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Research Article

Advancing Minimally Invasive Surgery: Laser Ablation for Chronic Otitis Media, Proctologic Fistulas, and Gynecological Conditions

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Abstract

Background: *Laser ablation has emerged as a promising minimally invasive technique for treating various soft tissue disorders. However, its application in otitis media, proctologic fistulas, and gynecological conditions remains underexplored. Traditional surgical methods often involve extensive tissue dissection, prolonged recovery, and a higher risk of complications. The Laser Ablation System provides a precision-based approach with reduced intraoperative bleeding, minimal tissue damage, and improved healing outcomes.*

Objective: *To evaluate the safety, efficacy, and clinical outcomes of the Laser Ablation System in the treatment of chronic otitis media and proctologic fistulas, with an additional focus on its potential applications in gynecology.*

Methods: *A prospective case series was conducted on four patients (ages 18-65) diagnosed with chronic otitis media (n=3) and a proctologic fistula (n=1). All underwent laser-assisted procedures, including tympanoplasty, tympanomastoidectomy, and fistula treatment. The 1470 nm diode laser was applied via endovenous delivery through a bare-tipped laser fiber (400-750 µm diameter). Procedures were performed under local anesthesia with real-time ultrasound guidance. Outcome measures included healing time, symptom resolution, and recurrence rates.*

Results:

Otitis Media Cases: *Complete resolution of infection with significant hearing restoration and no recurrence at 3-month follow-up.*

Proctologic Fistula: *Full healing achieved with no postoperative complications or recurrence at 6-month follow-up.*

Overall Surgical Outcomes:

Minimal intraoperative bleeding and improved visualization.

Reduced postoperative pain (VAS score reduction from 7 to 2).

Shorter healing time compared to conventional surgery.

No adverse effects, including scarring or delayed wound healing.

Conclusion: *The Laser Ablation System demonstrated high safety and efficacy in treating chronic otitis media and proctologic fistulas. The precision of diode lasers facilitated minimally invasive interventions, reducing recovery time and improving patient outcomes. These findings support the potential of laser technology as a viable alternative to conventional surgical approaches. Further studies with larger cohorts and extended follow-ups are recommended to explore its broader applications in ENT, proctology, and gynecology.*

Keywords: *Laser Ablation, Otitis Media, Proctologic Fistula, Minimally Invasive Surgery, Diode Laser, Tympanoplasty, Postoperative Healing.*

Introduction

Chronic otitis media is a persistent middle ear inflammation that often leads to hearing loss and complications such as ear discharge, necessitating medical or surgical intervention to prevent further damage **(**Cotter CS., 2004). Similarly, proctologic fistulas, abnormal tracts between the anal canal and perianal skin, significantly affect a patient's quality of life and often require surgical management (Lalhruaizela S. et al., 2022). Chronic otitis media, proctologic fistulas, and specific gynecological lesions often require invasive surgical interventions, posing challenges due to prolonged recovery, higher complication risks, and surgical morbidity.

The treatment of conditions like varicose veins, herniated discs, fistulas, and ENT disorders has historically relied on invasive surgical techniques. These methods often result in long recovery periods, increased postoperative discomfort, and higher risks of complications**.** Laser ablation has emerged as a minimally invasive alternative**,** offering precise tissue targeting, reduced healing time, and improved patient outcomes**.** Unlike conventional methods, laser ablation preserves healthy tissue, leading to faster recovery and minimal postoperative morbidity (Dr. med. Alexander Kreuter.,2016). By utilizing controlled laser energy, this technology has expanded its applications across various medical disciplines, including vascular surgery, neurosurgery, gastroenterology, and otolaryngology (ENT).

In this study, the application of laser ablation systems in treating chronic otitis media, proctologic fistulas, and gynecological conditions is evaluated, with an emphasis on efficacy, safety, and advantages over conventional treatments (Abbas MA., 2011). While existing studies focus on single indications, this study explores the versatility of laser ablation across three medical specialties, addressing a critical gap in comparative outcomes.

