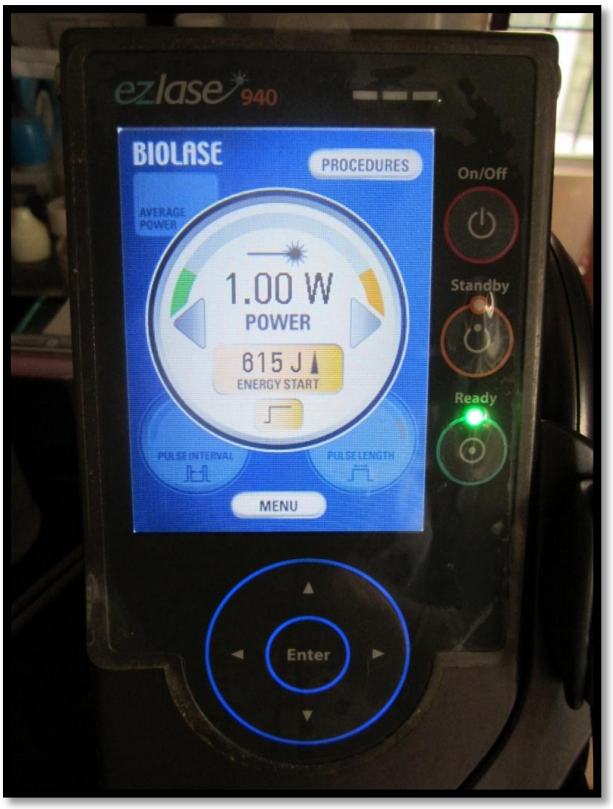


Fig.8: Diode laser setting for Diode laser procedure

Fig.9: Er,Cr:YSGG laser setting for Er,Cr:YSGG laser procedure

Fig.10: Initialization of Diode laser tip with carbon

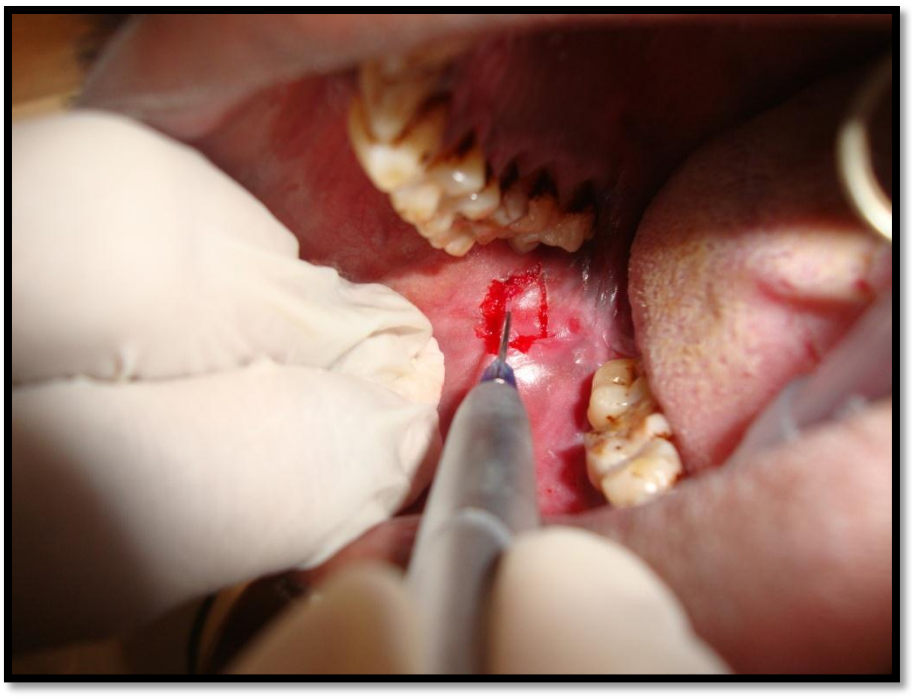


Fig.11: Laser incision done for biopsy using Diode laser

Fig.12: Site immediately after laser biopsy in posterior buccal mucosa

Fig.13: Laser biopsy specimen sent for histopathological evaluation

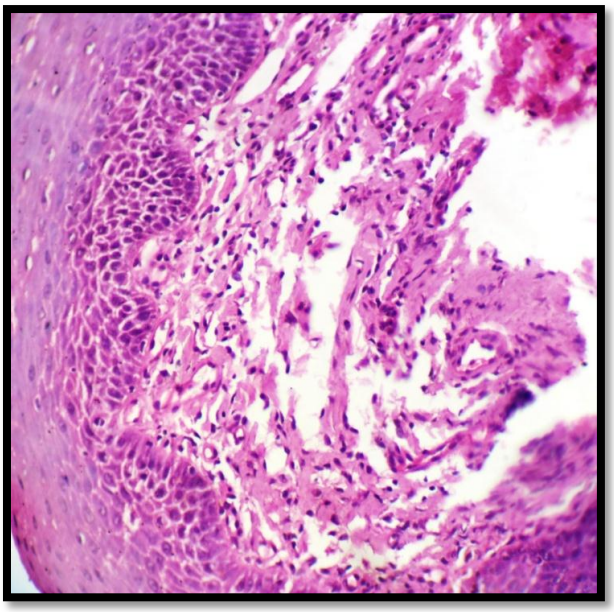


Fig.14: Histoplathologically confirmed oral leukoplakia with mild dysplasia- 40x resolution

Fig.15: One day wound healing after laser biopsy

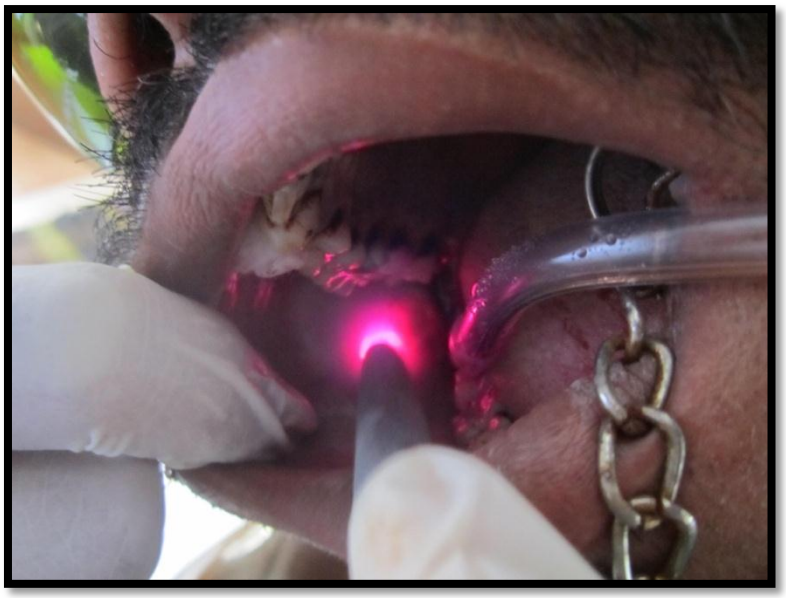


Fig.16: Laser procedure done

Fig.17: Diode laser used in anterior half and Er,Cr:YSGG laser procedure done in the posterior half of buccal mucosa showing no bleeding in anterior half and bleeding in posterior half- Immediately after laser procedure

Fig.18: One day after Diode laser and Er,Cr:YSGG laser procedure

Fig.19: 7th post- operative day wound healing

Fig.20: 14th post-operative day wound healing

Fig.21: 21st post-operative day wound healing

The present study is a comparative study which was conducted in the Department of Oral Medicine and Radiology of Ragas Dental College and Hospital, Uthandi, Chennai and Smile Dental Clinic, T.Nagar, Chennai. It was devised to assess the effectiveness of Diode laser and Er,Cr:YSGG laser in the treatment of Oral leukoplakia, and to assess pain during the procedure and 7 consecutive days after the procedure using three different pain rating scale. The data's obtained from the study were statistically analysed. Digital photographs were taken and visually analysed for bleeding during the procedure and wound healing on 7^{th}, 14^{th} and 21^{st} day. The results extracted were compared with various variables included in the study and are presented here.

Data Analysis obtained from Behavioral Observational Pain Rating Scale:

The **Behavioral Observation Pain Rating Scale** was used to determine pain in patient during Diode laser and Er,Cr:YSGG laser procedures separately in the treatment of oral leukoplakia. The categories used in the assessment of pain included face, leg, activity, cry and consolability.

- **In "Face" category:**

  '0'was scored for no particular facial expression or smile or disinterested. '1' was scored for occasional grimace or frown, withdrawn. '2' was scored for frequent to constant frown, clenched jaw, quivering chin.

- **In "Leg" category:**

  '0' was scored for relaxed position. '1' was scored if the patient's legs were uneasy, restless or tensed and '2' was scored if the patient kicked or drew his legs up.

- **In "Activity" category:**

  '0' was scored if the patient was lying quietly in normal position and moves easily. '1' was scored if the patient was squirming, shifting back and forth or tensed. '2' was scored if the patient was arched, rigid or jerking.

- **In 'Cry' category:**

  '0' was scored for no crying. '1' was scored if the patient moaned, whimpered or occasionally complained and '2' was if the patient cried steadily, screamed, sobbed or frequently complained.

- **In "Consolability" category:**

  '0' was scored if the patient was contented and relaxed. '1'was scored if the patient could be consoled when reassured by occasional touching, hugging or talking to and was distractable.'2' was scored when the patient was difficult to console or comfort.

Table 1: Comparison of 'facial expression' in Behavioral Observation Pain Rating Scale between Diode and Er,Cr:YSGG laser:

During the treatment of Oral leukoplakia with Diode laser it was observed that out of 5(100%) patients, 3(60%) patients had no facial expression or smile, whereas 1(20%) patient occasionally frowned and withdrew and constant frown, clenched jaw and quivering chin was observed in 1(20%) patient. During Er,Cr:YSGG laser procedure on oral leukoplakia it was noted that, out of 5(100%) patients, 4(80%) patients occasionally frowned and withdrew and 1(20%) patient had frequent to constant frown, clenched jaw and quivering chin .

On comparing the facial expression of patients during Diode and Er,Cr:YSGG laser procedure the results were **insignificant** with a **p- value of 0.082.**

Table 2: Comparison of 'leg movement' in Behavioral Observation Pain Rating Scale between Diode and Er,Cr:YSGG laser:

It was observed that during Diode laser Procedure, out of 5(100%) patients, 3(60%) patients had their legs relaxed, whereas 1(20%) patient had uneasy, restless and tensed legs and 1(20%) patient was kicking during the Diode procedure and legs were drawn up. During Er,Cr:YSGG laser procedure, it was noticed that 4(80%) patients out of 5(100%) patients had

uneasy, restless and tensed leg and 1(20%) patient legs were drawn up as well as kicking during the procedure.

On comparing the leg movements of patients during the Diode and Er,Cr:YSGG laser procedure it was noted that **no significant** difference was found with a **p- value of 0.082.**

Table 3: Comparison of 'activity' of patients during Diode and Er,Cr:YSGG laser procedures in Behavioral Observation Pain Rating Scale:

Out of 5(100%) patients, it was observed that during Diode laser procedure 4(80%) of patients were lying quietly in normal position and moved easily, whereas 1(20%) patient was arched, rigid and jerking. During Er,Cr:YSGG laser procedure it was observed that out of 5(100%) patients, 1(20%) patient was lying quietly, 3(60%) patients were tensed, whereas 1(20%) patient was arched, rigid and jerking.

On comparing the activity of patients during Diode and Er,Cr:YSGG laser procedure, **no significance** with a **p- value of 0.082.**

Table 4: Comparison of 'cry' of patient in Behavioral Observation Pain Rating Scale in between Diode and Er,Cr:YSGG laser:

During the treatment of Oral leukoplakia with Diode laser it was observed that out of 5(100%) patients 4(80%) patients did not cry, whereas 1(20%) patient was crying steadily, screamed and frequently complained.

During Er,Cr:YSGG laser procedure on oral leukoplakia it was noted that, out of 5(100%) patients, 2(40%) patients did not cry, 2(40%) patients moaned or whimpered and occasionally complained and 1(20%) patient was crying steadily, screamed and frequently complained during the procedure.

On comparing the cry of patients during Diode and Er,Cr:YSGG laser procedure the results were **insignificant** with a **p- value of 0.082.**

Table 5: Comparison of 'consolability' in Behavioral Observation Pain Rating Scale in between Diode and Er,Cr:YSGG laser:

During the treatment of Oral leukoplakia with Diode laser it was observed that out of 5(100%) patients, 4(80%) patients were content and relaxed, whereas 1(20%) patient was very difficult to console or comfort. During Er,Cr:YSGG laser procedure on oral leukoplakia it was noted that, out of 5(100%) patients, 2(40%) patients were content and relaxed, 2(40%) patients had to be reassured occasionally by touching or talking and were distractable and 1(20%) patient was difficult to console or comfort.

On comparing consolability during Diode and Er,Cr:YSGG laser procedure the results were **insignificant** with a **p- value of 0.082.**

Table 6: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Behavioral Observation Pain Rating Scale:

On comparing results obtained from Behavioral Pain Rating Scale from Diode laser and Er,Cr:YSGG laser, it was observed that for the five patients the mean value obtained was 2.40 for Diode laser and 5.00 for Er,Cr:YSGG laser with a standard deviation of 4.336 for Diode laser and 3.082 for Er,Cr:YSGG laser. Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Behavioral Observation Pain Rating Scale yielded **insignificant** result with a **p – value of 0.061.**

Data analysis of "Faces" pain rating scale:

The **"Faces" Pain Rating Scale** is a diagrammatic representation of the pain experienced by the patient. The patients were assessed immediately after the surgery for pain. The patients were called for all the seven post operative days right from the next day after treatment to the 7^{th} day. The emotion icons expressed were then correlated to a scale which is divided into six scores ranging from 0-5.

