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COMPARATIVE CLINICAL EVALUATION OF 450 NM AND 980 NM LASER WAVELENGTHS FOR SAFETY AND EFFICACY IN ENT TREATMENT VIA LASER ABLATION

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ABSTRACT

Mesic™ (Meril Medical Innovations Pvt. Ltd.,Vapi, Gujarat, India) Laser ablation as per International Organization for Standardization ISO 13485 user performance criteria. It has become a very useful method of ENT surgery because of its precision and minimally invasive nature. From the most widely used diode lasers, both the 450 nm (blue light) and 980 nm (near-infrared) wavelengths Mesic™ laser have their own specific benefits, which are to a great extent based on how different tissues absorb these wavelengths. These differences affect thesurgeon's capacity for precision, bleeding control, thermal effect management and the way patient recover from surgery. **Objective:** The main goal of this research was to assess surgical results in ENT/otolaryngology operations conducted with 450 nm and 980 nm diode lasers. The research particularly focused on evaluating surgical accuracy, the healing process, the degree of thermal tissue damage, and the efficacy of hemostasis obtained with each laser wavelength. **Methods:** Five ENT cases were treated with diode lasers of 450 nm and 980 nm wavelengths. Laser- assisted therapy was chosen on the basis of pathology, and parameters were tuned to achieve coagulation, carbonization, vapourization or precision ablation with minimal thermal injury to check postoperative healing speed and quality, and overall surgical efficacy. The treatment was done with 400 μm bare fiber optic in continuous mode. Postoperative management involved clinical monitoring, pharmacological support, and planned follow-ups to determine recovery, relief of symptoms, and recurrence of different otolaryngology. **Results:** The 450 nm laser was more precise in surgery, induced less thermal damage to neighboring tissues, and facilitated more rapid healing, and was particularly applicable for precise soft tissue procedures. The 980 nm laser, on the other hand, offered more force and penetration, and was more suitable coagulation force and penetration, and was more suitable for treating vascular lesions and excising greater volumes of tissue, although it produced more thermal effects. **Conclusion:** Both Mesic™ Laser wavelengths are valuable instruments in ENT surgery, but use must be determined by surgical requirements. 450 nm is best suited for delicate, subtle work and quick patient recovery, whereas 980 nm works better with strong hemostasis and more vascular or deeper tissues.

INTRODUCTION

Laser ablation is a simple yet efficient method used to remove solid material from surfaces by focusing a laser beam on a targeted area. The outcome depends on the laser's intensity at lower energy levels, the material either evaporates or sublimates due to heat absorption, while at higher intensities, the material can transition into plasma (Saha et al., 2023).This process relies on thermal evaporation, where a focused laser beam delivers energy to a specific part of a light- absorbing material, typically within a liquid or gas environment. The intense heat causes the surface atoms to evaporate. These atoms then interact with surrounding mol-

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ecules, triggering electron excitation, light emission, and the generation of ions and free electrons, which together form a laser-induced plasma plume. The characteristics of this plasma based on various parameters, including the type of material, the ambient medium, environmental pressure, and the properties of the laser itself (Shahid et al., 2022).

As a low-damage and specific treatment method, laser ablation successfully treats tumors within the liver, brain, thyroid, and even bones. It is a process in which focused laser light energy is directed to target tissues that absorb the energy and convert it into heat. The resulting heat kills abnormal cells, thereby facilitating the removal of the tumor. Silica fiber optics are ideally suited for such applications, as they can transmit high-energy through a thin, flexible platform well- suited for minimally invasive interventions (Ahrar et al., 2010).

Laser surgery offers numerous clinical advantages, including shorter operative times and the dual ability to cut and coagulate tissue simultaneously. This increases visibility of the operating field, in most instances eliminates the use of sutures, and can reduce postoperative pain by a great extent in others, making anesthesia unnecessary. In addition, laser treatment disinfects the surgical field and promotes quicker, more effective healing by biostimulation, reducing dependence on drugs and enhancing the general comfort of patients (Fornaini et al., 2017).Lasers either have continuous or pulsed mode of functioning depending on the clinical application. The choice relies on the tissue to be worked upon and the character of the desired therapeutic effect. Lasers may be used either in contact with tissue or in near-contact mode a few millimeters away from tissue. In contact mode, lasers vaporize or coagulate tissue depending on power levels, while in near-contact mode with the laser handpiece a few millimeters removed from tissue, photocoagulation is the prevailing effect. This is particularly useful in the management of bleeding as pigmented molecules like melanin and hemoglobin have very strong absorption of laser energy (Karkos et al., 2021).

To be applied to surgery, knowledge of the physics of lasers enters into the picture, especially

because very intense lasers are usually the instrument of choice. The intensity is achieved through light amplification, by the excitation of atoms in the optical cavity of the laser and their return to a lower energy state releasing additional photons. The photons bounce back and forth between the mirrors of the cavity, accumulating the light until it is emitted as an extremely collimated beam. The three optical properties that characterize surgical lasers are monochromaticity (emission of light of a single wavelength), coherence (synchronized light waves moving in concert), and directionality (an extremely collimated beam). They facilitate the focused tissue interaction that surgeons are able to achieve.

Laser power, in watts (W), sets the rate of energy delivery. Spot size, the region that delivers most of the energy of the beam, can be varied to control energy concentration. The quantity of delivered energy is measured in joules (J), whereas power density (irradiance), in watts per square centimeter (W/cm^2), dictates tissue removal rate. Although it might follow logically to use low power to reduce collateral damage, in practice, using higher power for a shorter duration may offer maximum precision with minimal thermal damage to the surrounding tissue (Yan et al., 2010).

Different types of lasers possess differing physical and optical properties, such as wavelength, a critical factor that dictates tissue interaction and depth penetration. The tissue (pigmented or non- pigmented) a laser can interact with and depth penetration are distinct by wavelength (Paiva et al., 2021).

