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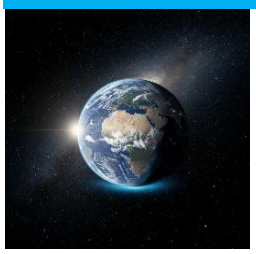

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Photodynamic Therapy in Otorhinolaryngology: Current Evidence, Clinical Applications and Future Perspectives

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ABSTRACT

Photodynamic therapy (PDT) is an interesting approach for the treatment of various otorhinolaryngological diseases, primarily when conventional therapeutic options are restricted

by antibiotic resistance, biofilms, or high relapse rates. This systematic review critically analyzes 20 open-access clinical, microbiological, and experimental studies with PDT reported between 1992 and 2025.

Initial clinical pilot data suggested a well-tolerated agent that improved symptoms and disrupted biofilm. In chronic and recurrent tonsillitis, existing evidence also indicates a decrease in microbial load, clinical improvement, and (in some cases) reduced infection over time. Case-based studies provide additional evidence for PDT as a non-invasive therapeutic option in pharyngotonsillitis.

PDT decreases lesion size and delays recurrence in recurrent respiratory papillomatosis when applied adjunctively to surgery. These indicate potential utility for persistent viral conditions, including HPV-related diseases. Further studies on PDT indicate the reduction of SARS-CoV-2 colonization during the COVID-19 pandemic. PDT nasal application decreases viral shedding.

New technologies, such as better photosensitizers, nanoparticle carrier delivery systems and improved light-delivery devices, have broadened the application of PDT in anatomically complex areas relating to ears, nose and throat (ENT). The above have improved treatment selectivity, reduced photo toxicity and increased the antimicrobial effect.

Despite these promising results, the available evidence is restricted by small sample size, heterogeneity of the protocols and inconsistency of outcome measures. Larger, uniform clinical trials are required to define the optimal treatment features and their therapeutic value. Due to its antiviral, antimicrobial, and antibiofilm potential in otorhinolaryngology, there may well be opportunities to further develop PDT field as a beneficial adjunctive treatment.

Keywords: Photodynamic therapy, Otorhinolaryngology, Chronic rhinitis, Chronic tonsillitis, Recurrent respiratory papillomatosis

INTRODUCTION

Upper respiratory tract infections (URTIs) are among the most common diagnoses in otorhinolaryngology. They occur in both pediatric and adult subjects and can affect quality of life. Recurrent and chronic conditions like rhinitis, chronic rhinosinusitis, tonsillitis, pharyngitis, and laryngeal diseases often require prolonged medical treatment (Domka et al., 2024; Kaura

et al.). 2020). Specifically chronic rhinosinusitis and recurrent tonsillitis ~~can~~ have significant health and economic impacts on patients.

Antimicrobial resistance and the ability of microorganisms to form biofilms are limiting factors for all conventional treatments. The bacteria that live in biofilm may have resistance that is several tens of times greater than bacteria in planktonic form This factor makes treatment of chronic rhinosinusitis and chronic tonsillitis specifically problematic (Biel et al., 2011; Rusanova et al., 2013; Zabolotna & Maliarenko, 2024), often requiring multiple courses of antibiotic treatments and invasive procedures such as tonsillectomy or endoscopy may be required.

PDT and antimicrobial photodynamic therapy (aPDT) are emerging, light-activated treatment approaches that use photosensitizers (PSs) in combination with visible light induce cell death. They do this by producing reactive oxygen species to eliminate microorganisms, pathological tissues or diseased cells. This orthogonal activity operates using bacterial antibiotic resistance and can be used to penetrate and degrade biofilms (Alves et al., 2022; Garapati et al., 2023). PDT has drawn the attention of researchers and patients who are interested in alternative treatments for ENT disorders, such as chronic rhinosinusitis, chronic tonsillitis, recurrent pharyngitis, and laryngeal pulmonary papillomatosis, and viral disorders such as SARS-CoV-2 (Abramson et al., 1992; Duarte et al., 2024; Fernández-Montero et al., 1987; Macias Valle et al., 2020).