- '0' representing no hurt.
- '1' representing hurts little bit.
- '2' representing hurts little more.
- '3' representing hurts even more.

- ‘4’ representing hurts whole lot.
- ‘5’ representing hurts worst.

The scores were entered into the case sheet proforma for each case for both the Diode and Er,Cr:YSGG on the day of treatment and 7 post-operative days following the day of treatment.

Table 7: Comparison of pain immediately after the procedure between Diode laser and Er,Cr:YSGG laser using ‘Faces’ Pain Rating Scale:

Immediately after the Diode laser procedure out of 5(100%) patients it was observed that in 3(60%) patients experienced no hurt, in 1(20%) patient, had hurt little bit whereas 1(20%) patient, the procedure hurted worse which was denoted by emotion icon and then correlated with scale. And immediately after Er,Cr:YSGG laser procedure it was observed 1(20%) patient had hurt little bit, 3(60%) patients hurt little more, and 1(20%) experienced worst hurt which was denoted by emotion icon and then correlated with scale. On comparing the pain observed immediately between the Diode and Er,Cr:YSGG laser procedure using ‘Faces’ Pain Rating Scale **insignificant** result was yielded with a **p- value of 0.235.**

Table 8: Comparison of pain on the 1st post-operative day following the day of the treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale:

On **"1st post-operative day",** after the Diode laser procedure out of 5(100%) patients it was observed that 3(60%) patients experienced no hurt, 1(20%) patient experienced hurt little bit denoted by emotion icon whereas in 1(20%) patient the procedure hurted whole lot. And after Er,Cr:YSGG laser procedure on the 1st post-operative day it was observed that in 4(80%) patients had experienced little bit hurt and 1(20%) experienced hurt whole lot denoted by emotion icon. On comparing the pain observed on the 1st post-operative day between Diode and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale yielded **insignificant** result with a **p- value of 0.082.**

Table 9: Comparison of pain on the 2nd post-operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale:

On **"2nd post-operative day",** after the Diode laser procedure out of 5(100%) patients it was observed that 4(80%) patients experienced no hurt, whereas 1(20%) patient denoted the emotion icon "hurts even more". And after Er,Cr:YSGG laser procedure on the 2nd post-operative day it was observed that in 4(80%) patients had experienced no hurt and 1(20%) experienced hurt even more which was denoted by emotion icon correlated

with a scale. On comparing the pain observed on the 2nd post-operative day between Diode and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale yielded **significant** result with a **p- value of 0.025.**

Table 10: Comparison of pain on the 3rd post-operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale:

On **"3rd post-operative day",** after the Diode laser procedure out of 5(100%) patients it was observed that 4(80%) patients experienced no hurt, whereas 1(20%) patient denoted the emotion icon "hurt little more". And on the 3rd post-operative day after Er,Cr:YSGG laser it was observed that 4(80%) patients had experienced no hurt and 1(20%) experienced hurt little more which was denoted by emotion icon. On comparing the pain observed on 3rd post operative day between Diode and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale yielded **significant** result with a **p- value of 0.025.**

Table 11: Comparison of pain on the 4th post- operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale:

On **"4th post-operative day",** after the Diode laser procedure out of 5(100%) patients it was observed that 4(80%) patients experienced no hurt, whereas 1(20%) patient experienced hurt little bit. And after Er,Cr:YSGG laser procedure on the 4th post operative day it was observed that 4(80%)

patients had experienced no hurt and 1(20%) experienced hurt little bit which was denoted by emotion icon. On comparing the pain observed on 4th post-operative day between Diode and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale yielded **significant** result with a **p- value of 0.025.**

Table 12: Comparison of pain on the 5th, 6th and 7th post-operative days following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale:

On **"5th, 6th and 7th post-operative days",** all 5(100%) patients experienced no hurt, in the areas treated with Diode and Er,Cr:YSGG laser. On comparing the pain observed on 5th, 6th and 7th day after Diode and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale yielded result with a **p- value which is constant,** which is **not significant.**

Table 13: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of 'Faces' Pain Rating Scale:

On comparing results obtained from 'Faces' Pain Rating Scale from Diode laser and Er,Cr:YSGG laser immediately after laser procedure and 7 days post-operatively, it was observed that for five patients the mean value obtained was 3.40 for diode laser and 5.20 for Er,Cr:YSGG, laser with a standard deviation of 6.542 for Diode laser and 5.495 for Er,Cr:YSGG laser. Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of 'Faces' Pain Rating Scale yielded **significant** result with a **p – value of 0.001.**

Table 14: 'Faces' Pain Rating Scale in Diode and Er,Cr:YSGG laser immediately after the procedure and 7 post-operative days:

Data analysis was done for Diode laser and Er,Cr:YSGG laser separately ranging from the day of procedure immediately after the laser procedure and 7 post-operative days to assess pain experienced in 'Faces' Pain Rating Scale, with Diode laser procedure, the mean rank was 5.80 immediately after treatment, 5.60 on the 1st post-operative day, 4.60 on the 2nd post- operative day, 4.40 on the 3rd post-operative day, 4.20 on the 4th post-operative day, 3.80 on the 5th, 6th and 7th post-operative day.

With the Er,Cr;YSGG laser procedure the mean rank was 7.90 immediately after treatment, 7.10 on the 1st post-operative day, 4.00 on the 2nd post-operative day, 3.80 on the 3rd post-operative day, 3.60 on the 4th post-operative day and 3.20 on 5th, 6th and 7th post-operative day with Er,Cr:YSGG laser procedure.

Analysis yielded **insignificant** results in 'Faces' Pain Rating Scale with a **p-value of 0.093** with Diode laser and yielded **highly significant** result in 'Faces Pain Rating Scale **with p- value of 0.000** with Er,Cr:YSGG laser.

Data analysis of Visual analogue scale:

The **Visual Analogue Scale** was used to assess pain which was experienced by the patient immediately after the procedure and for the 7 post operative days following the day of treatment by visually scoring pain with a scale ranging from 0 to 10. The patient was asked to score the experience of pain with "0" denoting no pain, "5" denoting distressing pain "10" denoting unbearable pain and if the patient experienced pain between these ranges denoted by respected numbers from 1- 4, 6 - 9. And the scores were entered into the case sheet proforma.

Table 15: Comparison of pain immediately after the procedure between Diode laser and Er,Cr:YSGG laser using Visual Analogue Scale:

Immediately after the Diode laser procedure, 2(40%) patients scored '0' on visual analogue scale, 2(40%) patients scored '1' on the scale and 1(20%) patient scored '10' on the scale. After the Er,Cr:YSGG laser procedure 3(60%) patients scored '3' on visual analogue scale,1(20%) patients scored '1' on the scale and 1(20%) patient scored '10' on the scale with Er,Cr:YSGG laser.

On comparing the pain observed immediately after the Diode and Er,Cr:YSGG laser procedure using Visual Analogue Scale yielded **insignificant** result with a **p- value of 0.155.**

Table 16: Comparison of pain on the 1st post-operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale:

On **1st post-operative day**, 3(60%) patients scored '0' on visual analogue scale, 1(20%) patient scored '1' on the scale and 1(20%) patient scored '8' on the scale with the use of Diode laser. After Er, Cr:YSGG laser, 3(60%) patient scored '2' on visual analogue scale, 1(20%) patient scored '3' on the scale and 1(20%) patient scored '8' on the scale.

On comparing the pain on 1st post-operative day after Diode and Er,Cr:YSGG laser procedure using Visual Analogue Scale yielded **significant** result with a **p- value of 0.040.**

Table 17: Comparison of pain on the 2nd post-operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale:

On **2nd post-operative day**, 4(80%) patients scored '0' on visual analogue scale, 1(20%) patient scored '5' on the scale with the use of Diode laser. It was observed that 4(80%) patients scored '1' on visual analogue scale, 1(20%) patient scored '6' on the scale with Er,Cr:YSGG laser.

On comparing the pain on 2nd post operative day after Diode and Er,Cr:YSGG laser procedure using Visual Analogue Scale yielded **significant** result with a **p- value of 0.025.**

Table 18: Comparison of pain on the 3rd post-operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale:

On **3rd post-operative day**, 4(80%) patients scored '0' on visual analogue scale, 1(20%) patient scored '4' on the scale with the use of Diode laser. It was noted that 4(80%) patients scored '0' on visual analogue scale, 1(20%) patient scored '4' on the scale with Er,Cr:YSGG laser.

On comparing the pain on 3rd post-operative day after Diode and Er,Cr:YSGG laser procedure using Visual Analogue Scale yielded **significant** result with a **p- value of 0.025.**

Table 19: Comparison of pain on the 4th post-operative day following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale:

On **4th post-operative day**, 4(80%) patients scored '0' on visual analogue scale, 1(20%) patient scored '3' on the scale with the use of Diode laser. It was noted that 4(80%) patients scored '0' on visual analogue scale, 1(20%) patient scored '3' on the scale with Er,Cr:YSGG laser.

On comparing the pain on 4th post-operative day after Diode and Er,Cr:YSGG laser procedure using Visual Analogue Scale yielded **significant** result with a **p- value of 0.025**

Table 20: Comparison of pain on the 5th, 6th and 7th post-operative days following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale:

On **5th, 6th day & 7 post-operative days"**, 5 (100%) patients scored '0' on the visual analogue scale with both Diode and Er,Cr:YSGG laser. On comparing the pain observed on 5th, 6th and 7th post-operative days after Diode and Er,Cr:YSGG laser procedure using Visual Analogue Scale yielded result with a **p- value which is constant** which denotes **no significant.**

Table 21: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Visual Analogue Scale:

On comparing results obtained from Visual Analogue Scale from Diode laser and Er,Cr:YSGG laser immediately after laser procedure and 7 post-operative days, it was observed that for five patients the mean value obtained was 6.60 with Diode laser and 11.40 for Er,Cr:YSGG laser with a standard deviation of 13.107 for Diode laser and 10.991 for Er,Cr:YSGG laser. Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Visual Analogue Scale yielded **highly significant** result with a **p – value of 0.000.**

Table 22: Visual Analogue Scale in Diode and Er,Cr:YSGG laser immediately after the procedure and 7 post-operative days:

Data analysis was done for Diode laser and Er,Cr:YSGG laser separately ranging from the day immediately after the laser procedure to 7 post-operative days to assess pain by Visual Analogue Scale.

With Diode laser, the mean rank was 6.50 immediately after treatment, 5.50 on the 1st post-operative day, 4.40 on the 2nd post-operative day, 4.30 on the 3rd post-operative day, 4.10 on the 4th post-operative day, 3.70 on the 5th, 6th and 7th post-operative days.

With Er,Cr:YSGG laser, the mean rank was 8.00 immediately after treatment, 7.00 on the 1st post-operative day, 6.00 on the 2nd post-operative day, 3.40 on the 3rd post-operative day, 3.20 on the 4th post-operative day, 2.80 on the 5th, 6th and 7th post-operative days.

Analysis yielded **significant** results in Visual Analogue Scale with a **p-value of 0.025** with Diode laser and yielded **highly significant** result in Visual Analogue Scale **with p- value of 0.000** with Er,Cr:YSGG laser.

Digital photographs analysed by visual method to analysed the bleeding during procedure and outcome of wound healing on 7^{th}, 14^{th} and 21^{st} post-operative day:

Digital photographs were taken pre - laser therapy, during the laser therapy to analysed bleeding and post laser therapy. The photographs were taken during the 7^{th}, 14^{th} and the 21^{st} post- operative day to analyze healing outcome of the patient treated with Diode laser and Er,Cr:YSGG laser.

Table 23: Comparison of Bleeding during the procedure between Diode and Er,Cr:YSGG laser:

During the Diode laser therapy on the anterior half of the lesion which was divided with the reference point with a marker between the premolars, all 5(100%) patients had minimal bleeding during ablation with occasional wiping of the area with the cotton roll to achieve hemostasis and it was scored '1'.

During Er,Cr:YSGG laser therapy which was carried out on the posterior half of the lesion, all 5(100%) patients experienced profused bleeding during ablation with the need of continuous need of wiping the area with the cotton roll during the procedure, the hemostasis was achieved after 2 or 3 times of wiping the area with the cotton roll which is denoted by score '2'.

Table 24: Comparison of digital photographs to assess wound healing on the 7^{th}, 14^{th} and 21^{st} post- operative day after Diode and Er,Cr:YSGG laser procedure:

In case 1, It was observed that on the '7^{th} post-operative day', in the areas treated with both Diode and Er,Cr:YSGG laser showed re- epithelisation with no scar formation. On the '14^{th} post-operative day', in both the areas treated with Diode laser and Er,Cr:YSGG laser showed signs of complete healing. On the '21^{st} post- operative day', normal buccal mucosa was observed with no lesion on the operated site.