Solid-state, diode lasers employ semiconductor technology to generate coherent light, often infrared. They find widespread application in precise treatment of soft tissues because they have high absorption by such chromophores as melanin and most significantly, oxyhemoglobin. The 980 nm wavelength finds widespread use in dental and soft tissue surgery, offering effective tissue removal and hemostasis. In recent years, the 450 nm blue diode laser has been launched for surgical applications. It is maximally absorbed by hemoglobin and so is best suited for quick, accurate soft tissue cuts with minimal oozing. It has been found to produce encouraging outcomes in the majority of intraoral procedures like gingivectomy, exposed impacted tooth, and soft tissue biopsy. Though an immense amount of comparative data on the previous scalpel techniques and 980 nm diode lasers is present, clinical studies on the efficacy of 450 nm blue diode lasers are just starting now. Current interest lies in comparing intraoperative and postoperative outcomes of procedures like frenectomy performed with 450 nm and 980 nm diode lasers (Sobouti et al., 2024).

The 450 nm blue diode laser wavelength is within the visible light range and is highly absorbed by hemoglobin, moderately absorbed by melanin, and weakly absorbed by water. It is thus best indicated for soft tissue surgery where it makes clean incisions with adequate coagulation and least thermal damage. It is best utilized in procedures like gingivectomy , soft tissue biopsy, and exposition of impacted teeth. It is not very useful in deep coagulation procedures as it has low absorption in water-retaining tissues.

In contrast, the 980 nm diode laser, which emits light in the near infrared, is strongly absorbed by hemoglobin and water. Although its hemoglobin absorption is slightly lower than that of the 450 nm laser, it remains highly effective in promoting hemostasis and coagulation, making it particularly suitable for treating highly vascular tissues. Due to its relatively greater deeper penetration in tissues and greater thermal effect, the 980 nm laser is employed routinely in soft tissue surgery, periodontal treatment, and frenectomy. Although it is very effective in removing large tissue quantities, however, the extra heat generated produces greater thermal damage and greater postoperative pain than the 450 nm laser.

In short, both the 450 nm and 980 nm laser wavelengths have distinct, procedure-specific advantages, making it advisable to select the wavelength based on the individual treatment requirements.

Table: 1 Comparison between 450nm and 980nm Laser

Feature	450 nm Laser	980 nm Laser
Wavelength	450 nm (Blue)	980 nm (Near-Infrared)
Absorption Target	Hemoglobin (high), Melanin, water(very high)	Hemoglobin (moderate), Water (high)
Cutting Precision	Very high	Moderate
Bleeding Control	Excellent	Good
Depth of Penetration	Shallow	Deeper
Thermal Damage	Minimal	Higher
Best Use	Fine, bloodless incisions	Coagulation and bulk tissue ablation
Color (Visible)	Bright Blue	Invisible(appear red with targeting beam)
Medical use	Dermatology, Dental application, surgical cutting, superficial skin treatment	Pain therapy, soft tissue surgery, vein ablation, hair removal, skin tightening
Optical Fiber	Poor transmission in fibers	Good transmission in fibers
Visible to Eye	Yes(very bright and intense)	No(requires guide beam)
Eye safety risk	High risk due to intensity	Higher risk (invisible beam)
Application Type	Surface level cutting	Internal/ Deep tissue treatment
Cost	Typically less expensive	Generally more expensive
Beam Divergence	Higher Divergence(spreads more quickly)	Lower Divergence(Tighter beam)
Chromophores Targeting	Targets superficial chromophores	Targets deeper Chromophore
Collimation and Focusing	Harder to maintain a tight beam at distance	Easier to collimate over long distances
Wavelength Stability	Slightly more sensitive to temperature change	More stable under temperature variation
Cooling Requirements	Easier to cool at moderate power	May need more active cooling at high power

Specific Advantages and recommended applications of 450nm and 980nm wavelength **Laser**

450 nm Laser Precise Soft Tissue Dissection: Hemoglobin has strong absorption at 450 nm and can thus provide very precise soft tissue dissection and vaporization with little heat-related injury to the surrounding tissues. Its precision makes it very useful for intricate procedures such as polyp removal and vocal fold surgery (Nguyen et al., 2021).

Less Blood Loss Intraoperatively: Its capability to close the vessels tightly during dissection reduces blood loss and improves visibility on the operating field, especially in highly vascular tissues like the nasal passages.

Improved Healing: It has been proven through research that the 450 nm laser has improved healing and less pain following surgery by initiating the regeneration of tissue.

980 nm **Laser**

Effective Blood Coagulation: Like the 450 nm laser, the 980 nm wavelength is also absorbed very effectively by water and hence very effective for coagulating blood vessels and arresting bleeding and thus enhancing surgical visibility.

Multi-purpose Applications: The 980 nm laser has multiple clinical applications in ENT surgery, including tissue incision, vaporization, coagulation, even photodynamic therapy (PDT) for cancer treatment.

Minimally Invasive: The accuracy of the 980 nm laser can lead to less invasive procedures with smaller cuts and faster recovery for the patient.

450 nm (blue light) and 980 nm (near-infrared) diode lasers are both common in medical and dental clinics, yet they interact differently with tissues and have specific clinical applications.

The 450 nm laser, which lasers in the blue range, is particularly useful in soft tissue surgery like frenectomies, tissue vaporization, vascular lesion treatments, root canal sterilizations, and some material processing therapy. Because it heavily absorbs in hemoglobin and melanin upon traveling over water, it can produce extremely precise cuts with minimal diffusion of heat, which facilitates faster healing. It can also be used in non-contact mode, preventing overheating of implants, and possesses high peak power with very short pulse durations. Its applications may be somewhat limited than the more versatile 980 nm laser.

In contrast, the near-infrared 980 nm laser is most commonly used for photocoagulation, wound healing, analgesia, photobiomodulation, and disinfection of root canals. Its high tissue coagulation factor has also rendered it a clinically beneficial tool in dermatology and other procedures, but it is found to require greater powers and to generate higher heat in surrounding tissues.

Though both lasers are highly utilized in dermatology and dentistry, the 450 nm laser is mainly used for accurate soft tissue operations and the 980 nm laser for coagulative and treatment purposes. Blue lasers, with their more compact wavelength, are intensely absorbed by major soft tissue components like hemoglobin and melanin. Blue light therefore penetrates to significantly shorter depth in tissue compared to red light.