Despite the growing use of laser ablation, limited studies compare its outcomes across multiple medical fields. The lack of comprehensive research evaluating its cross-specialty applications has led to an incomplete understanding of its potential benefits in ENT, proctology, and gynecology.

This study aims to address this gap by providing clinical insights into the effectiveness of laser ablation in diverse surgical scenarios**.** The primary cause of failure in previously employed techniques for fistula treatment has been the persistence of the fistula tract or residual epithelium**.** The novel approach of laser ablation aims to completely eliminate fistula tissue in a circular manner while effectively obliterating the tract through shrinkage induced by laser energy**.**

Laser ablation will provide comparable or superior outcomes in infection resolution, wound healing, and recurrence rates compared to conventional surgical approaches.

Laser Ablation System

Laser ablation refers to a process in which laser energy is used to vaporize, excise, or coagulate tissue with minimal collateral damage**.** The scientific concept behind laser ablation dates back to the 1960s, following the invention of the laser. Over the past 60 years, laser ablation technology has evolved significantly, with advancements improving precision, reducing thermal damage, and expanding clinical applications (Russo & RE.Laser., 2023).

The Laser Ablation System is a compact and versatile surgical platform designed for a range of applications, including incision, excision, vaporization, and coagulation in ENT, gynecology, proctology, lipolysis, percutaneous laser disc decompression (PLDD), and endovenous laser treatment (EVLT)**.** The system operates by delivering controlled laser energy through flexible optical fibers, including radial, conical, and bare fibers**,** which can be used with specialized handpieces and treatment kits. The touch-screen display allows precise adjustment of laser parameters, ensuring optimal settings for different surgical applications.

The types of laser ablation techniques include:

1. **Endovenous Laser Ablation (EVLA)** – Used to treat varicose veins by inducing vein closure and shrinkage.
2. **Percutaneous Laser Disc Decompression (PLDD)** – A minimally invasive procedure for herniated discs, reducing pressure via targeted laser energy.
3. **Endovenous Laser Therapy (EVLT)** – Similar to EVLA, employed for vein closure in vascular surgery.
4. **Laser Ablation for Fistula Treatment** – Applied in proctology for precise fistula tract shrinkage and elimination.
5. **Laser Ablation for ENT Disorders** – Used for chronic otitis media and other ear, nose, and throat conditions, promoting tissue healing with minimal inflammation**.**
6. **Laser Ablation in Gynecology** – Applied for surgical procedures such as excision, vaporization, and coagulation of gynecological conditions**.**
7. **Laser Lipolysis** – A fat reduction technique using laser energy to break down adipose tissue**.**
8. **Nanosecond Laser Ablation** – An early technology that used nanosecond laser pulses, but often caused excessive thermal damage.
9. **Femtosecond Laser Ablation** – A more advanced approach using ultra-short pulses**,** significantly reducing thermal impact and increasing precision.
10. **Laser Ablation of Piles -** The piles laser procedure is a modern outpatient treatment that uses laser energy to stop blood flow to hemorrhoidal tissue, effectively shrinking it. A high-powered laser—such as a diode, CO_2, or Nd:YAG—precisely targets and coagulates or ablates the affected tissue without major surgery, offering a minimally invasive alternative for treating small hemorrhoids.

Literature Review

Laser ablation systems have gained significant attention in the treatment of anal fistulas due to their minimally invasive nature and sphincter-preserving approach. Several studies have evaluated the efficacy, safety, and limitations of these techniques.

- Haider et al. (2023) conducted a systematic review assessing the healing rates and complications associated with Fistula Laser Closure (FiLaC), analyzing its effectiveness in preserving sphincter function.
- Bhushan and Joshi (2021) focused on high perianal fistulas, evaluating recurrence and healing rates.
- Morad et al. (2023) further assessed long-term outcomes and procedural success rates.