In case 2, on the '7^{th} post- operative day' the patient, was called for a review to analyse the outcome of wound healing. In the areas treated with Diode laser and Er,Cr:YSGG laser showed signs of re-epithelisation with no scaring and slight whitish areas was observed. On the '14^{th} post-operative day', in both the areas treated with Diode laser and Er,Cr:YSGG laser showed signs of complete healing. On the '21^{st} post- operative day', normal buccal mucosa was observed with no lesion on the operated site.

In case 3, on the '7^{th} post-operative day' the patient, was called for a review to analyse the outcome of wound healing. In the areas treated with Diode laser and Er,Cr:YSGG laser showed signs of re-epithelisation with no scaring and slight whitish areas was observed. On the '14^{th} post- operative day', in both the areas treated with Diode laser and Er,Cr:YSGG laser showed

signs of complete healing. On the '21st post-operative day', normal buccal mucosa was observed with no lesion on the operated site.

In case 4, on the 7th post-operative day the patient was called for a review to analysed the outcome of wound healing. In the areas treated with Diode laser and Er,Cr:YSGG laser showed re-epithelisation, no scaring only with whitish areas. On the 14th post- operative day review it was observed that in both the areas treated with Diode and Er,Cr:YSGG laser healing was seen with mild white areas. On 21st post- operative day normal buccal mucosa was observed with no lesion on both the operated areas.

In case 5, on the 7th post-operative day, patient had been called for review. In the area treated with Diode laser showed signs of re- epithelisation with no scarring and the area treated with Er,Cr:YSGG laser showed signs of re- epithelisation with pin point bleeding. On the 14th post- operative day, it was observed that the wound did not heal completely and whitish areas were noticed surrounding the region treated. On further enquiry the patient was not able to quit smoking habit. The patient was extremely un co-operative, was not willing for any further review and did not return for the 21st post-operative day review.

Table 1: Comparison of 'facial expression' in Behavioral Observation Pain Rating Scale between Diode and Er,Cr:YSGG laser

Diode Laser	Er,Cr:YSGG Laser			Total	P Value
	No particular expression or smile; disinterested	Occasional grimace or frown, withdrawn	Frequent constant frown, clenched jaw, quivering chin		
No particular expression or smile; disinterested	0 (0%)	3 (60%)	0 (0%)	3 (60%)	**0.082**
Occasional grimace or frown, withdrawn	0 (0%)	1 (20%)	0 (0%)	1 (20%)	
Frequent constant frown, clenched jaw, quivering chin	0 (0%)	0 (0%)	1 (20%)	1 (20%)	
Total	0 (0%)	4 (80%)	1 (20%)	5 (100%)	

Table 2: Comparison of 'leg movement' in Behavioral Observation Pain Rating Scale between Diode and Er,Cr:YSGG laser

Diode Laser	Er,Cr:YSGG Laser			Total	P Value
	No position or relaxed	Uneasy, restless, tense	Kicking, or legs drawn up		
No position or relaxed	0 (0%)	3 (60%)	0 (0%)	3 (60%)	**0.082**
Uneasy, restless, tense	0 (0%)	1 (20%)	0 (0%)	1 (20%)	
Kicking, or legs drawn up	0 (0%)	0 (0%)	1 (20%)	1 (20%)	
Total	0 (0%)	4 (80%)	1 (20%)	5 (100%)	

Table 3: Comparison of 'activity' of patients during Diode and Er,Cr:YSGG laser procedures in Behavioral Observation Pain Rating Scale

Diode Laser	Er,Cr:YSGG Laser			Total	P Value
	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking		
Lying quietly, normal position, moves easily	1 (20%)	3 (60%)	0 (0%)	4 (80%)	**0.082**
Squirming, shifting back and forth, tense	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Arched, rigid, or jerking	0 (0%)	0 (0%)	1 (20%)	1 (20%)	
Total	1 (20%)	3 (60%)	1 (20%)	5 (100%)	

Table 4: Comparison of 'cry' of patient in Behavioral Observation Pain Rating Scale in between Diode and Er,Cr:YSGG laser

Diode Laser	Er,Cr:YSGG Laser			Total	P Value
	No crying (awake or asleep)	Moans or whimpers, occasional complaint	Crying steadily, screams or sobs, frequent complaints		
No crying (awake or asleep)	2 (40%)	2 (40%)	0 (0%)	4 (80%)	**0.082**
Moans or whimpers, occasional complaint	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Cryng steadily, screams or sobs, frequent complaints	0 (0%)	0 (0%)	1 (20%)	1 (20%)	
Total	2 (40%)	2 (40%)	1 (20%)	5 (100%)	

Table 5: Comparison of 'consolability' in Behavioral Observation Pain Rating Scale in between Diode and Er,Cr:YSGG laser

Diode Laser	Er, Cr:YSGG Laser			Total	P Value
	Content, relaxed	Reassured by occasional touching, hugging, or talking to Distractable	Difficult to console or comfort		
Content, relaxed	2 (40%)	2 (40%)	0 (0%)	4 (80%)	**0.082**
Reassured by occasional touching, hugging, or talking to. Distractable	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Difficult to console or comfort	0 (0%)	0 (0%)	1 (20%)	1 (20%)	
Total	2 (40%)	2 (40%)	1 (20%)	5 (100%)	

Table 6: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Behavioral Observation Scale

	Mean	N	Std. Deviation	Std. Error Mean	Sig.
Diode laser	2.40	5	4.336	1.939	**0.061**
Er,Cr:YSGG laser	5.00	5	3.082	1.378	

Table 7: Comparison of pain 'immediately' after the procedure between Diode laser and Er,Cr:YSGG laser using 'Faces' Pain Rating Scale

Diode Laser	Er,Cr:YSGG Laser						Total	P Value
	No Hurt	Hurt little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst		
No Hurt	0 (0%)	0 (0%)	3 (60%)	0 (0%)	0 (0%)	0 (0%)	3 (60%)	
Hurt little bit	0 (0%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	
Hurts little more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.235**
Hurts even more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts whole lot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts worst	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	1 (20%)	
Total	0 (0%)	1 (20%)	3 (60%)	0 (0%)	0 (0%)	1 (20%)	5 (100%)	

Table 8: Comparison of pain on the '1st post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale

Diode Laser	Er,Cr:YSGG Laser						Total	P Value
	No Hurt	Hurt little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst		
No Hurt	0 (0%)	3 (60%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (60%)	**0.082**
Hurt little bit	0 (0%)	1 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	
Hurts little more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts even more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts whole lot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	0 (0%)	1 (20%)	
Hurts worst	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	0 (0%)	4 (80%)	0 (0%)	0 (0%)	1(20%)	0 (0%)	5 (100%)	

Table 9: Comparison of pain on the '2nd post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale

Diode Laser	Er,Cr:YSGG Laser						Total	P Value
	No Hurt	Hurt little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst		
No Hurt	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**4 (80%)**	
Hurt little bit	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts little more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.025**
Hurts even more	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	**1 (20%)**	
Hurts whole lot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts worst	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**4 (80%)**	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	**5 (100%)**	

Table 10: Comparison of pain on the '3rd post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale

Diode Laser	Er,Cr:YSGG Laser						Total	P Value
	No Hurt	Hurt little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst		
No Hurt	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**4 (80%)**	
Hurt little bit	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts little more	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	**0.025**
Hurts even more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts whole lot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts worst	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**4 (80%)**	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 11: Comparison of pain on the '4th post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale:

Diode Laser	Er,Cr:YSGG Laser						Total	P Value
	No Hurt	Hurt little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst		
No Hurt	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**4 (80%)**	**0.025**
Hurt little bit	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	
Hurts little more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts even more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts whole lot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts worst	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**4 (80%)**	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 12: Comparison of pain on the '5th, 6th and 7th post operative days' following the day of treatment between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale

Diode Laser	Er,Cr:YSGG Laser						Total	P Value
	No Hurt	Hurt little bit	Hurts little more	Hurts even more	Hurts whole lot	Hurts worst		
No Hurt	**5 (100%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	**(a)** Constant
Hurt little bit	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts little more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts even more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts whole lot	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Hurts worst	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**5 (100%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 13: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of 'Faces' Pain Rating Scale

	Mean	N	Std. Deviation	Std. Error Mean	Sig.
Diode laser	3.40	5	6.542	2.926	**0.001**
Er,Cr:YSGG laser	5.20	5	5.495	5.495	

Table 14: 'Faces' Pain Rating Scale in Diode and Er,Cr:YSGG laser immediately after the procedure and 7 post-operative days

	Immediately After treatment	1st post op day	2nd post op day	3rd post op day	4th post op day	5th post op day	6th post op day	7th post op day	P value
Diode laser	5.80	5.60	4.60	4.40	4.20	3.80	3.80	3.80	**0.093**
Er, Cr:YSGG laser	7.90	7.10	4.00	3.80	3.60	3.20	3.20	3.20	**0.000**

Table 15: Comparison of pain 'immediately' after the procedure between Diode laser and Er,Cr:YSGG laser using Visual Analogue Scale

Diode laser	Er,Cr:YSGG laser											Total	P value
	0	1	2	3	4	5	6	7	8	9	10		
0	0 (0%)	0 (0%)	0 (0%)	**2 (40%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**2 (40%)**	
1	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	1 (20%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**2 (40%)**	
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.155**
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
8	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
10	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	**1 (20%)**	
Total	0 (0%)	0 (0%)	0 (0%)	**3 (60%)**	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	**5 (100%)**	

Table 16: Comparison of pain on the 'first post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale

Diode laser	Er,Cr:YSGG laser											Total	P value
	0	1	2	3	4	5	6	7	8	9	10		
0	0 (0%)	0 (0%)	**3 (60%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**3 (60%)**	
1	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.040**
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
8	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	**1 (20%)**	
9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
10	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	0 (0%)	0 (0%)	**3 (60%)**	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	**5 (100%)**	

Table 17: Comparison of pain on the 'second post-operative day' following the day of procedure between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale

Diode laser	Er, Cr:YSGG laser											Total	P value
	0	1	2	3	4	5	6	7	8	9	10		
0	0 (0%)	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**4 (80%)**	
1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0 (20%)**	**0.025**
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
8	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
10	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	0 (0%)	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 18: Comparison of pain on the 'third post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale

Diode laser	Er, Cr:YSGG laser											Total	P value
	0	1	2	3	4	5	6	7	8	9	10		
0	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**4 (80%)**	
1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.025**
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
8	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
10	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 19: Comparison of pain on the '4th post-operative day' following the day of treatment between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale

Diode laser	Er, Cr:YSGG laser											Total	P value
	0	1	2	3	4	5	6	7	8	9	10		
0	**4 (80%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**4 (80%)**	
1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**1 (20%)**	
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.025**
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
8	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
10	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**4 (80%)**	0 (0%)	0 (0%)	**1 (20%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 20: Comparison of pain on the '5th, 6th and 7th post-operative days' following the day of treatment between Diode laser and Er,Cr:YSGG laser using Visual Analogue Scale

Diode laser	Er,Cr:YSGG laser											Total	P value
	0	1	2	3	4	5	6	7	8	9	10		
0	**5 (100%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	
1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**0.(a)** Constant
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
8	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
10	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
Total	**5 (100%)**	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	**5 (100%)**	

Table 21: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Visual Analogue Scale

	Mean	N	Std. Deviation	Std. Error Mean	Sig.
Diode laser	6.60	5	13.107	5.862	**0.000**
Er,Cr:YSGG laser	11.4	5	10.991	4.915	

Table 22: Visual Analogue Scale in Diode and Er,Cr:YSGG laser immediately after the procedure and 7 post-operative days

	Immediately After treatment	1st post op day	2nd post op day	3rd post op day	4th post op day	5th post op day	6thpost op day	7th post op day	P value
Diode laser	6.50	5.50	4.50	4.30	4.10	3.70	3.70	3.70	**0.025**
Er,Cr:YSGG laser	8.00	7.00	6.00	3.40	3.20	2.80	2.80	2.80	**0.000**

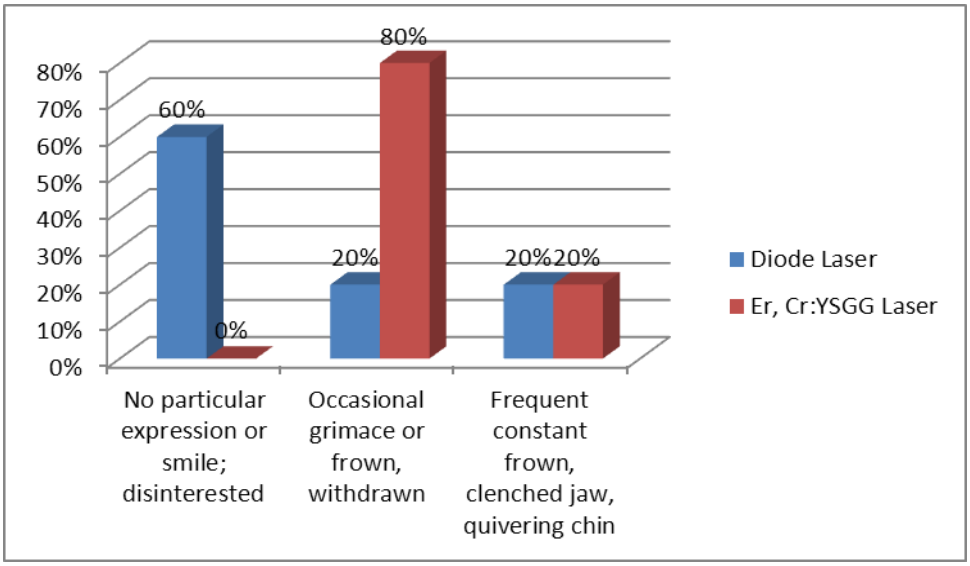
Table 23: Comparison of Bleeding during the procedure between Diode and Er,Cr:YSGG laser