This surface penetration decreases the chance of inadvertently changing deeper layers of tissue and provides the surgeon with greater control of the laser. Due to the high water, hemoglobin, melanin, lipid, and protein content of soft tissue, blue laser energy is well absorbed, allowing successful tissue ablation and coagulation. The coagulated tissue plug occludes the blood vessels, and minimal bleeding occurs to the surface. These absorption characteristics allow the blue laser to produce clean, bloodless incisions while minimizing harm to surrounding tissues. Early clinical studies indicate that 450 nm laser technology shows considerable promise as a surgical tool for precision cutting (Braun et al., 2018).

Blue lasers, when used at low energy levels, can make very accurate cuts with minimal bleeding, as well as prevent unwanted coagulation of the surrounding tissue. There is still not much evidence yet, however, of how high-power blue lasers function when it comes to soft tissue ablation, i.e., to vaporize and coagulate tissue. 450 nm high-power diode blue laser has, however, been shown to be able to vaporize tissue well with minimal penetration and with effective coagulation and minimizing thermal damage to surrounding tissue (Jiang et al., 2019).

The blue laser at 450 nm used in dermatology is also absorbed by melanin and may also be used to treat such cutaneous disorders as lentigines. Blue lasers and blue light sources are gaining growing interest for a variety of skin treatments. They are now being explored for uses such as photodynamic diagnosis and therapy (using blue-violet wavelengths), treatment of actinic keratosis, and managing lichen sclerosus. Blue light is also being used in acne therapy, for controlling excessive sebaceous gland activity, and even for stimulating hair growth (Szymanczyk et al., 2021).

A newer diode laser system with a wavelength of 980 nm is believed to provide the best compromise between water absorption and hemoglobin absorption such that it can ablate tissue as well as cause excellent haemostatic control (Wendt-Nordahl et al., 2007). The 980 nm diode laser is greatly prized in contemporary medical practice for its minimally invasive, precise, and capacity to facilitate faster patient recovery over conventional surgical methods. Its high coagulation effect greatly minimizes blood loss during operations, enhancing clarity for the surgeon, something particularly important in ENT procedures and other sensitive areas where precision and avoiding complications are essential (La Terra et al., 2025).In addition to its accuracy and coagulative advantages, the 980 nm laser is also extremely versatile, utilized for a range of ENT procedures including tissue ablation, coagulation, vaporization, and photodynamic therapy (PDT) for the treatment of tumors. Its capacity to allow smaller, more accurate cuts leads to less tissue damage and quicker healing for patients. The 980 nm diode laser's versatility is also seen in many medical specialties, being found to work well in dentistry, neurosurgery, dermatology, and photobiomodulation therapy (Gupta et al., 2012). In dentistry procedures, it is used for many soft tissue procedures like gingivectomy and gingival troughing, with good control of bleeding and moisture. Clinical outcomes indicate tissue healing generally happens within two weeks (Paiva et al., 2021). In neurosurgery, the intense coagulative ability of the laser assists in reducing intraoperative hemorrhage and preventing damage to the adjacent brain tissue.

This leads to shorter surgery times and improved patient safety (Desiate et al., 2009). In dermatology, 980 nm wavelength has been effectively utilized to cure benign pigmented and vascular facial lesions with complete healing and without scarring within 15 days. In photobiomodulation therapy, the wavelength also causes bone regeneration by causing differentiation of periodontal ligament stem cells, and thus becomes a new dental regenerative treatment instrument (Tabatabaei et al., 2023).

Overall, the 980 nm diode laser stands out as fairly effective and little more versatile technology with wide-ranging applications across surgical and therapeutic domains.

LITERATURE REVIEW

Laser ablation, a process where material is removed from a solid surface using a concentrated laser beam, originated in the early 1960s, around the same time the laser itself was invented (Choy, 1988). Early research focused largely on understanding how lasers interact with matter, with most applications confined to laboratory experiments. However, by the 1980s, growing interest in the technique began to reveal its potential in a wide range of scientific and medical fields (Miller, 1994).

A major breakthrough came in 1985 when Alan Gray at the University of Surrey successfully combined laser ablation with inductively coupled plasma mass spectrometry (LA-ICP-MS), enabling highly precise chemical analysis of solid materials (Sylvester et al., 2016). Since then, the use of laser ablation has broadened considerably. In medicine, it has become an essential tool in procedures such as laser angioplasty and treatment of cancer, e.g., laser interstitial thermal therapy (Smilowitz et al., 2016). In materials science, it is also widely used to synthesize nanoparticles, deposit thin films, and examine advanced materials (Yan & Douglas, 2012). Laser ablation has also been used in life sciences for particular studies of tissue and nerves. Key milestones include clinical uses of laser angioplasty in 1983, first laser-assisted synthesis of nanoparticles in 1987, and FDA approval of some laser treatments by 2002 (Wang & Grace, 2004). New technologies, such as the invention of femtosecond lasers and advanced imaging modalities, continue to enhance the accuracy, productivity, and resolution of laser ablation in a wide range of applications.

Since the late 1990s, laser ablation has made tremendous progress, particularly with the medical use of the 980 nm lasers and more recently the 450 nm lasers for soft tissue surgery and dermatology. Classic diode lasers of the 810 nm and 980 nm wavelengths were the most frequently used choice for clinical applications because of their high hemoglobin and water absorption, giving precise cutting and coagulation (Mordon et al., 2007). However, the 450 nm blue laser has become a favorite of late years for its unparalleled precision and with the promise of advantages in delicate surgical areas like oral and urological surgeries (Fornaini et al., 2017). As a relatively new technology, the 450 nm laser is now studied intensively for procedures like gingivectomy and bladder tissue ablation. With high hemoglobin absorption, it offers precise cutting with less thermal damage to surrounding tissues, hence being best suited for mucosal and epithelial surgery (Min et al., 2001). Its effectiveness is also studied for ablation of upper tract urothelial lesions and other soft tissue applications (Jiang et al., 2023). The 980 nm diode laser, on the other hand, is already a mature and stable technology that has been extensively applied to endovenous laser ablation (EVLA) for varicose vein treatment. Comparative analysis has testified to its clinical effectiveness and safety over other wavelengths, e.g., 1470 nm (Min et al., 2001), (Kadakol et al., 2011). Outside the field of vascular therapy, the 980 nm laser is also in high demand in dermatology for the treatment of vascular lesion, wart, sebaceous cyst, and superficial metastasis (Kadakol et al., 2011). It has also been successful in renal and prostate tissue ablation, leveraging its deep penetration and high coagulation (Lee et al., 2012).