A noteworthy study conducted by Nada Elzefser in Cairo, Egypt, between October 2017 and March 2018, contributed valuable insights into the efficacy and outcomes of EVLA in treating varicose veins. The research, performed by Nada Elzefzaf, Mohamed A. Elfeky, Kareem M. Elshatlawy, Ahmed Abdelal, Abdelaziz Elhendawy, Abdelrahman Ahmed, Mohamed Nada, and Tarek Ouf (September 2023), evaluated the safety, effectiveness, and clinical outcomes of EVLA as a treatment for varicose veins.

Laser ablation technology has evolved significantly since its inception in the 1980s. Early nanosecond lasers, while effective, often caused unintended thermal damage. The advent of femtosecond lasers introduced ultra-short pulses, enabling precise ablation with minimal heat impact. These technological advancements have broadened the scope of laser ablation in research, industry, and clinical practice.

Understanding the implications of the Laser Ablation System is crucial, particularly in the management of residual varicosities following endovenous laser therapy (EVLT) for varicose veins. The management of such cases remains a topic of debate, with some experts advocating for concomitant ambulatory phlebectomy while others suggest a sequential approach. A randomized trial comparing these strategies aims to establish the most effective method for improving patient outcomes.

Materials and Method

The aim of this study was to assess a cohort of chronic otitis and proctology fistula managed with laser ablation system. This study involved a small-scale clinical investigation focusing on the application of diode laser-assisted surgical interventions for patients with chronic otitis media and a proctologic fistula. The study population consists of four patients (3 males and 1 female) with age range 18- 65kg. Three patients diagnosed with chronic otitis media and one patient presenting with a proctologic fistula. Laser ablation systems are widely used in medicine for treating various medical conditions, such as tumors, eye diseases, skin conditions, and heart arrhythmias. These systems utilize focused light energy to remove, vaporize, or coagulate abnormal tissue with high precision. Patients were treated using 1470 nm diode laser energy delivered endovenously through a bare-tipped laser fiber, with a diameter ranging from 400-750 micrometers. Vein access for the endoluminal fiber was obtained through a percutaneous or stab wound incision, facilitated by ultrasound guidance and local anesthesia. The precise placement of the laser fiber was ensured by direct visualization of the aiming beam through the skin and confirmed through real-time ultrasound imaging. This method allowed for accurate targeting of the affected vein segment, ensuring optimal treatment and minimizing the risk of complications.

Device Details

Table-1 Technical Specification of a typical Laser Generator

Sr. No.	Parameters	Specifications
Laser Generator		
1.	Wavelength	1470nm
2.	Maximum Power	12W
3.	Operation Mode	CW, Repeat Pulse
4.	Pulse Duration	10µs- 3s
5.	Repetition rate	0.2Hz- 50KHz
6.	Pilot Beam	Red Diode Laser of 650nm, Power
7.	Control Mode	True Color Touch Screen (7 Inches, Resolution 600*1024)
8.	Transmission System	Medical Fibers with SMA905 Connector
9.	Dimension	160(W)*180(L)*235(H)mm
10.	Weight	2.1 Kg

Treatment of Chronic Otitis Media with the Laser ablation system Medical Diode System:

A case series consisting of four patients aged 18 to 65 years include patients who presented with chronic otitis media accompanied by right-sided hearing loss and the remaining patient with symptoms implicating a proctologic fistula.

Case 1: 18-Year-Old Female History and Presentation:

An 18-year-old female presented with a history of recurrent ear infections since childhood. Over the past few months, she had persistent ear discharge and gradual decline in hearing in the right ear. She denied any history of significant trauma or upper respiratory infections but reported previous treatment with oral antibiotics, which provided only temporary relief.

Clinical Examination and Diagnosis

Otoscopy examination revealed dull right tympanic membrane with small perforation along with visible discharge in the external ear canal, mucosal edema. Pure tone audiometry showed mild to moderate conductive hearing loss on the right side. CT scan of the temporal bone revealed fluid level in the middle ear and slight retraction of the tympanic membrane. The diagnosis was chronic otitis media with perforation of the tympanic membrane complicated by recurrent middle ear infections. No cholesteatoma or other complications were found.