PDT can fill therapeutic gaps that result when conventional treatments fail. Some investigations suggest that PDT can reduce the recurrence of tonsillitis (Santiago et al., 2025), as well as the number of surgical interventions required in laryngeal papillomatosis (Zhou et al., 2016), and even reverse SARS-CoV-2 nasal carriage (Fernández-Montero et al., 2023). In addition, systematic reviews and studies that consider new technologies, including nanoparticles, highlight the increasing potential of this technique (Kazemi et al., 2024; Ouda et al., 2021).

This article reviews the literature on current indications of photodynamic therapy in otorhinolaryngology with specific references to its effectiveness, safety, shortcomings and prospects. A review of 20 modern and archetypal publications focuses on the most relevant

fields of ENT to provide state-of-the-art knowledge and highlight priorities for future investigation.

MATERIALS AND METHODS:

Materials and methods

This paper provides an overview of the scientific literature on the application of PDT and aPDT in otorhinolaryngology research. In total authors analyzed 20 empirical scientific papers published between 1992 and 2025. All the selected papers had open access, which provided the review with transparency and reproducibility. The included studies were clinical trials, pilot studies, case reports, microbiological evaluations, and narrative or systematic reviews related to diseases of the upper aerodigestive tract.

Paper authors conducted a manual literature search based on academic resources such as PubMed, Google Scholar, MDPI, and Frontiers as well as open access journals. The keywords used included “photodynamic therapy,” “antimicrobial photodynamic therapy,” “PDT,” “aPDT,” in combination with keywords such as "otolaryngology," "ENT," "tonsillitis," "chronic rhinosinusitis," "laryngeal papillomatosis," "biofilm", and "SARS-CoV-2." Authors screened the list of included for completeness.

Inclusion criteria

Studies qualified for inclusion in the review if they:

- studied PDT or aPDT for ENT diseases or associated parts of the anatomy (oral cavities, nasopharynx, larynx, and sinuses);
- reported clinical, microbiological or mechanistic data of importance to practice in ENT;
- were published in a peer-reviewed journal, or
- had the full text available without subscription.

Exclusion criteria

Studies were excluded if they:

- were limited to therapeutic oncologic applications of PDT and unrelated infectious or inflammatory ENT diseases;
- were not available in full text;

- were not relevant to the upper aerodigestive tract or
- did not contain original data, such as editorial comments, opinion papers or conference abstracts.

Selection process

The search process included screening of titles and abstracts, followed by the analysis of the full texts of selected studies. Finally, the 20 studies were analyzed to ensure they covered several clinical entities specific to ENT, such as chronic rhinosinusitis (Biel et al., 2011; Kaura et al., 2020; Macias Valle et al., 2020; Zabolotna & Maliarenko, 2024), or chronic or recurrent tonsillitis (Rusanova et al., 2013; Yaromenka et al.

In this review, the referenced articles were sorted by disease category and qualitatively analyzed to extract common themes such as efficacy, safety, action mechanisms and developed technologies. Authors used a narrative review form since it was not possible to conduct a formal meta-analysis due to the heterogeneity in the study design, population and therapeutic regimen.

RESULTS AND DISCUSSION

3.1. Photodynamic therapy in the context of chronic rhinosinusitis (CRS)

Chronic rhinosinusitis (CRS) is a common otorhinolaryngological disease that results in considerable patient and healthcare burden. The formation of bacterial biofilm is a significant factor in CRS pathogenesis as it obstructs the action of conventional antibiotic and anti-inflammatory therapy treatments. Biofilm is often impervious to pharmacotherapy and can lead to chronic symptoms despite numerous cycles of antibiotics. In such cases, PDT may represent an appropriate therapeutic option.

One of the first studies treating CRS with PDT was carried out by Biel et al. (2011), and it demonstrated safe and therapeutically beneficial decrease of bacterial biofilm. The authors noted significant destruction of the biofilm structure and reduction in microbial load following

the application of a photosensitizer and laser light at an appropriate wavelength. It suggested that PDT was a potential treatment option for chronic, refractory forms of CRS.

A pilot investigation by Macias Valle et al. (2020) also tested PDT treatment on refractory CRS subjects. The study indicated clinical amelioration of symptoms, low symptom scores and good treatment tolerability, suggesting that PDT may be an ancillary tool in patients who do not respond to the usual therapeutic agents.