Lastly, the choice between a 450 nm or a 980 nm laser is one of the specific clinical case, the tissue in question, and the desired operative result. Although the gold standard of 980 nm dominates for most accepted indications, the 450 nm laser is rapidly becoming an invaluable tool for precision procedures, a welcome enhancement to the clinical use of laser technology (Jiang et al., 2023), (Fornaini et al., 2017).

"Mesic™ Laser System: Versatile. Precise. Portable."

Meril's Mesic™ Laser Ablation System is carefully engineered to address the changing needs of contemporary medical devices. Lightweight and transportable, this third-generation device boasts unmatched mobility for clinicians, supported by a powerful built-in rechargeable lithium battery. In hospital or outpatient clinic environments, Mesic™ offers hassle-free operation with its easy-to-use high-resolution touchscreen display, which offers direct access to a library of advanced preset treatment protocols, helping to streamline procedures and improve patient care.

At the heart of Mesic™ is a highly engineered laser generator, allowing the practitioner the versatility to optimize important parameters such as wavelength, output power, pulse duration, repetition rate, and pilot beam settings to each individual case. The working with sensitive tissues or addressing deeper structures, the system accommodates with ease in the instrument. The intentional provision of varied cannula sizes ensures flexibility between diverse anatomical areas, while specially engineered ergonomic handpieces firmly support the laser fiber to provide accurate and uniform energy delivery precisely where it's required.

In clinical application, Mesic™ revolutionizes varicose vein treatment. It targets specific laser energy to ablate and close dysfunctional veins, alleviating discomforts of pain, swelling, and inflammation. The patient enjoys a less invasive method, often having faster recoveries and rapid return to normal activities. Yet the worth of Mesic™ goes far beyond vascular treatment Its availability makes it an effective collaborator in physiotherapy, ENT treatments, and even veterinary medical devices, offering targeted tissue therapy facilitating increased healing and better outcomes in all medical specialties. Its being able to function for both contact and non- contact applications adds to its versatility.

In contact mode, the laser fiber is in direct contact with the tissue to have precise photocoagulation or vaporization depending on the power levels low for coagulation and high for ablation of the tissue. For very sensitive procedures, non-contact mode allows the fiber tip to hover millimeters above the tissue, with touchless photocoagulation that is ideal for sensitive areas like the ear, nose, and throat.

Table 2 . Generator Specifications

Technical Specifications of Generator	
Wavelength	450nm | 980nm
Maximum Power	10W
Operation Mode	CW, or Repeat Pulse
Pulse Duration	10μs - 3s
Repetition Rate	1Hz - 20KHz
Pilot Beam	Red Diode Laser of 650nm,Power <5mw
Control Mode	True Color Touch Screen (7 Inches, Resolution 600*1024)
Transmission System	Medical Fibers with SMA905 Connector
Dimensions	160(W)*180(L)*235(H)mm
Weight	2.1 Kg

Clinical Study

Table 3. Patient`s Details

Cases	Sex	Age	Medical history	Diseases	Wavelength utilized	Locations
1	Female	32yrs	Tobacco addiction and Hypertension	Ranulas or Mucous Retention cysts	980nm	Bhavnagar
2	Male	33yrs	Tobacco and smoking	Pharyngeal Papilloma	980nm	Rajkot
3	Female	35yrs	-	Cholesteatoma cyst	980nm	Rajkot
4	Male	40yrs	Tobacco, High Blood Pressure	Granuloma	450nm	Mumbai
5	Male	48yrs	Diabetes	Stapes Otosclerosis	450nm	Hyderabad

Case-1

In the case under consideration, a patient who was 32 years old came with mucoceles that had extended to Ranulas, benign mucous retention cysts present below the mucosal lining of the throat. The cysts were dome-shaped, fluid-filled, painless lesions, but were very uncomfortable for the patient on swallowing, produced mild pain, partial airway blockage, and difficulties in speaking. The patient had a history of hypertension and previous tobacco consumption.

After initial treatment with pharmacological management of inflammation and symptom relief, the decision was made to continue with laser ablation therapy as a minimally invasive procedure.

The treatment was undertaken with a diode laser system having a solitary generator unit attached to a bare fiber optic of 400 µm diameter. Laser parameters were established at continuous mode, emitting 0.4 watts of power, with 20 joules of total energy delivery and an energy density of 0.4 J/cm. The laser was applied at treatment to precisely ablate and cauterize the inflamed cystic tissue, effectively relieving the patient's symptoms. Postoperative care included strict clinical observation over the following days, as well as a specially prescribed course of medication to facilitate healing and prevent secondary infection.

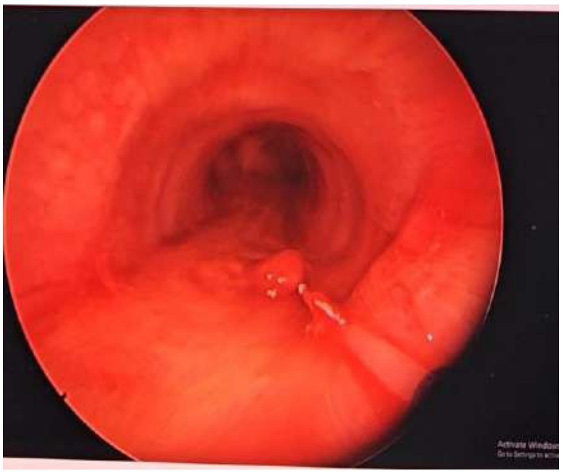

Fig. 1. Image presenting Mucocele cyst before the treatment by laser ablation

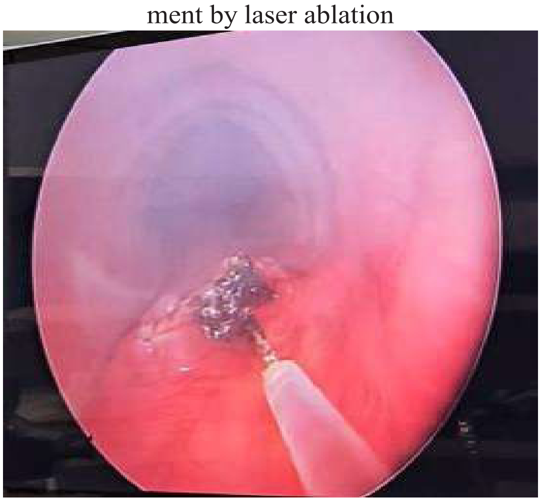

Fig.2. Image presenting Mucocele cyst after treatment by Laser ablation diode

One month after the procedure, a follow-up assessment was carried out to track recovery, when the patient exhibited noticeable improvement in symptoms and general well-being.