	Case 1	Case 2	Case 3	Case 4	Case 5
Diode laser	1	1	1	1	1
Er, Cr:YSGG laser	2	2	2	2	2

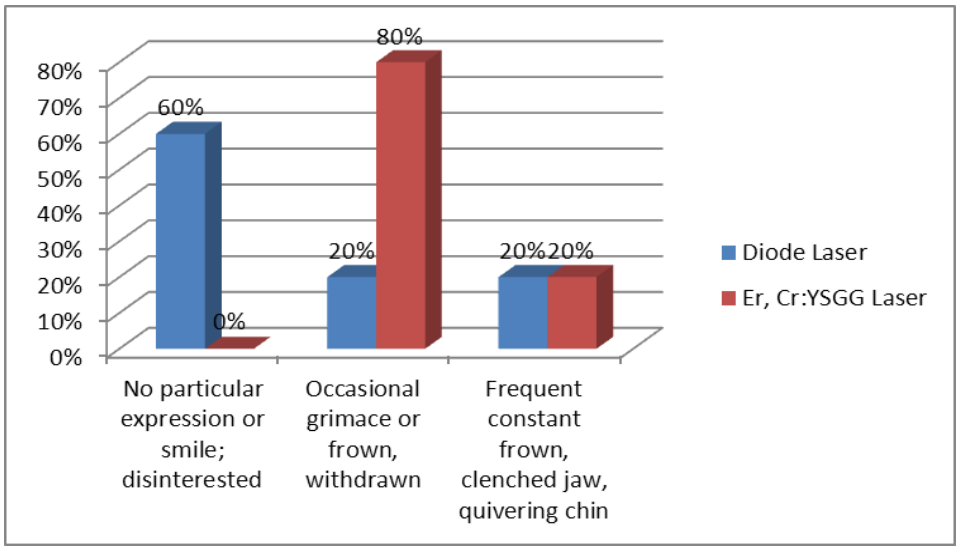
Table 24: Comparison of digital photographs after Diode laser and Er,Cr:YSGG laser procedure to assess wound healing on the 7th, 14th and 21st post operative days

Case No.	Days	Diode Laser	Er,Cr:YSGG Laser
Case 1	7th day	Re- epithelisation /no scarring	Re- epithelisation/ no scarring
	14th day	Complete healing	Complete healing
	21st day	Normal buccal mucosa	Normal buccal mucosa
Case 2	7th day	Re- epithelisation / no scarring with slight whitish areas	Re- epithelisation / no scarring with slight whitish areas
	14th day	Complete healing	Complete healing
	21st day	Normal buccal mucosa	Normal buccal mucosa
Case 3	7th day	Re- epithelisation / no scarring with slight whitish areas	Re- epithelisation / no scarring with slight whitish areas
	14th day	Complete healing	Complete healing
	21st day	Normal buccal mucosa	Normal buccal mucosa
Case 4	7th day	Re- epithelisation / no scarring with slight whitish areas	Re- epithelisation / no scarring with slight whitish areas
	14th day	Healing with mild whitish areas	Healing with mild whitish areas
	21st day	Normal buccal mucosa	Normal buccal mucosa
Case 5	7th day	Signs of re- epithelisation seen with no scarring	Signs of re- epithelisation with pin – point bleeding
	14th day	No successful healing, whitish area surrounding the region	No successful healing, whitish area surrounding the region
	21st day	Not willing for review- Did not report back	Not willing for review- Did not report back

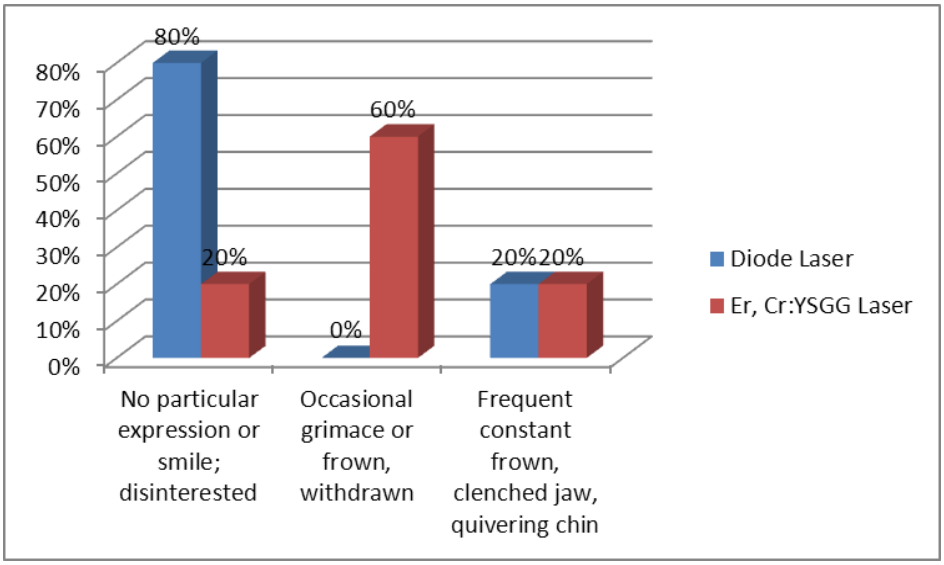
Graph 1: Comparison of 'facial expression' in Behavioral Observation Pain Rating Scale between Diode and Er,Cr:YSGG laser



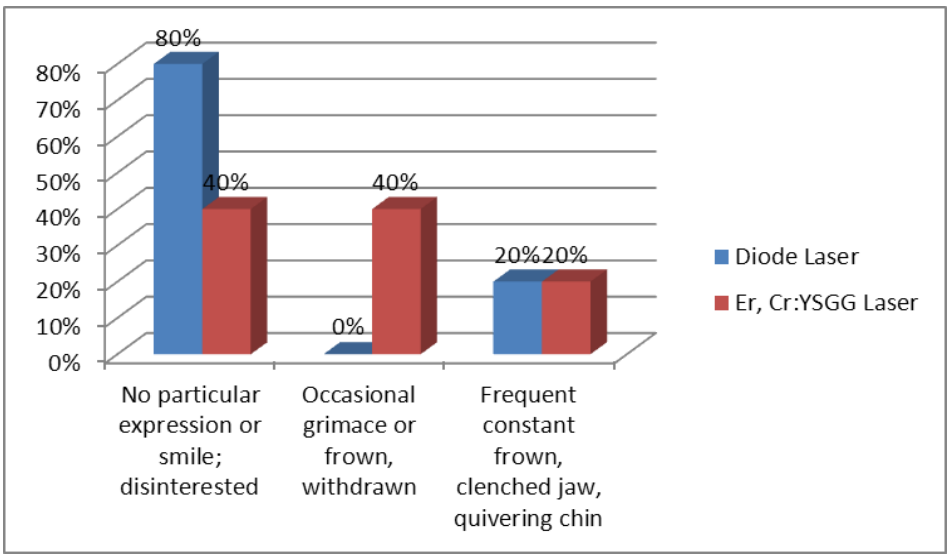
Graph 2: Comparison of 'leg movement' in Behavioral Observation Pain Rating Scale between Diode and Er,Cr:YSGG laser



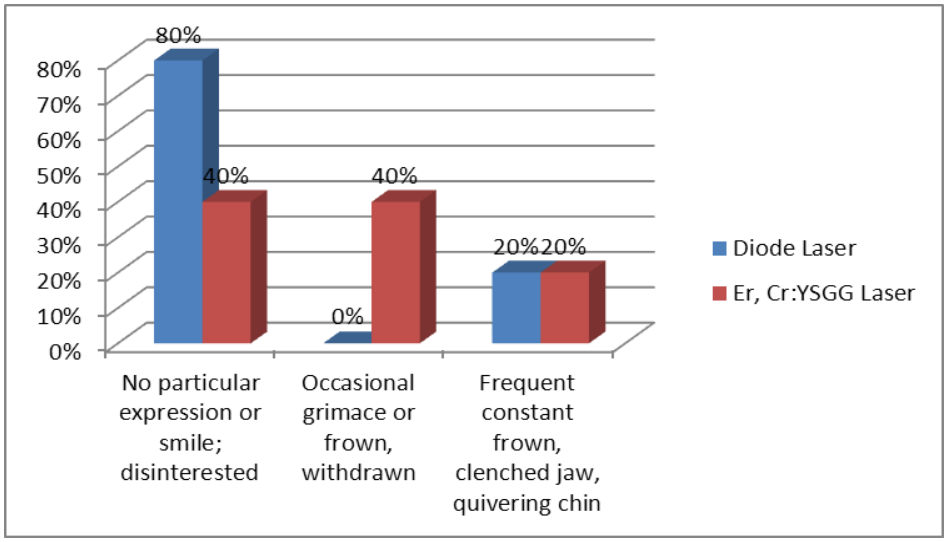
Graph 3: Comparison of 'activity' of patients during Diode and Er,Cr:YSGG laser procedures in Behavioral Observation Pain Rating Scale



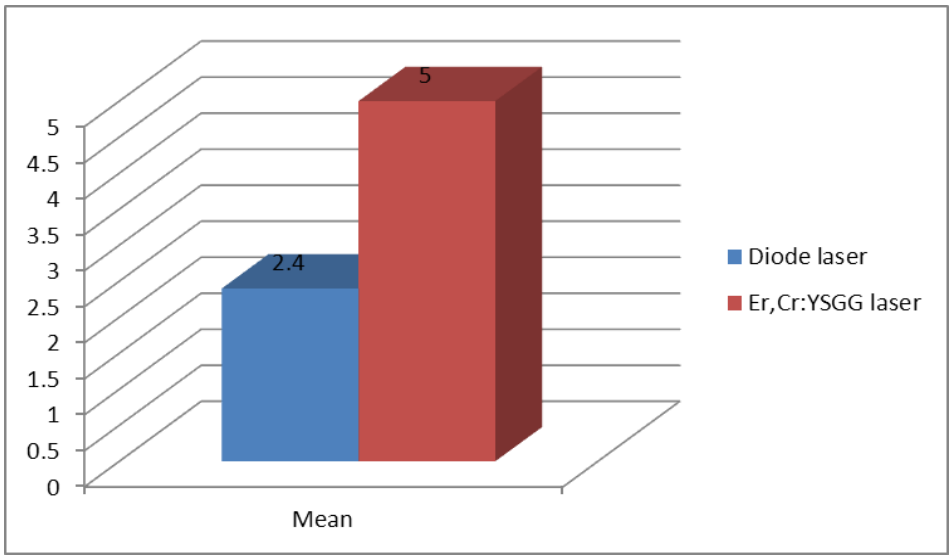
Graph 4: Comparison of 'cry' of patient in Behavioral Observation Pain Rating Scale in between Diode and Er,Cr:YSGG laser



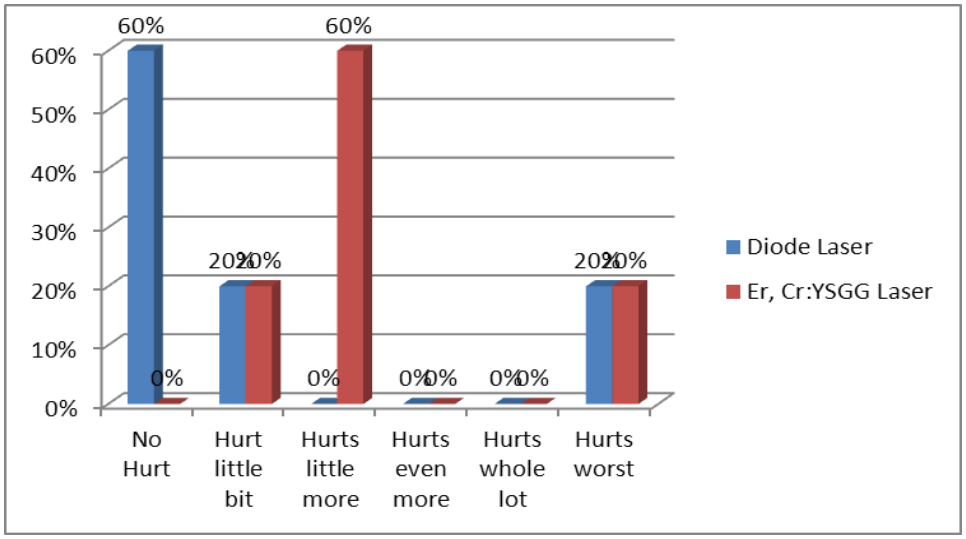
Graph 5: Comparison of 'consolability' in Behavioral Observation Pain Rating Scale in between Diode and Er,Cr:YSGG laser