A systematic review by Kaura et al. (2020) further highlighted the importance of PDT as an adjunctive therapy for CRS, particularly in biofilm-involved cases with a potential likelihood of increased antibiotic resistance. The need to standardize PDT protocols was emphasized as previous studies had used different energy amounts and laser light parameters as well as several types of photosensitizers.

Zabolotna and Maliarenko (2024) provide the most recent information on the impact of biofilm in CRS. The authors describe the pathogenesis of diseases caused by biofilm and review several available therapeutic approaches, including PDT. They state that biofilm continues to be a significant clinical and therapeutic issue in CRS. Photodynamic therapy is one of the very few available treatment strategies to effectively disrupt biofilm.

Evidence thus suggests that PDT could be used in the management of CRS when biofilm is present and conventional treatments have failed. While these initial results are encouraging, there is a need to conduct larger randomized trials and define PDT parameters before it can be adopted routinely in clinical practice.

3.2. Photodynamic Therapy in Chronic and Recurrent Tonsillitis

Chronic and recurrent tonsillitis also pose therapeutic challenges in otorhinolaryngology. These conditions are associated with increased intolerance to multiple rounds of antimicrobial drug therapy, missed days of work or school and periods of hospitalization for tonsillectomies in treatment-resistant cases. Classic therapeutic options often fail due to the bacterial biofilm located in the tonsillar crypts, which hampers antibiotic diffusion, thus limiting its effectiveness.

PDT and aPDT represent potential alternatives for combating bacteria in planktonic form and biofilm-embedded microorganisms.

The first microbiological evidence of the potential effectiveness of PDT in tonsillar disease was published by Rusanova et al. (2013). Authors demonstrate that bactericidal PDT decreases bacterial load and changes the microbial markers of sustained inflammation in chronic tonsillitis. They conclude that PDT could promote local immune responses and, consequently, support the elimination of microorganisms in patients with recurrent tonsillitis. These data were later confirmed in several other prospective studies, including Yaromenka et al. (2020), who demonstrate a measurable reduction in bacterial colonization and patient-reported improvements in symptoms after aPDT as applied to chronically infected tonsils.

Subsequent studies also support the long-term advantages of PDT in recurrent tonsillitis. Clinical results published by Santiago et al. (2025) show that PDT significantly reduced tonsillar infections and antibiotic use in patients thus improving their quality of life. These extended observations demonstrate that PDT may offer both immediate and chronic therapeutic benefits. It shows advantage in comparison to traditional pharmaceutical therapies, which tend only to ameliorate symptoms temporarily.

The role of PDT in tonsillar disease is also supported by evidence from a case series published by Duarte et al. (2024), who report that PDT led to a significant alleviation of inflammation, pain and multiple recurrences of infection in patients with pharyngotonsillitis. These findings suggest that PDT is a flexible non-invasive treatment option with a favorable safety profile that may also potentiate tumor homing agents, such as peptides.

In sum, current evidence suggests PDT is a potential therapeutic option for patients with chronic and recurrent tonsillitis. PDT therapeutic action breaks down microbial biofilm, a leading contributor to disease chronicity and is accompanied by quantifiable clinical benefits. Even though existing results are promising, further extensive, controlled studies are required to clarify standardized protocols and confirm PDT position in the treatment of tonsilitis.

3.3. Photodynamic therapy in pharyngotonsillitis (case-bastudiessed evidence)

Pharyngotonsillitis is a common reason for consultation in general practice and otolaryngology. Most cases of acute prostatitis tend to be self-limited; however, recurrent or chronic forms of the infection are a significant clinical problem that requires repeated courses of antibiotics and, in some circumstances, surgical treatment. Increasing concerns about antibiotic resistance and antibiotic overuse seem to be triggering an upsurge in interest in non-antibiotic methods of infection treatment, such as PDT.