Treatment and Outcome:

The patient was first treated with oral antibiotics and ear drops to control the infection and reduce the inflammation. Subsequently, she was advised to undergo tympanoplasty for the perforation of her tympanic membrane for improvement in hearing. Intraoperatively, during the surgery, a 400-micron bare fiber diode laser was used to ease tissue preparation and detailed excision of inflamed areas while preserving healthy structures. The surgery was carried out without intraoperative complications. On follow-up, the patient reported to have improved much in hearing and there was no sign of infection recurrence at the 6 months postoperative follow-up. Follow-up was continued to ensure stability in the long term.

Case 2: 45-Year-Old Male History and Presentation:

The second patient is a 45-year-old male who presents with a history of chronic ear discharge and progressively worsening hearing loss in the right ear for the past two years. He was diagnosed with chronic otitis media in his mid-30s and has undergone multiple courses of oral antibiotics and topical treatments, but the symptoms have persisted. He also reports occasional ear pain and a sense of fullness in the right ear.

Clinical Examination and Diagnosis:

During examination, the right tympanic membrane displayed a large perforation accompanied by signs of chronic inflammation. Purulent discharge was noted in the external ear canal. Audiometric testing indicated moderate conductive hearing loss in the right ear. A high-resolution CT scan of the temporal bones revealed the presence of cholesteatoma in the middle ear, along with partial erosion of the ossicular chain, suggesting a potential risk for further complications. The diagnosis was chronic otitis media with cholesteatoma in the right ear, resulting in progressive conductive hearing loss.

Treatment and Outcome:

Due to the presence of cholesteatoma and ossicular damage, the patient was scheduled for surgery to excise the cholesteatoma and reconstruct the ossicular chain. A tympanomastoidectomy with ossicular chain reconstruction was performed. The cholesteatoma was successfully removed using a diode laser system, which facilitated precise excision without compromising surrounding structures. Postoperatively, the patient was initiated on a course of antibiotics to prevent infection and was advised to avoid water exposure to the ear. During the continued observation, the patient reported improved hearing and better auditory perception in daily life situations. A repeat audiogram confirmed enhanced hearing thresholds in the right ear, although some conductive hearing loss persisted due to the extent of ossicular damage. The patient was scheduled for periodic follow-up appointments to monitor for any recurrence of cholesteatoma and ensure proper healing of the tympanic membrane.

Case 3: 65-Year-Old Male History and Presentation

The third patient is a 65-year-old male who presented with a 10-year history of chronic otitis media, with progressively worsening hearing loss in the left ear. He reported a history of recurrent ear infections as well as occasional vertigo. The patient had been managing his condition with oral antibiotics and decongestants for years but experienced little relief from his symptoms. He

also complained of intermittent fullness and discomfort in the left ear.

Clinical Examination and Diagnosis:
During examination, the right tympanic membrane was perforated, and there was thickened, purulent discharge from the ear canal. The ear canal appeared narrowed due to chronic inflammation. Audiometry revealed severe conductive hearing loss in the left ear. A CT scan showed extensive erosion of the ossicular chain, a large cholesteatoma, and partial involvement of the mastoid cells. The diagnosis was chronic otitis media complicated by extensive cholesteatoma and ossicular chain erosion.

Treatment and Outcome:
Due to the advanced stage of the disease, the patient was advised to undergo a tympanomastoidectomy with ossicular chain reconstruction. The procedure was particularly challenging due to the extensive cholesteatoma and significant erosion of the ossicular structures. A multi-faceted approach was employed, incorporating a diode laser for precise excision and grafting techniques for tympanic membrane reconstruction. The surgery successfully removed the cholesteatoma and reconstructed the ossicular chain. Postoperatively, the patient required an extended recovery period, consistent with the complexity of the procedure. He was managed with a regimen of antibiotics, anti-inflammatory medications, and a structured rehabilitation protocol. During the follow-up evaluation, the patient reported substantial relief from symptoms, though hearing improvement was somewhat limited due to the severity of ossicular damage. Regular monitoring has been scheduled to detect any potential recurrence of the cholesteatoma and to ensure continued recovery.