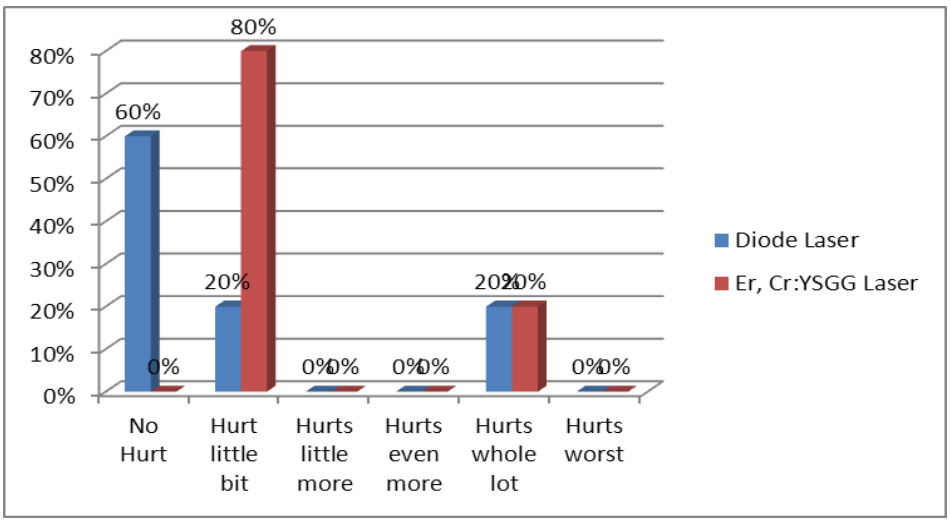
Graph 6: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Behavioral Observation Scale



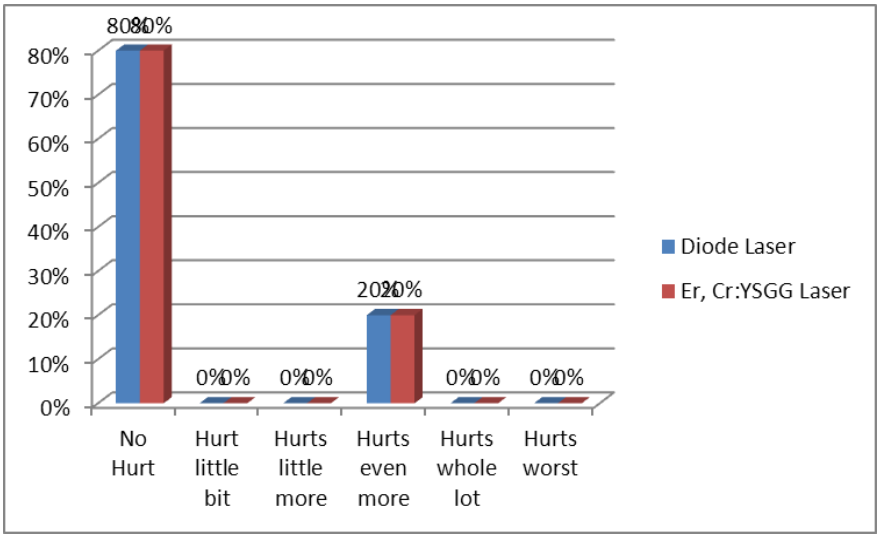
Graph 7: Comparison of pain immediately after the procedure on the '1st day' between Diode laser and Er,Cr:YSGG laser using 'Faces' Pain Rating Scale



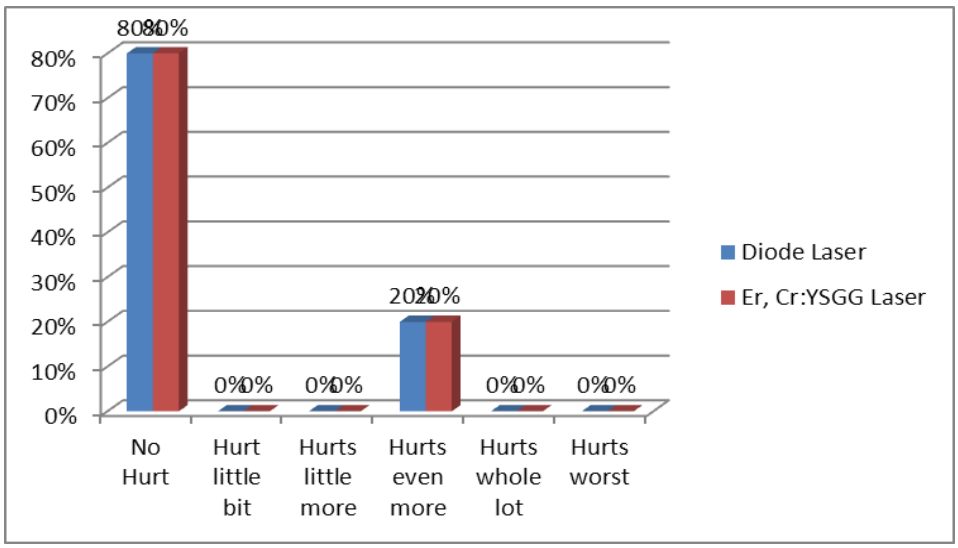
Graph 8: Comparison of pain on the '2st day' after procedure between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale



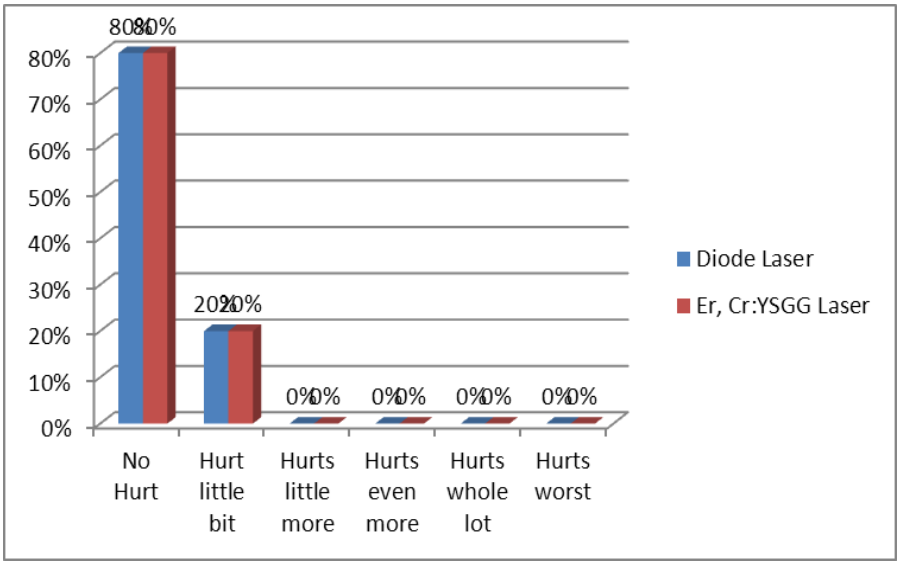
Graph 9: Comparison of pain on the '3rd day' after procedure between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale



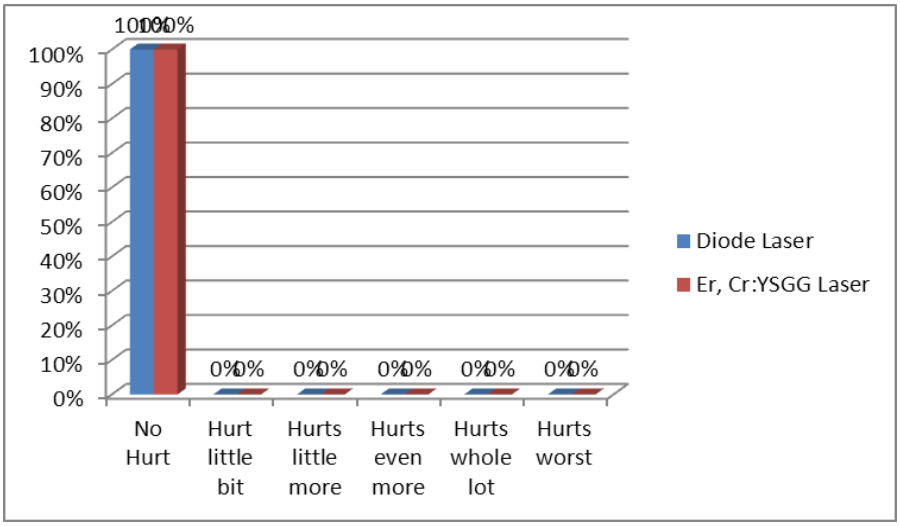
Graph 10: Comparison of pain on the '4th day' after procedure between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale



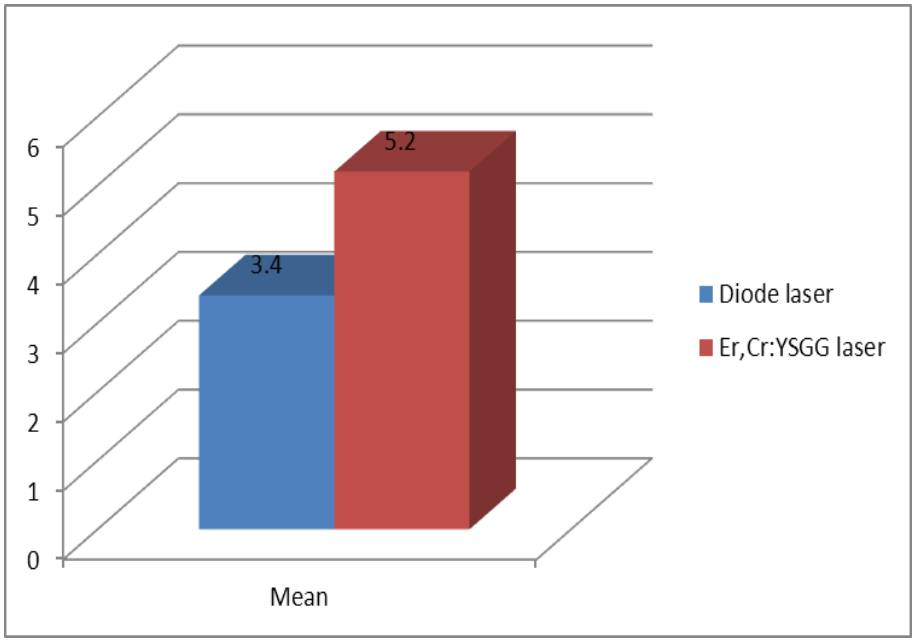
Graph 11: Comparison of pain on the '5th day' after procedure between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale



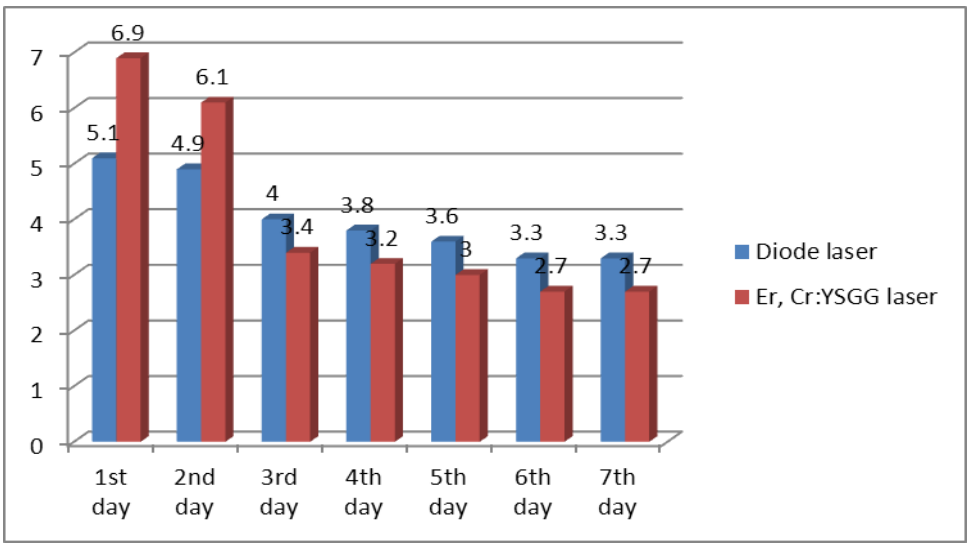
Graph 12: Comparison of pain on the '6th and 7th day' after procedure between Diode laser and Er,Cr:YSGG laser procedure using 'Faces' Pain Rating Scale



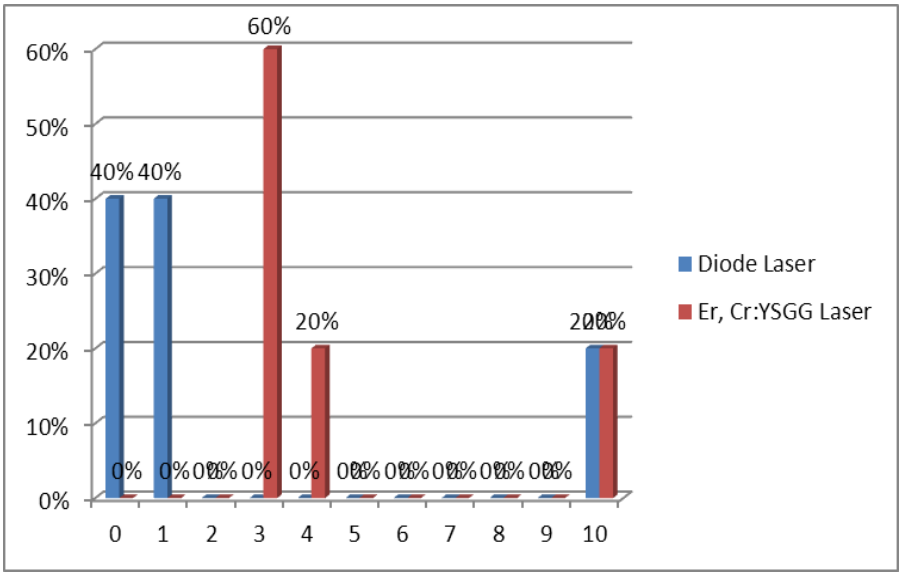
Graph 13: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of 'Faces' Pain Rating Scale