Practice-based evidence has contributed significantly to the clinical implementation of PDT in pharyngotonsillitis. Duarte et al. (2024) provide an anecdotal account of three cases that suggest PDT may be a therapeutic option for patients with recurrent pharyngotonsillitis, who are not responding to conventional therapy. In these cases, use of PDT resulted in significantly reduced pain, erythema, bacterial load~~,~~ and less-severe symptoms during treatment. The authors report accelerated recovery, which could be due to the direct antimicrobial effect of PDT and its capacity to dislodge biofilm bacterial consortia.

Most recent findings such as data provided by Santiago et al. (2025) illustrate that PDT not only offers immediate clinical relief but may also lower long-term recurrence. If confirmed in further studies, this suggests that PDT could serve as an acute anti-inflammatory treatment and help modify the local tonsillar environment to reduce the frequency of recurrent infections.

Both Duarte et al. (2024) and Santiago et al. (2025) demonstrate the safety and tolerability of PDT applied to the oropharynx. Patients described little, if any, pain during and after treatment, with no reported adverse events. Due to surgery-related risks, such as bleeding, post-operative soreness, and rare anesthetic complications, PDT could be a valuable option for patients who may not want or cannot tolerate surgery.

While the evidence is currently restricted to case reports and small clinical series, the uniformity of advantages claimed for PDT indicates that this technique should be evaluated further as an adjunct or alternative treatment for recurrent pharyngotonsillitis. Controlled trials with well-defined criteria are necessary to establish an optimal protocol for the use of PDT in ENT.

3.4. RRP and photodynamic therapy

Recurrent respiratory papillomatosis (RRP) is a persistent and frequently distressing condition of the larynx that is related to human papillomavirus (HPV) infection, predominantly types 6 and 11. It is characterized by the recurrence of multiple papillomata in the airway with resultant progressive dysphonia, airway obstruction, It has high a rate of recurrence despite surgical intervention. Current treatment is based on routine microlaryngoscopic excision; although this is effective for visible lesions, the viral infection and persistence of the attachment have not been eliminated. (Dwojak L: La verrue lar.Yingee Centre Oto-Rhinoi.Aisute en 196s; V moi Ve.lume) Adjunctive therapeutic modalities are welcome when treating this condition.

PDT has been used as an adjuvant therapy for RRP for many years. Abramson et al. (1992) conducted one of the first clinical assessments of PDT agents in this disease. The study determined that PDT could decrease papilloma volume and prolong the time between surgical debulking and recurrence. The available technology at the time was primitive compared to current PDT apparatuses. However, the Abramson et al. trial convincingly demonstrated the potential antiviral and cytotoxic effects of PDT applied to laryngeal papilloma.

The initial observations described above have been confirmed in further studies. Zhou et al. (2016) evaluated effectiveness of topical PDT in juvenile-onset RRP. The study showed that there was a marked clinical improvement, involving airway patency and shrinkage of the lesion. No significant complications were observed. The authors also highlighted the possibility of performing PDT with minimal invasion, which would be attractive for pediatric patients who frequently require multiple surgeries.

Ouda et al. (2021) present a-more global approach. The authors comprehensively summarize the pathogenesis of HPV-related diseases, including RRP. While the work presented concentrates on HPV biology, these authors emphasize that other therapeutic modalities that directly target virally infected tissues (such as PDT) may offer specific advantages. PDT-mediated cytotoxicity and its potential to influence local immune responses may be crucial to suppressing HPV replication. PDT also helps reduce lesion recurrence.

In summary, the available data suggest that PDT may function in an adjunctive role in treating RRP. PDT capacity to clear the burden of papilloma deposits, delay recurrence, and potentially modulate viral activity marks a strong rationale for further study. Although the data are limited and non-uniform, due to the involvement of various photosensitizers and light parameters, the homogeneity in reported favorable clinical results justifies further controlled work. Such work would enable PDT to find its exact place within the long-term armamentarium against RRP.

3.5. Photodynamic Inactivation for Virologic and Bacteriologic Syndromic ENT (including SARS-CoV-2)

Infections of the upper respiratory tract by viruses are a significant clinical and public health burden, particularly when high levels of transmission and/or prolonged viral shedding are involved. Interest in PDT and aPDT increased during the COVID-19 pandemic due to their broad spectrum of antimicrobial action, and ability to inactivate a range of viruses through ROS. While PDT is usually studied in bacterial infections, some publications have suggested its potential use in otorhinolaryngological viral diseases.