Case-2

A 33-year-old man with a history of tobacco and cigarette smoking was seen with chronic discomfort in the throat. His symptoms were chronic cough, hoarseness, respiratory distress due to airway partial obstruction, a feeling of a mass during swallowing, and dysphagia. He was diagnosed with Pharyngeal Papilloma—a benign epithelial tumor in the oropharyngeal area, which appears visually as warts and is correlated with an active viral infection. As a component of diagnostic investigation, the patient had an HPV test and an endoscopy, both of which indicated the existence of Pharyngeal Papilloma due to Human Papilloma Virus (HPV). There was no relevant relief in symptoms after pharmacological therapy, and therefore, laser ablation therapy was opted as an interventional treatment.

The treatment was performed by means of a diode laser system that included a laser generator, an unclad fiber optic (400 µm in diameter), a precision handpiece, and two cannulas (18G*30 and 18G*80) to enhance access and control. Laser parameters were adjusted to work in continuous mode, providing 2 to 4 watts of power with a total energy of 36 joules. This configuration allowed for the accurate and controlled ablation of the papillomatous tissue with a minimum of collateral thermal damage.

After the removal of successful lesions, the patient was admitted to a postoperative care unit and treated with supportive therapy to facilitate healing and minimize the chances of infection. He was discharged after stabilization with a planned follow-up scheme, starting with frequent post- procedure check-ins before graduating to monthly reviews to check for recovery milestones as well as any recurrence of the lesion.

Fig. 3. Image presenting treatment of Papillomatous growths by laser ablation system during clinical trial

Fig. 4. Image of post clinical trial

Case-3

In the third scenario, a 35-year-old female patient came with hearing loss, ear discomfort, and purulent, foul-smelling discharge from the infected ear. After ENT specialist evaluation, a full physical examination was conducted with added imaging through computed tomography (CT) and extensive audiological examinations. The patient was finally diagnosed with a Cholesteatoma—a cystic growth lined with skin located in the middle ear under the tympanic membrane.

Cholesteatomas usually arise due to an accumulation of skin cells in a closed pocket, which becomes air, fluid, or debris-filled. Contributing etiologies include chronic otitis media, previous ear surgery, ear trauma, or Eustachian tube dysfunction, usually secondary to upper respiratory tract infections or allergies. Negative pressure generated in the middle ear space can pull the eardrum inward, resulting in the formation of a retraction pocket where there is an accumulation of skin cells, ultimately forming a Cholesteatoma.

Associated symptoms like dizziness and the feeling of ear fullness were reported by the patient. After an incomplete response to initial medical treatment, it was decided to go in for laser

ablation as a minimally invasive procedure. The treatment was done with a 980 nm diode laser system with a single laser generator, bare fiber optic (400 µm diameter), precision handpiece, and cannulas of 18G*30 and 18G*80 sizes. The laser machine was optimized to deliver 1.5 to 2 watts of power in continuous mode, with an overall energy delivery of 25 joules, for targeted ablation of the cholesteatomatous tissue.

Following a procedure, the patient was monitored in a regulated clinical environment and provided with adjunct medications to promote healing and protect against infection. Once stabilized, she was discharged on a follow-up regimen that involved regular visits over the next days and months for monitoring the healing process and potential recurrence

Ablation system during clinical procedure

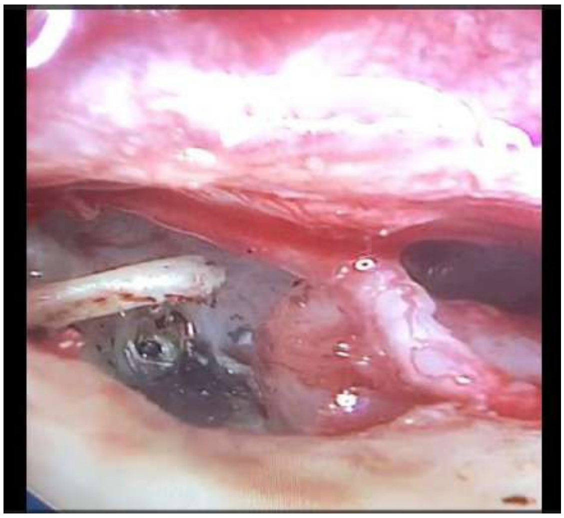

Fig. 5. Pre-procedure image

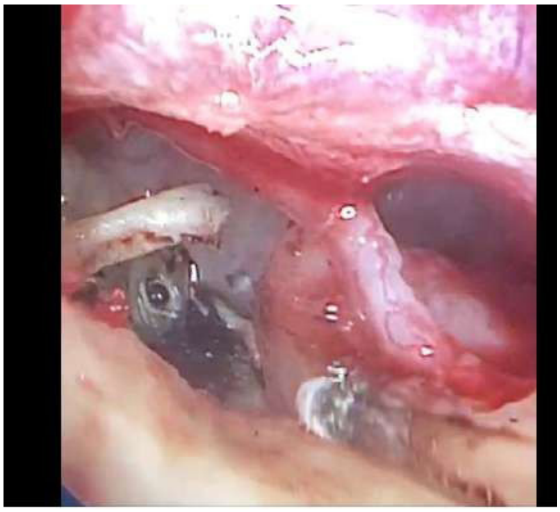

Fig. 6. Blue circle indicating diode of laser

Case-4

A 48-year-old male patient was diagnosed in this case with a Granuloma—a nodule of inflammation that forms as part of the immune response to wall off and encapsulate components that cannot be readily excised. Such materials may be infectious such as bacteria, fungus, or parasites, or non-infectious such as foreign material or autoimmune stimuli. Histologically,

Granulomas are made up of immune cells, macrophages, which have the capability to merge and form multinucleated giant cells, and are typically bordered by fibroblasts and lymphocytes.