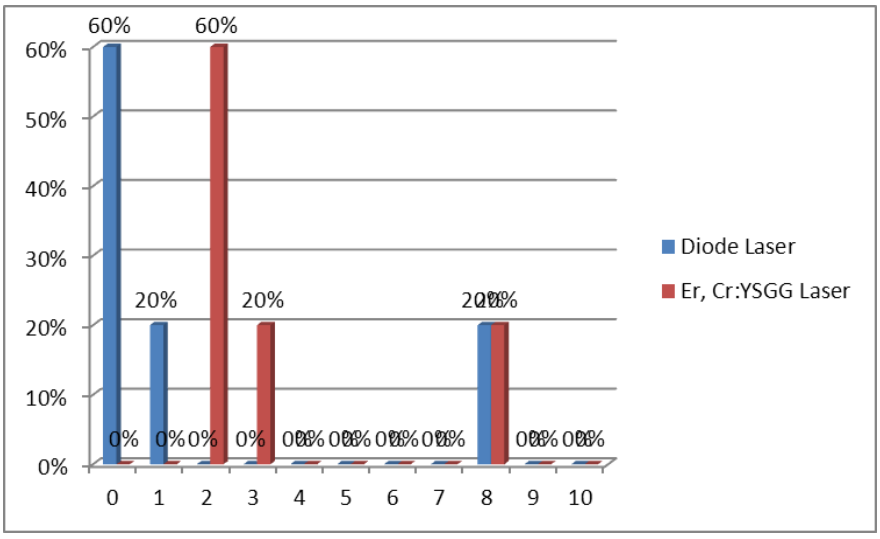
Graph 14: 'Faces' Pain Rating Scale in Diode and Er, Cr:YSGG laser immediately after the procedure till the 7th day



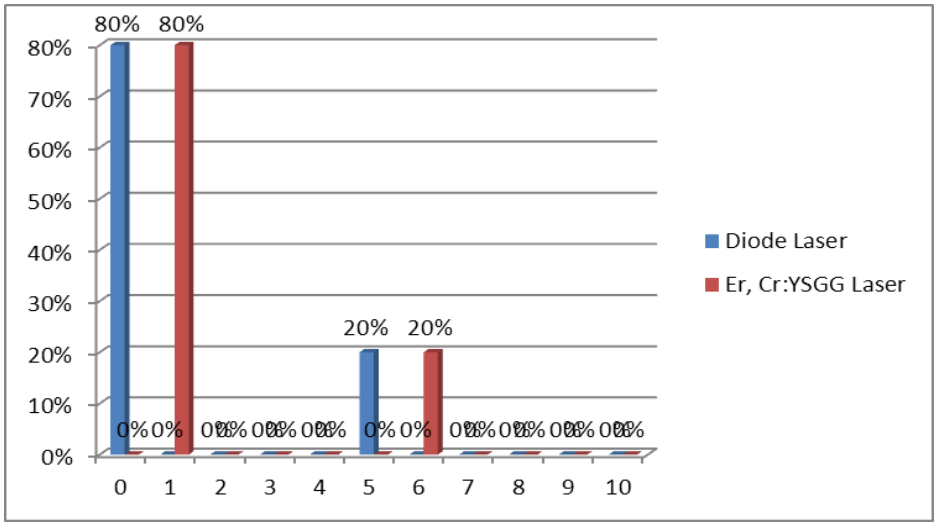
Graph 15: Comparison of pain immediately after the procedure on the 1st day between Diode laser and Er,Cr:YSGG laser using Visua Analogue Scale



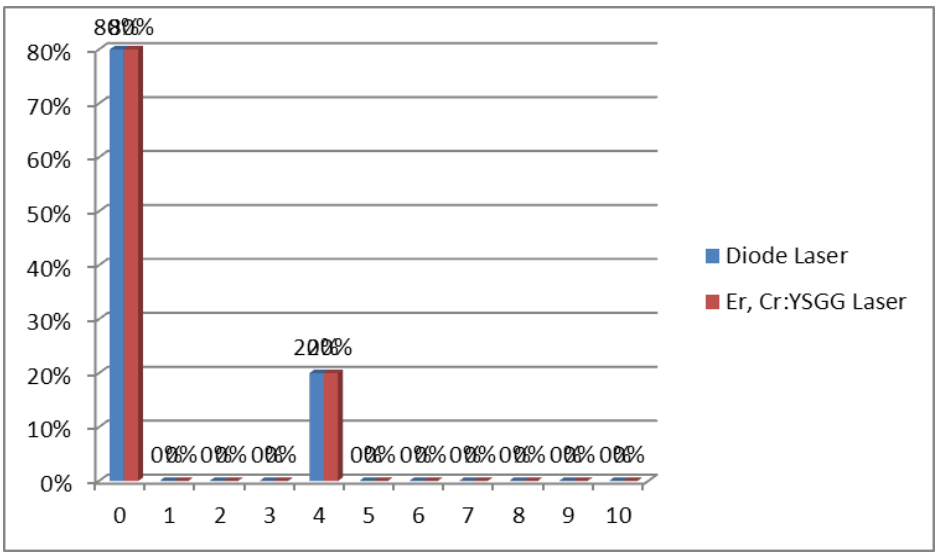
Graph 16: Comparison of pain on the 2nd day after procedure between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale



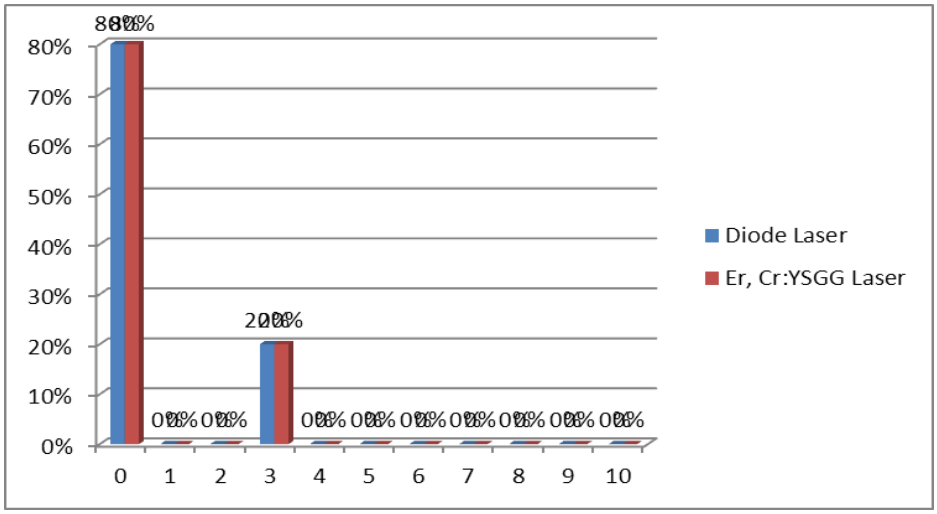
Graph 17: Comparison of pain on the 3rd day after procedure between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale



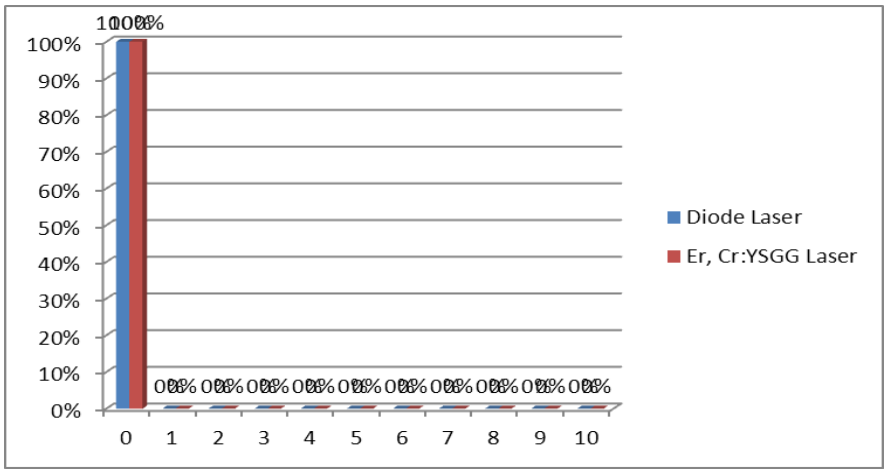
Graph 18: Comparison of pain on the 4th day after procedure between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale



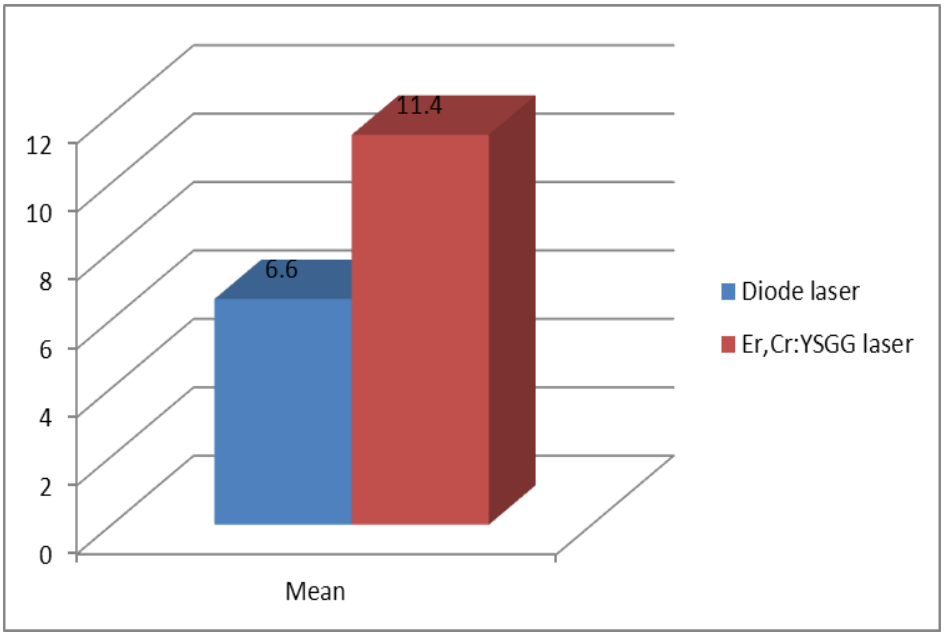
Graph 19: Comparison of pain on the 5th day after procedure between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale



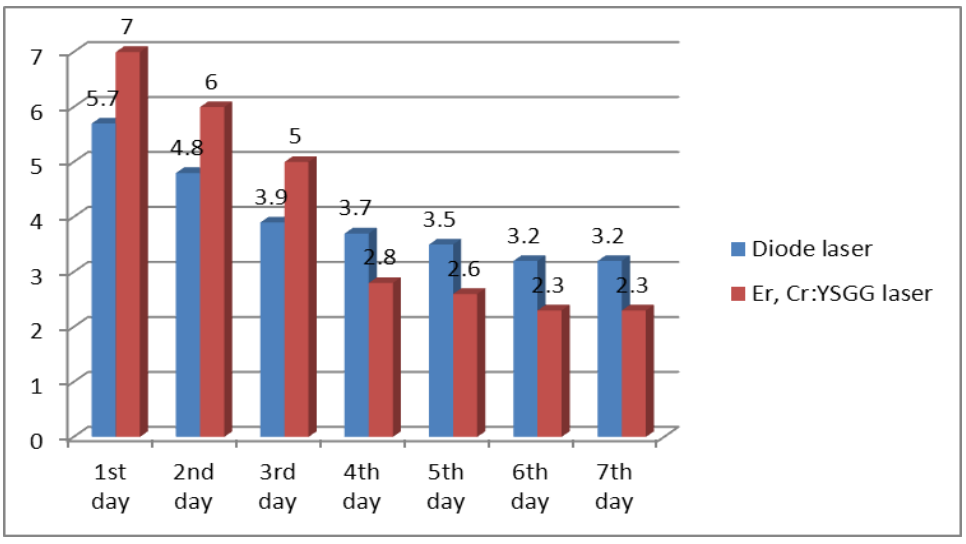
Graph 20: Comparison of pain on the 6th and 7th day after procedure between Diode laser and Er,Cr:YSGG laser post operatively using Visual Analogue Scale



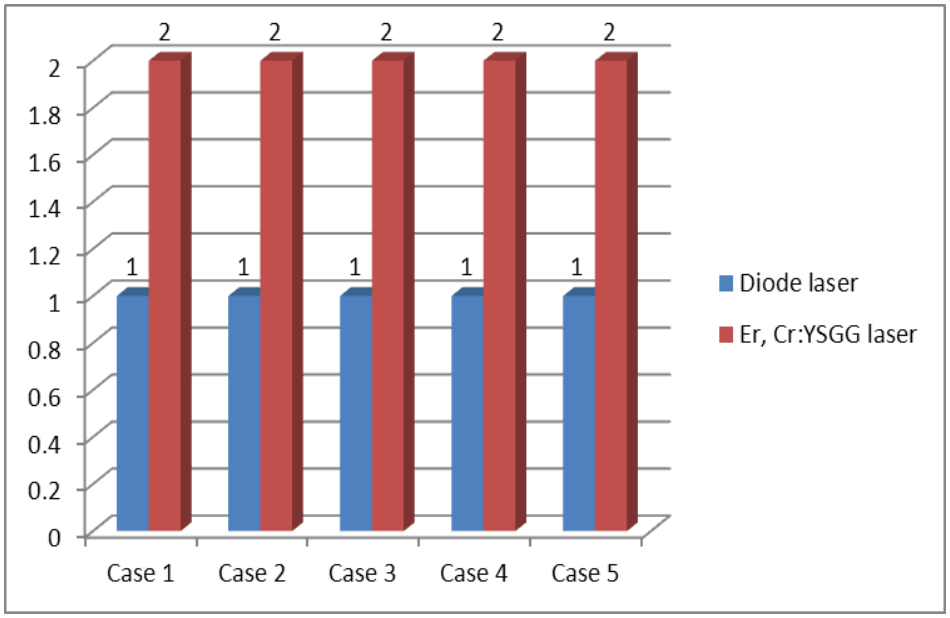
Graph 21: Data analysis of Diode laser and Er,Cr:YSGG laser obtained by the use of Visual Analogue Scale



Graph 22: Visual Analogue Scale in Diode and Er, Cr:YSGG laser immediately after the procedure till the 7th day



Graph 23: Comparison of Bleeding during the procedure between Diode and Er,Cr:YSGG laser



WHO (2005) declared that the term "leukoplakia should be used to recognize white patch of questionable risk having excluded other known diseases or disorders that carry no increased risk for cancer".[44]

Many causative agents have been implicated in the etiology of leukoplakia. They include tobacco, alcohol, chronic friction due to sharp tooth, electro galvanic reaction, UV radiation, syphilis and so on.[45] Tobacco use is considered to be the primary cause for occurrence of leukoplakia.[46]

There seems no well accepted treatment method for removal of oral leukoplakia. Leukoplakia is limited to the epithelium, so selected removal of this part of the mucosa seems to be the best choice of treatment.