Several studies have explored PDT for SARS-CoV-2 antiviral effects. Almeida et al. (2020) focused on the mechanistic foundations for PDT antiviral activity. They noted that light-induced photosensitizer produced, reactive oxygen species can disrupt viral particles by destabilizing viral envelopes, reducing viral infectivity as well as through nucleic acid damage. The study highlights that PDT could be a valuable adjuvant to the therapy during viral pandemics, due to its ability to exert effect regardless of viral mutations or resistance.

Mahmoudi (2022) demonstrates that PDT can potentially inactivate SARS-CoV-2 in controlled experimental models, and suggests that novel, PDT-based protocols could lower viral load at such sites as the nasal cavity and oropharynx. These anatomic sites are crucial to the otorhinolaryngologist as they serve as epicenters for viral colonization, replication and dissemination course.

The clinical evidence for the use of PDT to decrease SARS-CoV-2 carriage is demonstrated by Fernández-Montero et al. (2023) for the application of nasal PDT to reduce viral shedding

among patients. Their work indicates reductions in viral loads and time to PCR negativity after PDT treatment. It supports the theory that photodynamic approaches might affect the clinical evolution of infections and their transmissibility. These results could be relevant to clinical outpatient ENT environments, where reduction in viral load might limit transmission.

These studies suggest that PDT could play a potential role in treatment of viral and upper respiratory tract infections. Further studies are warranted to determine the optimal treatment parameters and assess long-term outcomes. Existing data indicate that PDT has antiviral activity and reduces viral colonization in the nasal cavity. It could shorten the duration of infectivity and thus PDT is an attractive option for ENT practice.

3.6. PDT in Antibacterial and Antibiofilm Mechanisms

Bacterial biofilms are commonly present in several chronic infections that occur in the upper respiratory tract such as chronic rhinosinusitis, tonsillitis, and recurrent pharyngotonsillitis. Biofilms offer an architectural barrier to microbes and inhibit the penetration of antibiotics. Consequently, traditional antimicrobial therapy is largely ineffective. This challenge has led to renewed focus on PDT, which can specifically target biofilm-growing pathogens and avoid antibiotic resistance.

Biel et al. (2011) conducted a pivotal experiment to demonstrate proof of concept for the antibiofilm effect of PDT in ENT diseases. Their investigation indicated that PDT successfully destroyed mature, patient-derived biofilms present in chronic, recurrent sinusitis. The authors determined that PDT could reduce the viability of the biofilm and limit its structural damage. The authors' findings supported clinical evidence of PDT as a biofilm-targeting treatment.

Rusanova et al. (2013) provides additional proof of the antimicrobial and antibiofilm effect of PDT. The study determined that PDT significantly decreases the colonization of pathogenic bacteria in chronic tonsillitis patients. The authors report reduction in microbial biomarkers of inflammation, indicating that PDT could influence infection burden and local immune response. Their results concur with those of Yaromenka et al. (2020), who also describes PDT

role in reducing bacterial count and clinical symptoms in cases of chronically infected tonsillar tissue.

The more general antimicrobial capabilities of PDT are appraised in a clinical review by Alves et al. (2022) on randomized and controlled antibacterial PDT trials. Their research confirms that PDT is an effective treatment for various bacterias (gram positive, gram negative and biofilm forming). Notably, PDT mechanism - a product of ROS (reactive oxygen species) - operates independently of antibiotic resistance mechanisms, making it an invaluable option for growing antimicrobial resistance.

Finally, Zabolotna and Maliarenko (2024) highlight the role of biofilms in chronic rhinosinusitis and the fact that PDT can effectively destroy them. Their study emphasizes that the disruption of biofilm is essential in regaining sensitivity to antibiotics and suppressing the ongoing chronic inflammation in sinonasal layers.

Overall, PDT has potent antibacterial/antibiofilm properties that are clinically applicable in several ENT conditions. By disturbing biofilm formation, killing microbes, and possibly enhancing local immune reactions, PDT influences key biological processes in chronic ENT infections. These mechanisms explain increasing interest in PDT as an adjunct or primary mode of treatment.