The patient had clinical presentations including fever, cervical lymphadenopathy (cervical lymph nodes), dyspnea (shortness of breath), and odynophagia (painful drinking and swallowing). The initial management was pharmacological for the purpose of reducing inflammation and controlling symptoms. Due to continued clinical presentation, a CT scan was recommended for further assessment. As some uncertainty existed in the imaging findings, the trachea was then endoscopically examined, and a granulomatous lesion was confirmed.

After preoperative medical stabilization, the patient had local anesthesia for laser ablation of the granuloma. A 450 nm wavelength laser was employed, using a 400 μm diameter bare fiber optic, with the laser generator set to continuous mode at a power setting of 5 watts, dispensing a total energy of 90 joules to specifically ablate the lesion.

Given the patient's medical history of hypertension and past history of tobacco chewing, he was kept under close postoperative observation. The patient was kept under clinical watch for a few days to achieve steady recuperation, following which he was released with a prescribed medication schedule. A systematic follow-up schedule was followed, with checks taking place over the subsequent days, months, and during the year to check for healing advancement and to identify any possible complications or recurrence.

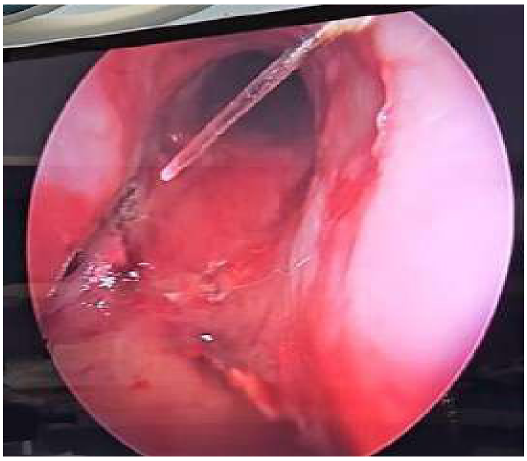

Fig.7. Granuloma being treated with 450nm laser ablation during clinical trial

Case-5

A 40-year-old male patient with a known case history of diabetes was presented with ongoing otalgia (ear ache) and progressive hearing loss. Careful clinical evaluation, including endoscopic evaluation of the middle ear, led to the diagnosis of Stapes Otosclerosis—abnormal growth of bone leading to the fixation of the stapes with the surrounding bony structures. This fixation disrupts the passage of sound vibrations from the tympanic membrane to the inner ear, resulting in conductive hearing loss. The stapes, one of the three middle ear ossicles (the malleus and incus being the other two), is involved in the mechanical transmission of sound

Its fixation in Otosclerosis appreciably handicaps hearing. On diagnosis, the patient was recommended to have a stapedectomy, a surgery for the rehabilitation of hearing by replacing the fixed stapes with an artificial implant. The prosthesis circumvents the stapes that are fused, allowing better transmission of sound waves to the inner ear.

Among the surgical technique, laser-assisted stapedectomy was chosen to provide greater accuracy and less trauma to adjacent tissues. After general anesthesia, a 450 nm diode laser was inserted into the middle ear cavity. The generator of the laser was adjusted to run continuously with 2 watts of power and 25 joules total energy. A blue laser beam was focused onto the stapes bone, allowing for the accurate ablation and removal of ossified bone. Laser energy was delivered via a 400 μm bare fiber optic, allowing controlled and accurate tissue interaction.

Postoperatively, the patient was closely observed under inpatient management and given proper medications to enhance healing and avoid postoperative complications. At the time of discharge, he was started on a protocol follow-up program, with frequent assessments over the ensuing days, months, and into the first postoperative year. Follow-ups were to assess auditory recovery, confirm prosthesis stability, and look for any delayed complications.

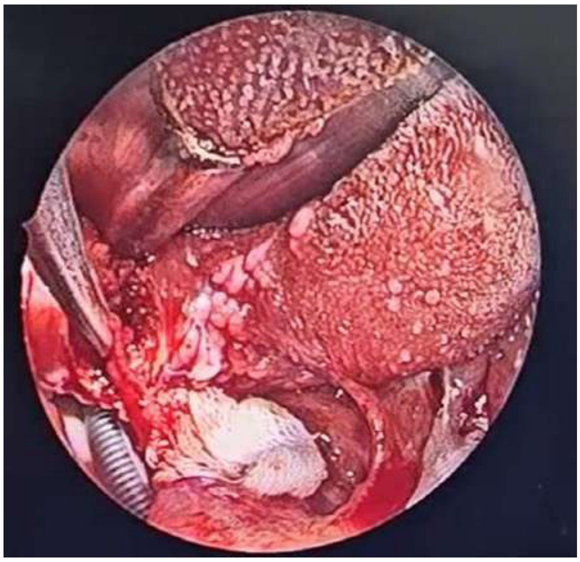

Fig. 8 . Treatment of Stapes Otosclerosis during the clinical trial

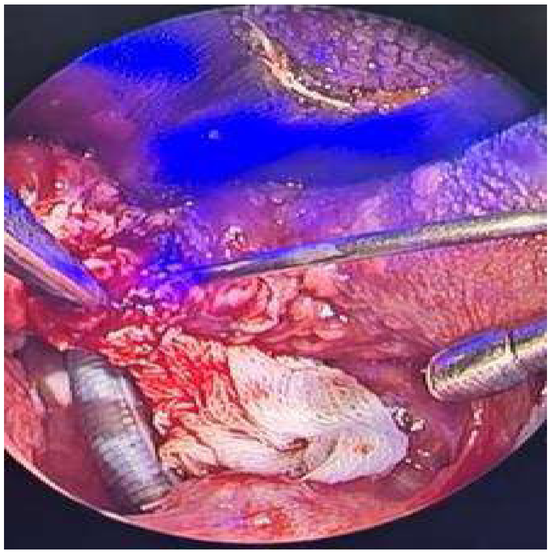

Fig. 9. Treatment of stapes Otosclerosis with blue laser during clinical trial

STATISTICAL ANALYSIS

The combined bar chart reflects a strong preference for the 980 nm laser based on physician ratings, with a greater percentage of "Excellent" ratings than the 450 nm wavelength. But both lasers exhibited good tissue ablation and patient recovery without any reported bad outcomes. The statistical comparison of the five ENT clinical cases proves that diode laser ablation employing both 980 nm and 450 nm wave lengths is very effective and safe for minimally invasive procedures in ENT.