There are different treatment modalities adopted for leukoplakia once it has occurred. First and foremost any tobacco related habits have to be stopped forthwith to be followed by administration of retinoids and other drugs or other surgical procedures such as surgical excision, cryosurgery, laser surgery and photo dynamic therapy.[3]

Laser surgery has been the latest treatment modality for leukoplakia. Different soft tissue lasers, semiconductor Diode laser and hard tissue lasers can be used for the treatment of oral leukoplakia. Today there are different types of lasers available and used in dentistry such as Nd:YAG, Holmium: Yttrium, Aluminium, Garnet, Er,Cr:YSGG laser, Nd:YAP, GaAs, Diode and

Argon laser. Thus different types of lasers are used for different soft tissue surgeries.[6]

In comparison with conventional scalpel therapy, laser has many benefits such as ease of soft tissue ablation, hemostasis, instant sterilization, reduced bacteremia, reduced edema due to reduced mechanical trauma, and little wound contraction resulting in minimal scar, less intra- operative and post- operative pain, increased patient acceptance or few sutures, no need for topical anesthesia.[9,16]

Diode lasers are semiconductor lasers and are generally considered to be soft tissue lasers. Diode lasers have a solid active medium, manufactures from semiconductor crystals, using some combination of Aluminium, Gallium and Arsenide. The available wavelengths are 810nm, 940nm and 980nm. Laser with wavelength of 810nm is highly absorbed by melanin and hemoglobin, whereas those of 940nm and 980nm are strongly absorbed by hemoglobin and water.[8]

Er,Cr:YSGG laser belongs to the Erbium family. They are hard tissue lasers with a wavelength of 2780nm and contain Yttrium, Scandium, Gallium, Garnet doped with Erbium and Chromium. This laser is well absorbed by water enabling it to be used on soft tissues without causing thermal damage.[12,13]

The present study was conducted in the department of Oral Medicine & Radiology, Ragas Dental College & Hospital, Chennai. This was a comparative study conducted between March 2012 to June 2012. The study population included five subjects reporting to Ragas Dental College and Hospital, Out-patient department seeking dental advice and who were from a wide variety of socio- economic background. The age group selected was above 18 years.

Clinical examination was done on all the patients coming to out-patient, five subjects were selected who were provisionally diagnosed as having oral leukoplakia involving the length and width of the buccal mucosa measuring minimum of 10mm and the lesion was measured and entered in a case sheet proforma. History of habits, such as smoking, alcohol consumption and tobacco chewing was recorded in the case sheet proforma with the duration and frequency of use. The patients were advised to cease the habit and were explained about the laser therapy modality. Informed consent to participate in the study were obtained from each of the five patients included in the study in a written format both in vernacular and English language. The treatment was undertaken at Smile Dental Clinic, T.Nagar, Chennai.

On all the five patients laser biopsy was done using Diode laser (940nm, power of 1.00 Watt, 615 Joules using contact mode) including the lesion and the normal mucosa. The specimen was stored in 10% formalin and was transported for histopathological analysis to the oral pathologist. After the

specimen was histopathologically confirmed as oral leukoplakia the laser treatment was started. Each patient was then prepared by dividing the lesions into two halves with the help of a hematoxylin marker with the maxillary and mandibular premolars being the reference points. Anterior to the marked line, the lesion on the buccal mucosa was treated with Diode laser. The Diode laser (Ezlase 940, Biolase, USA) was used in the wavelength of 940nm, power of 1.00 watt, 615 Joules using contact mode. The lesion area posterior to the marked line on the buccal mucosa was treated with Er,Cr:YSGG laser. The Er,Cr:YSGG laser (Waterlase MD, Biolase, USA) was used in the wavelength of 2780nm, S mode, 1.5W, Air-30% and Water 10%, MZ , 25 Hz.

During the procedure the patients were assessed for pain with the use of Behavioral Observational Pain Rating Scale and the scores were entered in the case sheet. Bleeding was assessed intra-operatively during the Diode and Er,Cr:YSGG laser procedures and the results were then entered into the case sheet proforma. If there was minimal bleeding then it was scored ‘1’ and if there was profuse bleeding then it was scored as ‘2’.

The patients were assessed for post-operative pain using ‘Faces’ Pain Rating Scale starting from day one immediately after the procedure and day after the procedure for all 7 post- operative days. They were asked to denote pain which they were experiencing by identifying the emotion icon on the scale. The emotion icons expressed were then correlated to a scale which was divided into six scores ranging from 0-5. The pain scores on the day of

treatment and for the 7 post- operative days following the day of treatment were then entered into the case sheet proforma for each case for both Diode and Er,Cr:YSGG laser procedures.

The Visual Analogue Scale was used to assess pain which was experienced by the patient immediately after the procedure and for 7 post-operative days following treatment scoring pain with a scale ranging from 0 to 10. Asking the patient to score the experience of pain with '0' denoting no pain,'5'denoting distressing pain,'10'denoting unbearable pain and if experienced pain between these ranges denoted by respected numbers from 1-4, 6-9. The scores were entered into the case sheet proforma.

Photographs were taken using DSLR camera (Nikon 550D) during the treatment and on 7^{th}, 14^{th} and 21^{st} post- operative days to assess wound healing by visual method.

All the data's were then entered in Microsoft excel sheets. Statistical analysis was done using SPSS software SYSTAT Version 15.0. The statistical analysis was done using Chi- Square test, Independent and Paired 't' test and Friedman test.

The test of significance with p- value less than 0.05 at 95% confidence interval is taken to correlate the variables to determine the significance.

DATA ANALYSIS:

PAIN ANALYSIS:

In the present study pain was assessed for each patient using Behavioral Pain Rating Scale separately during the Diode laser procedure and Er,Cr:YSGG laser procedure. On comparing the results obtained from all five patients, Behavioral Pain Rating Scale yielded insignificant results with a p-value of 0.061.

So far no study has been reported in the literature using the Behavioral Pain Rating Scale to compare between Diode laser and Er,Cr:YSGG laser. In this study for the first time we have attempted to analyze pain using Behavioral Pain Rating Scale in Diode laser and Er,Cr:YSGG laser in the treatment of oral leukoplakia.

A diagrammatic representation of the pain experienced by the patient using 'Faces' Pain Rating Scale was assessed immediately after the laser surgery using Diode and Er,Cr:YSGG laser and seven consecutive days post-operatively starting from the next day after treatment. The emotion icons expressed were then correlated to a scale which was divided into six scores ranging from 0-5. Data analysed from the 'Faces' Pain Rating Scale comparing Diode laser and Er,Cr:YSGG laser on all five patients yielded significant result with a p-value of 0.001 which implied that pain experienced

by patients with Diode laser procedure was less in comparison to the use of Er,Cr:YSGG laser.

In this present study the analysis of pain reduction post-operatively yielded insignificant results in 'Faces' Pain Rating Scale with a p-value of 0.093 with Diode laser and with Er,Cr:YSGG laser highly significant results were obtained which showed that pain gradually reduced from the first day after treatment and patient experienced no pain on the 5^{th}, 6^{th} and 7^{th} post- operative days in all five patients with Diode and Er,Cr:YSGG laser.

No study has been reported using the 'Faces' Pain Rating Scale comparing Diode laser and Er,Cr:YSGG laser. This present study is an attempt to analyse pain using 'Faces' Pain Rating Scale comparing Diode laser and Er,Cr:YSGG laser in the treatment of oral leukoplakia.

In this present study Visual Analogue Scale was also used in all five patients to assess pain experienced by patient after the Diode and Er,Cr:YSGG laser procedure. It was observed that the mean value with Diode laser was 3.40 and with Er,Cr:YSGG laser was 5.20. On comparing Diode laser and Er,Cr:YSGG laser to assess pain the Visual Analogue Scale yielded highly significant results with a p- value of 0.000. This implied that Diode laser procedure caused minimal pain when compared to Er,Cr:YSGG laser in treatment of oral leukoplakia.

It was observed in the present study that pain reduced gradually after the treatment with no pain experienced by the patient on the $5^{th,}$ 6^{th} and 7^{th} post- operative days in both Diode and Er,Cr:YSGG laser. The analysis yielded significant results with Diode laser with p- value of 0.025 and yielded with Er,Cr:YSGG laser.

In the present study the post- operative analysis as expressed by each individual patient using 'Faces' Pain Rating Scale and Visual Analogue Scale is unique with the sense that each patient had separately experienced both the laser procedures using Diode laser and Er,Cr:YSGG laser and that their experiences of pain under each procedure became all the more significant in comparing both the procedures than if it were done by two different groups of unrelated patients under each laser procedure.

It is to be noted that so far no study has been reported in the literature using the Behavioral Pain Rating Scale and 'Faces' Pain Rating Scale to compare Diode laser and Er,Cr:YSGG laser. We have attempted to analyze pain using Behavioral Pain Rating Scale and 'Faces' Pain Rating Scale along with Visual Analogue Scale in applying Diode laser and Er,Cr:YSGG laser in the treatment of oral leukoplakia.

BLEEDING ANALYSIS:

In this present study bleeding was assessed visually during both the Diode laser and Er,Cr:YSGG laser procedure. It was found that during Diode treatment in all five patients minimal bleeding was observed during ablation and needed only occasional wiping of the area, whereas during Er,Cr:YSGG laser ablation in all five patients profused bleeding was observed which needed continuous wiping of the area with cotton roll, hemostasis was achieved after 2-3 times of wiping the area with the cotton roll.

This is in accordance to the study conducted by **George Romanos et al (1999)**[27] in which Diode laser (980nm) was used in the removal of soft tissue tumors and was observed that minimal bleeding was seen. **Goharkhay et al (1999)**[28] used Diode laser with 810nm wavelength on soft tissue lesions resulted in excellent coagulation ability. **Deppe, H and H.H Horch (2007)**[3] reviewed the use of Diode laser in removal of premalignant lesions of oral mucosa and concluded minimal bleeding during treatment. Also the present study is in accordance to **Prajwalit Kende et al (2011)**[33] whose case report of excisional biopsies performed on oral premalignant lesion using Diode laser indicated reduced operative blood loss.

The Er,Cr:YSGG laser procedure in this present study showed profuse bleeding which is in accordance to the study reported by **Lee SC (1998)**[36] who concluded that hemostatic ability is limited with use of Er,Cr:YSGG laser

because only the water on the surface of the blood in the surgical site is vaporized. There is neither deep penetration nor sustained heat to provide rapid vessel shrinkage.

In the present study hemostasis was well achieved with the use of Diode laser than Er,Cr:YSGG laser which is in accordance with the study conducted by **Stabholz A et al (2003)**[39] which describes that hemostasis is better achieved by use of Diode laser than Er,Cr:YSGG laser because Diode laser are well absorbed by melanin and hemoglobin. There wavelengths (810-980nm) will pass through water and penetrate much deeper into the soft tissue unlike Erbium laser where they are not well absorbed by these chromophores concluding that Erbium family lasers are not ideal wavelength for soft tissue surgeries in which ideal hemostasis is desired.

WOUND HEALING ANALYSIS:

In this present study it was observed that both Diode and Er,Cr:YSGG laser in all five patients showed signs of re- epithelisation with no scarring on the 7th post- operative day, whereas with three patients out of 5 showed slight whitish areas on the 7th post- operative day. Complete healing was observed in all five patients on the 14th post – operative with the use of both Diode and Er,Cr:YSGG laser. And four patients out of five showed normal buccal mucosa on the 21st day. Except for one patient who showed no successful healing with whitish area surrounding the region on 14th post- operative day

with the use of both Diode and Er,Cr:YSGG laser and the patient was not willing for anymore review and did not return back on the 21st day. The patient gave the reason of unable to quit smoking and alcohol consumption and was obviously continuing with the habits all through the post- operative period rendering the healing process to fail.