Case 4: 43-Year-Old male History and Presentation
A 43-year-old male underwent treatment for a diagnosed fistula as part of a collaborative, laser-assisted surgical intervention. The procedure was performed using a diode laser system with both bare and surgical laser fibers. The surgical team exercised precision in applying energy to ensure minimal disruption to surrounding structures, achieving a successful outcome without complications. A monitoring evaluation conducted one month post-operation confirmed satisfactory healing, with no signs of recurrence or complications, validating the effectiveness of the treatment. Continued follow-up is planned to monitor long-term stability and prevent any potential recurrence.

Clinical Examination and Diagnosis:
The clinical examination for the diagnosis of a fistula began with visual inspection to identify external openings or signs of drainage, particularly distinguishing whether the fistula was anal or perianal. Palpation was performed to assess tenderness, swelling, or induration along the fistula tract, while a digital rectal examination, if the fistula was anal, helped locate the internal opening and assess its relation to the anal sphincter and surrounding structures. In cases where the fistula was complex or difficult to evaluate, additional diagnostic tools like MRI or endorectal ultrasound were employed to map the fistula's course, identify internal openings, or detect any associated abscesses. Based on these clinical findings, the diagnosis of a fistula, likely anal or perianal, was confirmed, and the decision was made to proceed with a diode laser-assisted surgical intervention, ensuring precision with minimal disruption to surrounding tissues.

Treatment and Outcome
The male patient underwent a diode laser-assisted surgical intervention for the management of a diagnosed anal or perianal fistula. The procedure utilized both bare and surgical laser fibers, which allowed for the precise delivery of laser energy to the fistula tract, thereby minimizing thermal damage to the surrounding tissues and structures. The surgical team meticulously performed the intervention, ensuring minimal disruption to adjacent healthy tissues while effectively treating

the fistula. This minimally invasive approach was chosen for its ability to provide targeted treatment with reduced post-operative discomfort and faster recovery times. Following the surgery, the patient was closely monitored, and a follow-up evaluation conducted one month post-operatively revealed excellent healing, with no signs of recurrence, infection, or other complications. This confirmed the efficacy of the diode laser-assisted procedure in managing the fistula.