3.7. Other Developments in Photodynamic Therapy (Nanocarriers, New Photosensitizers, Innovations)

PDT has advanced considerably over the past decade. Specifically, due to enhancements in photosensitizer chemistry, light delivery techniques, and drug carriers based on nanoparticles. These advances are of special relevance to otolaryngology, as therapeutic challenges include accessing anatomical sites, biofilm formation by microbes, and the requirement for site-specific delivery to infected or dysplastic tissues.

Alves et al. (2022) performed a systematical review of clinical trials on antibacterial PDT. They accentuated considerable achievements in investigating treatment strategies and enhancing

therapeutic responses. They indicate that contemporary PDT regimens have trig-pontified wavelengths, designed photosensitizer constructs and delivery efficiencies, which prompted improved clinical benefits and consolidated therapeutic aims.

Nanocarrier-based systems represent a promising technological trend in PDT. Garapati et al. (2023) point out the benefit of nanocarriers - such as liposomes, polymeric nanoparticles, or metallic nanosystems - in improving the solubility and stability of the photosensitizer in the tissue it penetrates. These advancements will be particularly valuable in ENT, as biofilms and complex mucosal cavities can impede the penetration of known photosensitizers. Nanocarriers can target delivery, reduce phototoxicity, improve active compounds accumulation in the infection or dysplasia of primary tissues. Thus, they can improve PDT effectiveness with the concomitant reduction of systemic exposure.

Kazemi et al. (2024) demonstrate additional progress in photosensitizer development. The authors provide a summary of new PDT applications in head and neck medicine, with a particular interest in oral cavities. They review several newly developed photosensitizers, which have superior photophysical properties, including higher quantum yields, better tissue selectivity, and the ability to activate at longer wavelengths for deeper tissue penetration. These developments are essential for clinical otolaryngology conditions such as tonsillar infections, oral cavity lesions, and laryngeal papillomatosis.

Domka et al. (2024) provide a general summary of innovative PDT applications for the eyes, ears, larynx, nose, and oral cavities. They highlight ongoing advances in illumination system design such as fiber-optic catheters, endoscopic light guides, and LED-based devices. These are applicable in the delivery of accurate and minimally-invasive light to anatomically challenging sites encountered in ENT practice.

These innovative breakthroughs enhance PDT efficacy and extend its clinical applications. Advances in photosensitizer design, nanocarrier-based strategies, and targeted light application represent the most recent trend in increasing therapeutic efficacy and selectivity while diminishing systemic toxicity. PDT has now an emerging role not just in the adjuvant setting but as a gamechanger in the future ENT landscape.

3.8. Applications of Photodynamic Therapy in the Oral Cavity Related to ENT Disorders

The oral cavity forms an integral component of the upper aerodigestive tract. Disorders of the oral mucosa, microbial colonization, and inflammatory diseases originating within the oral cavity may directly or indirectly influence ENT health. Photodynamic therapy (PDT) presents therapeutic potential extended into ENT-related conditions, notably in the ones requiring microbial decrease and reduction of local inflammation.

Wiśniewski et al. (2025) contribute a relevant study evaluating the combined effect of PDT and glucocorticosteroids in patients with oral lichen planus (OLP). OLP is not strictly considered an ENT pathology, it shares pathophysiological features with inflammatory mucosal diseases treated in the ENT department. What their randomized clinical trial demonstrates is that PDT significantly reduces oxidative stress markers in saliva and contributes to clinical improvement. Wiśniewski et al. study results indicate that PDT may play a role in immunomodulation and mucosal healing mechanisms that may translate to ENT applications, such as chronic tonsillar or oropharyngeal inflammation.

Kazemi et al. (2024) further expand on the role of PDT in oral cavity disorders within the broader context of head and neck diseases. Their review highlights that PDT exhibits promising effects in managing premalignant lesions, bacterial infections, and inflammatory mucosal conditions. The oral cavity serves as a high-risk region for microbial accumulation, and reductions in microbial load or biofilm formation observed after PDT may have beneficial effects on adjacent anatomical areas, including the oropharynx, tonsils, and even the nasopharynx.