In this study it was observed that out of five patients except for one patient all other showed excellent wound healing at the 21st post- operative day which is in accordance to **George Romanos et al (1999)[27], Mona Soliman et al (2005)[29]**, **Depp,H and HH Horch (2007)[3]**, **Nilesh Ravel et al (2011)[34]** .

George Romanos et al (1999)[27] in their study, examined wound healing of soft tissue after application of Diode laser and concluded that good wound healing was observed. **Mona Soliman et al (2005)[29]** also showed similar results with complete wound healing after second week in treatment of oral lichen planus with Diode laser. **Depp,H and HH Horch (2007)[3]** in their study also concluded that premalignant lesions treated with Diode laser showed excellent wound healing. In accordance to the present study, a study conducted by **Nilesh Ravel et al (2011)[34]** showed complete wound healing with the use of Diode laser.

In the similar way Er,Cr:YSGG laser in this present study showed excellent wound healing which is in accordance to the study conducted by **Rizolu et al (1996)**[35] and **Boj et al (2007).**[20]

Rizolu et al (1996)[35] in their study concluded that all 12 mucocutaneous soft tissues treated using Er,Cr:YSGG laser showed good signs of re-epithelisation. And **Boj et al (2007)**[20] study on squamous cell papilloma treated with Er,Cr:YSGG laser also showed excellent wound healing similar to this present study.

In this present study Diode laser and Er,Cr:YSGG laser showed good wound healing after 14th post- operative day which is not in accordance to the study conducted by **Jin et al (2010)**[41] which was a comparative study to assess healing of buccal mucosa in 24 guines pigs and it was concluded that Diode laser has better effect on wound healing when compared to Er,Cr:YSGG laser**.** This contradiction may be due to the fact that in the study conducted by **Jin et al (2010)**[42] on buccal mucosa of guinea pigs were used in assessing the healing, whereas in our study healing was assessed in buccal mucosa of humans.

So the best test species for humans are humans. It is not possible to extrapolate animal data to humans, due to inter- species variation in anatomy, physiology and bio-chemistry.[47]

This present study was conducted to compare the effectiveness of Diode laser (940nm) and Er,Cr:YSGG laser (2780nm) in the treatment of oral leukoplakia. The study was undertaken in the department of Oral Medicine & Radiology, Ragas Dental College & Hospital, Uthandi and Smile Dental Clinic, T.Nagar, Chennai. Five subjects were selected for the laser treatment who were provisionally diagnosed and histopathologically confirmed as having oral leukoplakia involving the buccal mucosa.

In each patient the lesion was marked into two halves and the anterior part was treated with Diode laser and the posterior half with Er,Cr:YSGG laser. Two different lasers were used to treat two separate halves of the same lesion in order to compare the pain experienced by the patient with the use of both lasers and also to compare bleeding during procedure and wound healing on 7^{th}, 14^{th} and 21^{st} post- operative days simultaneously.

This is a pioneer study, as previously no studies have been reported in the literature comparing the effectiveness of Diode laser (940 nm) and Er,Cr:YSGG laser (2780 nm) in the treatment of oral leukoplakia.

In this present study pain has been assessed using three different Pain Rating Scales such as Behavioral Pain Rating Scale, 'Faces' Pain Rating Scale and Visual Analogue Scale. This is the first time that all three Pain Rating Scales have been incorporated in assessing pain.

The following results were obtained from this present study:

1. Comparing and assessing for each patient using Behavioral Pain Rating Scale during the Diode laser and Er,Cr:YSGG laser procedure yielded **insignificant** result with **p- value of 0.061**.

2. The 'Faces' Pain Rating Scale yielded **significant** result with a **p-value of 0.001** which implied that pain experienced by patients with Diode laser procedure was less in comparison to use of Er,Cr:YSGG laser. And it was noted that pain gradually reduced from the first post-operative day after treatment and patient experienced no pain on the 5^{th},6^{th},7^{th} post- operative days in all five patients with Er,Cr:YSGG laser and Diode laser.

3. The Visual Analogue Scale yielded **highly significant** result with a **p- value of 0.000** which implied that Diode procedure caused minimal pain when compared to Er,Cr:YSGG laser in the treatment of oral leukoplakia and pain reduced gradually after treatment with no pain experienced on the 5^{th}, 6^{th}, 7^{th} post- operative day in both Diode laser and Er,Cr:YSGG laser.

4. In the present study hemostasis was well achieved with the use of Diode laser than Er,Cr:YSGG laser because Diode laser (940nm) is well absorbed by hemoglobin. No comparative study has been previously conducted to analyze hemostasis between the Diode laser

and Er,Cr:YSGG laser in the treatment of oral leukoplakia but has comparative studies on other soft tissue lesions.

5. And in the present study both Diode laser and Er,Cr:YSGG laser showed soft tissue wound healing after 14th post–operative day. This is the first time a comparative study has been conducted to assess wound healing using Diode laser and Er,Cr:YSGG laser in the treatment of oral leukoplakia.

This pioneer study in which the effectiveness of Diode laser with a wavelength of 940 nm has been compared with the effectiveness of Er,Cr:YSGG laser with a wavelength of 2780 nm which is a hard tissue laser. In this present study it was noted that both Diode laser and Er,Cr:YSGG laser showed excellent wound healing post- operatively concluding that both the lasers can be used in the treatment of oral leukoplakia. In relation to hemostasis, Diode laser was found to be superior to Er,Cr:YSGG laser as Diode laser is well absorbed by hemoglobin, whereas Er,Cr:YSGG laser is absorbed by water and hydroxyappetite crystal. In relation to pain, Diode laser caused minimal pain when compared to Er,Cr:YSGG laser which caused more pain during the procedure except for one patient who experienced severe pain with the use of both the lasers which concluded that pain can be subjective. Diode laser is less painful when compared to Er,Cr:YSGG laser because the wavelength of 940nm is less when compared to Er,Cr:YSGG laser

wavelength which is about 2780 nm which could cause more thermal damage causing more pain compared to Diode laser.

Moreover Diode laser was portable and easy to handle and less expensive when compared to Er,Cr:YSGG laser.

The study concluded that Diode laser with the wavelength of 940nm can be used in the treatment of oral leukoplakia with no to minimal pain , excellent hemostasis and wound healing with no post- operative complications and Er,Cr:YSGG laser being a hard tissue laser with a wavelength of 2780nm caused minimal discomfort to patient and profuse bleeding during procedure and good healing outcome in treatment of oral leukoplakia concluding that Er,Cr:YSGG laser can also be considered in the treatment of oral leukoplakia.

While comparing both the lasers, in this present study it has been concluded that Diode laser (940nm) is superior to that of Er,Cr:YSGG laser in treating oral leukoplakia.

Considering the small sample size used in this present study, the study with large proportion of samples may be necessary to confirm the results of our study conclusively.

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BOPRS_Diode Laser					BOPRS_Erbium Laser					FPRS_Diode Laser							FPRS_Erbium laser							VAS_Diode Laser							VAS_Erbium Laser						
Face_D	Legs_D	Activity_D	Cry_D	Consolability_D	Face_E	Legs_E	Activity_E	Cry_E	Consolability_E	1st day_D	2nd day_D	3rd day_D	4th day_D	5th day_D	6th day_D	7th day_D	1st day_E	2nd day_E	3rd day_E	4th day_E	5th day_E	6th day_E	7th day_E	1st day_D	2nd day_D	3rd day_D	4th day_D	5th day_D	6th day_D	7th day_D	1st day_E	2nd day_E	3rd day_E	4th day_E	5th day_D	6th day_D	7th day_D
0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0	0
0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0	0
0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0	0	0	3	2	1	0	0	0	0
1	1	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0	2	1	0	0	0	0	0	1	1	0	0	0	0	0	4	3	1	0	0	0	0
2	2	2	2	2	2	2	2	2	2	5	4	3	2	1	0	0	5	4	3	2	1	0	0	10	8	5	4	3	0	0	10	8	6	4	3	0	0

smoking duration	smoking frequency	alcohol duration	alcohol frequency	Chewing duration	chewing frequency	Size of Lesion	Type of Leukoplakia
20	9	15	15	5	3	3	2
7	6	7	15	0	0	2	1
7	6	7	15	0	0	2	1
10	9	10	4	0	0	2	1
25	15	25	15	15	3	2	1

RAGAS DENTAL COLLEGE AND HOSPITAL

Department of Oral Medicine and Radiology

CASE HISTORY PROFORMA

Comparing the Effectiveness of Diode Laser and Er,Cr:YSGG Laser in the treatment of Oral Leukoplakia.

OP No: Date:

Serial No:

Name:

Age: years: Gender: Male / Female

Occupation: Monthly income: Rs.

Address:

Phone number:

Chief Complaint:

- Duration

History of Presenting Illness:

Past Medical History:

Personal History: Habits with duration, frequency and intensity

Smoking:

- Cigarette :
- Beedi :
- Pipe :
- Hookah :
- Reverse smoking :

Smoke less tobacco consumption:

Alcohol consumption:

Intraoral Examination:

B) Soft Tissue Examination: Lesion:

Site -

Size -

Type -

Extent-

Scrapable/ Non- Scrapable

Provisional Diagnosis:

Histopathological Report:

I. Dates on which the treatment was commenced and the follow- up:

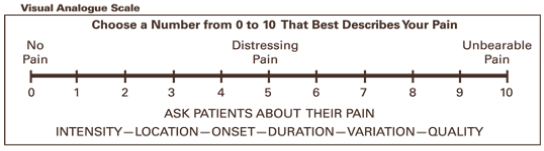
Diode Laser and Er,Cr:YSGG Laser Therapy:

Day of Treatment	7th post operative day	14th post operative day	21st post operative day

II. Pain Scale of patient assessed for the study:

Figures: Tools Commonly Used to Rate Pain

Visual Analogue Scale



"Faces" Pain Rating Scale

Behavioral Observation Pain Rating Scale

Categories	Scoring		
	0	1	2
Face	No particular expression or smile; disinterested	Occasional grimace or frown, withdrawn	Frequent to constant frown, clenched jaw, quivering chin
Legs	No position or relaxed	Uneasy, restless, tense	Kicking, or legs drawn up
Activity	Lying quietly, normal position, moves easily	Squirming, shifting back and forth, tense	Arched, rigid, or jerking
Cry	No crying (awake or asleep)	Moans or whimpers, occasional complaint	Crying steadily, screams or sobs, frequent complaints
Consolability	Content, relaxed	Reassured by occasional touching, hugging, or talking to. Distractable	Difficult to console or comfort
Each of the five categories (F) Face; (L) Legs; (A) Activity; (C) Cry; (C) Consolability is scored from 0-2, which results in a total score between 0 and 10.			

III. Bleeding scored during both Diode laser and Er,Cr:YSGG laser procedure:

	Minimal	Profuse
BLEEDING	1	2

LETTER INFORMED CONSENT

I, ……., the undersigned hereby give my consent for using the Diode Laser and Erbium, Chromium: YSGG laser for the treatment of white lesion on the cheek inside my mouth, for the study of 'Comparing the effectiveness of Diode laser and Er,Cr:YSGG laser in the treatment of Oral leukoplakia' by Dr. Sonali Sarkar under the guidance of Dr. S. Kailasam, Professor and Head, Department of Oral Medicine and Radiology, Ragas Dental College and Hospital, Chennai-600119. I have been informed and explained the status of my disorder, evaluation procedure, risk involved in the treatment and the likelihood of the outcome. I also understand and accept this as part of the study protocol there by voluntarily, unconditionally and freely give my consent to participate in the study without any fear or pressure in a mentally sound and conscious state.

Patient's signature

Witness / representative:

Date:

Place:

ஒப்புதல் படிவம்

---------- என்கின்ற நான், சென்னை ராகாஸ் பல் மருத்துவக் கல்லூரி மற்றும் மருத்துவமனையின் வாய் மருத்துவம் மற்றும் ஊடுகதிர் துறையில் பேராசிரியர் **மரு. கைலாஸம்** அவர்களின் மேற்பார்வையில், முதுநிலை (M.D.S) பட்டப்படிப்பு பயிலும் மரு. சோனாலி சர்கார் அவர்கள் மேற்கொள்ளும் ‘‘வாய் உட்புறத்திசு வெண்படலத்துக்கான சிகிச்சையில் Er,Cr:YSGG லேசர் மற்றும் டையோடு லேசர் சிகிச்சைமுறையின் மேம்பாட்டினை ஒப்பிட்டு அமையும் ஆய்வு’’ என்கின்ற ஆராய்ச்சிக்கான பரிசோதனைகளுக்கு என்னை உட்படுத்துவதற்கு எனது மனமுவந்த பரிபூரண சம்மதத்தினை அளிக்கிறேன்.

மேலும் எனக்கு என்னுடைய நோயின் தன்மையைபற்றியும், அதனால் ஏற்படக்கூடிய விளைவுகளைப்பற்றியும் எடுத்துக் கூறப்பட்டுள்ளது எனவும், இந்த பரிசோதனைக்கு நான் எந்தவித அச்சமுமின்றி தன்னிச்சையாகவும், தெளிவான முழு மனதுடன் என்னுடைய பரிபூரண சம்மதத்தினை அளிக்கிறேன் என இதன் மூலம் தெரியப்படுத்துகிறேன்.

சாட்சியாளர்கள்: இப்படிக்கு