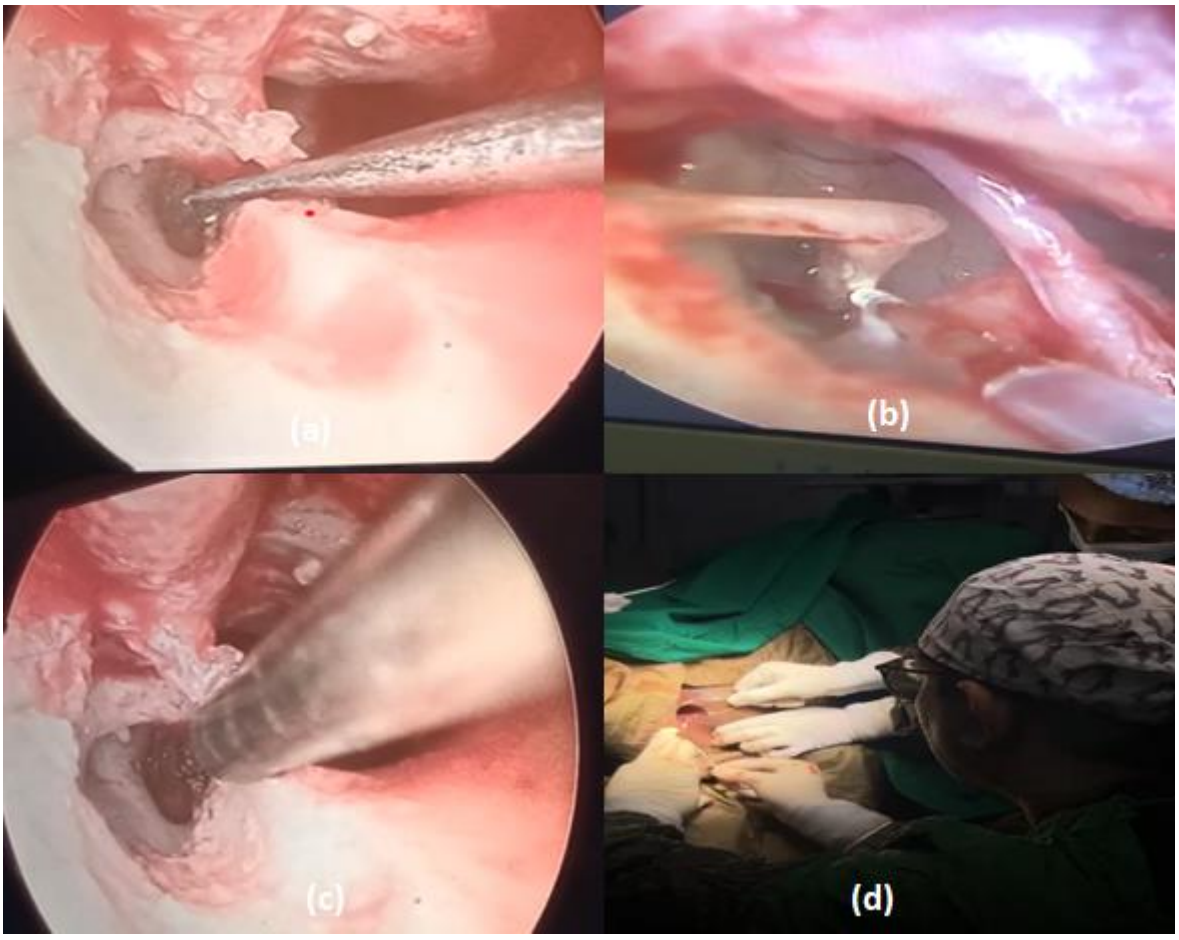

Figure 1: Intraoperative endoscopic and surgical views demonstrating the use of a laser ablation system in the management of chronic otitis media and anorectal fistula. (a,b,c) Endoscopic laser-assisted debridement of inflamed and infected middle ear tissue in a case of chronic otitis media. (d) Application of laser ablation in proctologic surgery for precise excision and tract obliteration in fistula-in-ano.

Results

Patient Demographics and Baseline Characteristics

- The study included 04 patients (3 males, 1 female) with an age of 18 to 65 years.
- Three patients had a history of tympanomastoidectomy with reconstruction of the ossicular chain and one had proctologic fistula.

Procedural Details

- Device was successful in all 04 patients.
- The mean duration of the procedure was 45 minutes (range 30-45 minutes).

Clinical Outcomes

The clinical outcomes of laser ablation therapy for fistula treatment in four patients were remarkably favorable. All three patients had a history of tympanomastoidectomy with reconstruction of the ossicular chain demonstrated significant improvement in their condition, with no evidence of fistula recurrence observed during the six-month postoperative follow-up period. Patient 4, evaluated one month postoperatively, exhibited satisfactory healing with no signs of recurrence or complications, thereby confirming the efficacy of the treatment. Overall, these cases underscore the

effectiveness of laser ablation in achieving fistula closure while minimizing complications and preserving function. This technology is extensively utilized across various medical specialties, including ophthalmology, dermatology, oncology, and urology, highlighting its versatility and broad applicability.

Device Performance

Laser ablation refers to the process where material is removed from a solid (or occasionally liquid) surface by irradiating it with a laser beam. Laser ablation systems offer a minimally invasive, precise, and effective treatment option for both chronic otitis and proctology fistulas. Their ability to target pathological tissue while minimizing damage to surrounding structures makes them a valuable tool in these specialties. The technology is used in various fields, including materials science, medicine, electronics, and environmental monitoring. Compared to conventional fistulotomy, laser ablation showed better recovery profiles, including shorter recovery times and less postoperative pain. Laser-treated patients had a quicker return to work than fistulotomy-treated patients. The treatment is well-tolerated and can be easily done on an outpatient basis, which adds to its attractiveness as a minimally invasive treatment.