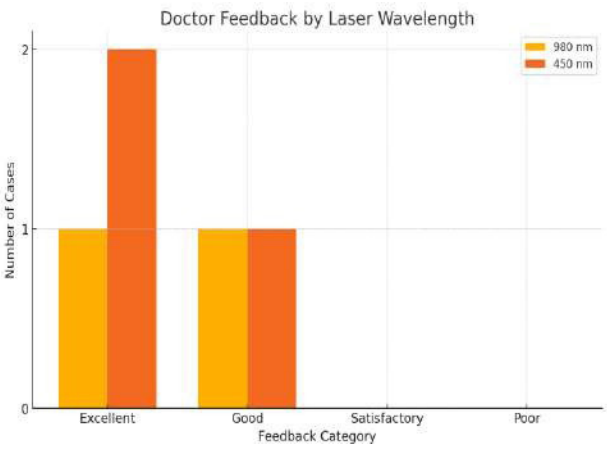

Fig.10. Graphical analysis of clinical outcomes by doctors

There were 60% "Excellent" responses, and 40% were classified as "Good" with no "Satisfactory" or "Poor" results. The overall rate of success was 100%, with no postoperative complications and complete significant clinical improvement in all patients. Postoperative follow-up compliance was also 100%, providing stable postoperative monitoring. When broken down by wavelength, the 980 nm laser attained a greater percentage of "Excellent" feedback (66.7%) than the 450 nm laser (50%), suggesting that there is a slight preference for the 980 nm wavelength according to physician ratings. Both laser modalities were successful with tissue ablation, gave favorable healing results, and exhibited uniform procedural success without complications, validating their clinical value in ENT procedures.

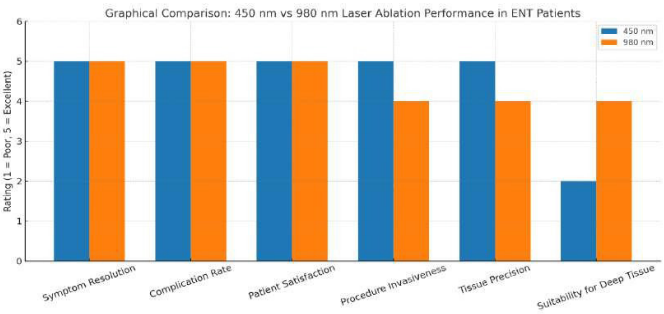

Fig.11. Comparison: 450 nm vs 980 nm Laser Ablation Performance in ENT Patients

The bar graph provides a comparative analysis of the performance of two laser wavelengths— 450 nm (blue light) and 980 nm (near-infrared)—used in ENT (ear, nose, and throat) laser ablation procedures. The evaluation is based on six key performance indicators, each rated on a scale from 1 (Poor) to 5 (Excellent).

In terms of symptom resolution**,** complication rate**,** and patient satisfaction, both 450 nm and 980 nm lasers show equal effectiveness, with each scoring a consistent rating of 5. This indicates that both laser types are similarly effective in treating ENT conditions and maintaining patient safety and satisfaction.

However, when it comes to procedure invasiveness, the 450 nm laser performs significantly better, receiving a full rating of 5, compared to the 980 nm laser which scores only 4. This suggests that the 450 nm laser enables a less invasive surgical approach, potentially reducing patient recovery time and surgical trauma.

Similarly, the 450 nm laser outperforms the 980 nm in tissue precision, again achieving a rating of 5 against the 980 nm's 4. This implies superior control and accuracy in targeting tissues with the 450 nm laser, which is particularly important in delicate ENT surgeries.

In contrast, for suitability for deep tissue applications, the 980 nm laser is rated higher (4), whereas the 450 nm laser scores only 2. This highlights that the 980 nm wavelength has better penetration depth, making it more appropriate for procedures that require deep tissue access.

In summary, while both lasers offer excellent outcomes in general effectiveness and patient satisfaction, the 450 nm laser is superior in terms of precision and minimally invasive application, whereas the 980 nm laser is more suitable for deeper tissue ablation.

RESULTS

This clinical series presents the results of laser ablation treatment in five patients with a variety of otolaryngologic diseases, all of whom had successful outcomes.

In the initial case, a 32-year-old woman diagnosed with Ranulas complained of ongoing difficulty in swallowing and airway obstruction. Following suboptimal response to conservative management, low-power laser treatment (0.4 W, 20 J, 400 μm fiber) was employed, and there was excellent relief of symptoms and improvement in functioning of the airway.

The second patient was a 33-year-old male with chronic sore throat and dysphagia and was finally diagnosed as suffering from Pharyngeal Papilloma caused by HPV infection. Following conservative management failure, the patient received targeted laser excision (2–4 W, 36 J), which eradicated the lesions successfully.

The third patient was a 35-year-old woman with Cholesteatoma-related ear discharge, hearing loss, and vertigo. The 980 nm laser system (1.5–2 W, 25 J) was used to remove the cystic lesion accurately, with progressive hearing recovery and symptom resolution noted on follow-up.

In the fourth case, a 48-year-old male presented with a tracheal Granuloma, dyspnea, cervical lymphadenopathy, andodynophagia. After diagnostic confirmation, high-energy laser ablation (480 nm, 5 W, 90 J) led to substantial improvement of respiratory function and symptom relief.

Finally, the fifth patient, a diabetic male age-40 who had Stapes Otosclerosis causing conductive progressive hearing loss, underwent laser-assisted stapedectomy. A diode laser at 450 nm (2 W, 25 J) enabled precise removal of the immobile stapes, restoring hearing function with no complications.

Together, this series illustrates the versatility, accuracy, and minimally invasive character of laser ablation in various ENT pathologies. Smooth postoperative recovery and lasting symptom alleviation were experienced by patients in all instances, with no serious complications encountered during follow-up.

Acceptance Criteria

450 nm diode laser should exhibit excellent surgical precision with minimal thermal damage to surrounding tissues and be well suited for accurate soft tissue use. Healing in the postoperative period should be significantly quicker and less inflamed in tissues when utilizing this wavelength. The 980 nm diode laser should provide good tissue penetration and vigorous coagulation capability, which is of particular value in vascular lesions and those involving large tissue volumes. Admissible results demand that any resultant ther-

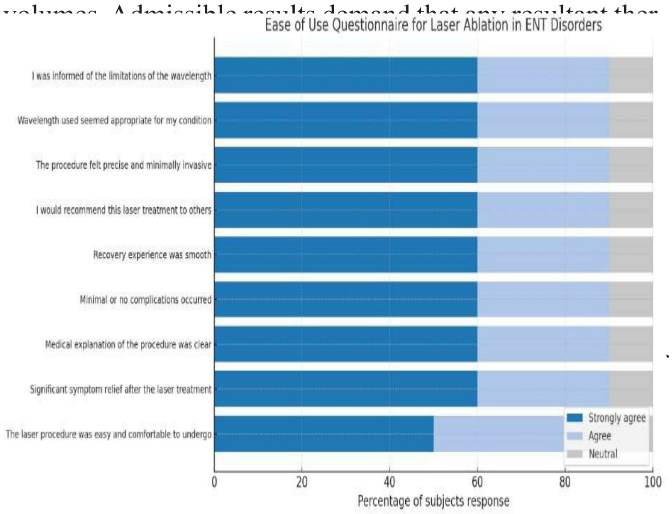

Fig. 12. Ease of Use Questionnaire for Laser Ablation in ENT Disorders

DISCUSSION

Application of 450 nm and 980 nm lasers in otolaryngologic surgery has unique benefits, offering enhanced accuracy in surgery and promoting minimally invasive outcomes. The highly absorbed 450 nm wavelength by hemoglobin can impart superior cutting and vaporization of soft tissue and is thus ideal for delicate procedures such as surgical intervention on the vocal folds and polyp resection. Its efficiency in constricting blood vessels during cutting minimizes bleeding and greatly improves surgical visibility especially in highly vascular regions like the nasal cavity. Furthermore, this wavelength has been associated with inducing greater tissue regeneration, which could lead to quicker healing and reduced postoperative pain.

Conversely, the 980 nm laser, which has high water absorption, is a superior vessel coagulator with effective intraoperative hemostasis. It is also versatile and, as such, can be applied to a broader range of ENT procedures, from tissue coagulation and ablation to PDT for cancer control. The two wavelengths are supportive of minimally invasive surgery, thus resulting in less invasive incisions, minimal tissue trauma, and rapid recovery of patients.

Both the 450 nm blue diode and 980 nm infrared diode lasers are well used in otolaryngology because of their respective tissue interactions. The high melanin and hemoglobin affinity of the 450 nm laser make it ideal for precise cutting with minimal collateral thermal damage and, thus, ideal for soft tissue procedures, such as resection of benign oral lesions. Clinical evidence has shown minimal postoperative discomfort and enhanced healing with this wavelength. It also shows efficient photocoagulation, frequently being associated with a quicker recovery than the 980 nm laser.

The 980 nm diode laser, on the other hand, with its ability to penetrate deeper tissues due to its absorption in both water and hemoglobin, provides robust coagulative effects. It is frequently used in treating pigmented and vascular lesions in the oral and facial regions, and has shown comparable outcomes to CO lasers in laryngeal cancer surgeries.

Ultimately, wavelength selection is based on the surgical intent. The 450 nm is chosen for its accuracy and enhanced healing characteristics in superficial tissue procedures, with the 980 nm being chosen for its high coagulative effects and use in procedures needing deeper tissue ablation. In practice, these two wavelengths are complementary to each other in ENT laser ablation: the 980 nm laser is optimum for hemostasis and vascular lesion control in deeper tissues, but its increased risk of penetration could extend thermal spread. On the other hand, the blue 450 nm laser provides for accurate surface ablation with minimal thermal damage, which is ideally suited for delicate procedures like the removal of small mucosal or oral lesions, where healthy tissue saving and rapid healing are most important. Clinical data demonstrates the 450 nm laser encourages faster healing and enhanced tissue integrity, but the 980 nm laser remains the one utilized for procedures involving more coagulation and greater removal of tissue.

Limitations

Both the 450 nm and 980 nm diode lasers are subject to inherent operating and clinical constraints. The power output is capped at 10W, which could limit their usability in procedures requiring higher energy levels. Moreover, the pulse length varies from 10 microseconds to 3 seconds, and the repetition rate is restricted to 1Hz to 20KHz. These working ranges can restrict the degree of flexibility of energy delivery, particularly for those procedures requiring very variable pulse settings. Clinically, the 980 nm laser demonstrates poor penetration and significant absorption by water-rich tissues, raising the likelihood of thermal damage and diminishing its efficacy in non-water tissues. The 450 nm laser with very shallow penetration is strongly absorbed by surface chromophores and has a tendency towards superficial tissue injury. It will also be less useful for deeper tissue applications. With these limitations, the wavelengths are best applied for directed, superficial treatments, not deep tissue operations.

CONCLUSION

With regard to using 450 nm and 980 nm diode lasers in ENT surgical procedures, in compliance with the ISO 13485, we conclude that, the distinctions in clinical results become especially apparent, particularly in tissue conservation and patient recuperation as Meril's Mesic™ laser ablation systems, which come in 450 nm and 980 nm wavelengths, were designed to meet different procedural requirements with accuracy and adaptability.

Research indicates that the 450 nm Mesic™ laser causes significantly less thermal damage to surrounding tissues, helping maintain the structural integrity of cells more effectively compared to the 980 nm variant. This results in a more favorable healing environment, and clinical experiences have shown that patients treated with the 450 nm Mesic™ laser typically experience quicker recovery and less postoperative discomfort than those treated with the 980 nm system.

While both systems are valuable tools in ENT procedures, their use should align with the specific clinical goal. The 450 nm Mesic™ laser is particularly suitable for procedures where high accuracy and low thermal spread are needed, particularly in sensitive anatomical areas. The 980 nm system is more appropriate in cases needing coagulation to deeper levels and robust hemostasis. In other words, both the 450 nm and 980 nm laser wavelengths have distinct, procedure-specific advantages, making it advisable to select the wavelength based on the individual treatment requirements.

Conflict of Interest: None

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