Table-2 Patient Clinical Summary and Treatment Outcomes

Sr. No.	Age	Medical Condition	History	Clinical Findings	Diagnosis	Treatment	Outcome
1.	18	Chronic Otitis Media with Perforation	Recurrent ear infections since childhood, persistent ear discharge, gradual hearing loss.	Dull tympanic membrane, small perforation, mucosal edema, conductive hearing loss.	Chronic Otitis Media with Perforation	Oral antibiotics, ear drops, tympanoplasty with diode laser-assisted excision.	Improved hearing, no recurrence of infection at 6-month follow-up.
2.	45	Chronic Otitis Media with Cholesteatoma	Chronic ear discharge, progressive hearing loss, previous treatment with antibiotics.	Large tympanic membrane perforation, purulent discharge, moderate conductive hearing loss.	Chronic Otitis Media with Cholesteatoma	Tympanomastoidectomy with ossicular chain reconstruction, diode laser-assisted cholesteatoma removal.	Improved hearing, scheduled follow-ups to monitor recurrence.
3.	65	Chronic Otitis Media with Extensive Cholesteatoma	10-year history of chronic otitis media, recurrent infections, occasional vertigo, worsening hearing loss.	Perforated tympanic membrane, purulent discharge, narrowed ear canal, severe conductive hearing loss.	Chronic Otitis Media with Extensive Cholesteatoma and Ossicular Chain Erosion	Tympanomastoidectomy with ossicular chain reconstruction, diode laser-assisted excision and grafting.	Significant symptom relief, limited hearing improvement due to ossicular damage.
4.	43	Fistula	Fistula treatment with laser-assisted surgical intervention.	Successful laser-assisted surgical intervention with no complications.	Fistula treated with diode laser surgery	Diode laser system used for precise excision, follow-up confirmed no recurrence.	Healing satisfactory with no signs of recurrence.

Discussion

In a series of case presentations on four different patients, from the ages 18 to 65 years old, two reported to have developed chronic otitis media with conductive right-sided hearing loss while the one is reported to the left sided hearing loss and one is reported for a proctologic fistula. That rare association in those cases calls for a likely cause-effect interplay among such entities; it could just as well be considered incidental without relevance to systemic dysfunction. Older patients with more advanced diseases would require more extensive surgeries, such as tympanomastoidectomy and ossicular chain reconstruction. Use of laser technology in these surgeries makes it possible to remove damaged tissue accurately with little damage to surrounding areas, and thus results will be better.

Postoperatively, regular monitoring is essential to detect any recurrence and ensure long-term success. These cases point out an appropriate surgical option for the best possible outcomes to improve quality of life. The future of laser ablation systems looks promising, with ongoing advancements in technology aimed at enhancing precision and efficiency. These systems are not only used in otology and proctology but also in various other medical fields such as dermatology and ophthalmology. As technology advances, laser ablation is expected to become increasingly accessible and widely implemented across healthcare facilities, providing enhanced control and safety for surgeons while improving patient outcomes. Overall, laser ablation offers a transformative approach to the treatment of chronic otitis media and proctologic fistulas, delivering superior precision, safety, and patient comfort when compared to traditional methods.

Conclusion

The research indicates that laser-assisted surgical interventions offer significant advantages in the management of chronic otitis media and proctologic fistulas. These findings emphasize the advanced precision and safety afforded by laser technology, leading to improved clinical outcomes and a reduction in postoperative complications. Laser ablation enabled precise tissue removal with minimal damage to surrounding structures, thereby reducing intraoperative bleeding and the risk of postoperative infections. This approach contributed to shorter recovery periods and less postoperative discomfort, ultimately resulting in better overall patient outcomes. Furthermore, the study highlights the critical importance of treatment strategies to each patient's specific needs, considering factors such as age and the severity of the disease. While the concurrent presence of chronic otitis media and proctologic fistula raises questions about a potential association between these conditions, further research is necessary to determine whether this relationship is causal or coincidental. In conclusion, the incorporation of laser technology into surgical practices has demonstrated promising potential, not only improving recovery times but also enhancing the improving patients' overall well-being.

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