Advancements in PDT-related technology support application of therapy in the oral cavity. Garapati et al. (2023) describe the use of nanocarrier systems which enhance delivery platforms, in patients with changed oral mucosa. The improvement manifested in adequate tissue penetration combined with the minimization of phototoxicity enables selectivity and best possible effectiveness of the treatment while reducing adverse effects.

Border reviews, such as the one by Domka et al. (2024), highlight the interconnectedness of oral cavity health and upper airway function. They reinforce the rationale for incorporating PDT across multiple anatomical sites within ENT. Their findings underscore that photodynamic therapy can be safely applied to regions including the oral cavity, nasal passages and larynx, suggesting a versatile therapeutic approach for mucosal conditions across the head and neck.

Applications of PDT are documented more extensively in dental and oral medicine than in strict ENT practice but are still relevant to otorhinolaryngology. Oral cavity according to its microbial burden, mucosal continuity with the oropharynx, leading to upper airways, is an important therapeutic target because of easy inflammation transmission. PDT appears to be a promising tool in managing oral conditions with potential impact on ENT health. Future research may further clarify its role within interdisciplinary treatment strategies.

The combined evidence gathered from the reviewed studies highlights the considerable therapeutic potential for PDT across otorhinolaryngology. While the heterogeneity of study settings and protocols limits formulating universal guidelines, the beneficial effects correspond to various disease entities. This article summarizes the evidence base for PDT efficacy, biofilm eradication, developments in technology, and its future potential as an adjuvant or replacement of current ENT treatment.

In chronic bacterial infections (especially chronic rhinosinusitis and chronic/recurrent tonsillitis), PDT appears to have promising antimicrobial/antibiofilm effects. Work by Biel et al. (2011) and Zabolotna and Maliarenko (2024) provides strong rationale that PDT can eliminate mature bacterial biofilms, which contribute to therapeutic resistance in CRS. Corresponding results for tonsillitis are exhibited by Rusanova et al. (2013) and Yaromenka et al. (2020), who demonstrate that PDT may not only lead to a reduction in microbial burden but could also ameliorate clinical signs. These findings show that PDT intervenes with direct specific pathophysiological processes, including the formation of bacterial biofilm and antimicrobial resistance mechanisms, which restrict the outcome of standard treatments.

PDT may be used as an application for viral infections, e.g., for SARS-CoV-2 colonization in the upper airway. Studies by Almeida et al. (2020), Mahmoudi (2022) and Fernández-Montero et al. (2023) indicate that PDT has antiviral effects and can decrease viral load and shorten shedding duration. Research results point to the fact that PDT could contribute to infection control in community ENT practice settings, especially during viral epidemics.

PDT can be applied to other ENT disorders, such as respiratory recurrent papillomatosis (RRP). Evidence presented by Abramson et al. (1992), Zhou et al. (2016), and Ouda et al. (2021) indicate that PDT may reduce burden and the later appearance of lesions. It thus may constitute a legitimate addition to surgical excision. Although the design and treatment parameter differ from one study to another, a body of evidence provides the rationale for further research into PDT as a targeted therapy relevant to HPV-related laryngeal disease.

Progress in technology has increased the possible uses of PDT. Research by Garapati et al. (2023), Kazemi et al. (2024), Alves et al. (2022), and Domka et al. (2024) indicate advances in photosensitizer chemistry, drug nanocarrier, and light application systems. The imaging and treatment of ENT anatomy is even more critical. Complex geometries can cause shadowing (thereby interfering with light delivery) from folds and creases. They are often responsible for poor access, which causes inadequate PS (photosensitizers) distribution. Advanced technologies could significantly improve treatment accuracy in PDT and lower phototoxicity.

Despite the promising outcomes, the research has several limitations. The majority of the studies have a small sample size or are pilots or case reports. RRP and tonsilitis are relevant examples. There is a substantial heterogeneity in light wavelengths, photosensitizers and doses or treatment intervals used, which makes the PDT studies difficult to compare. PDT protocols must be standardized before clinical utilization is widespread.

Moreover, in most pathologies, the long-term results, taken from a small number of studies, are poorly reported, e.g., Santiago et al. (2025), which prolongs the period of follow-up data collecting.

Although there is evidence for PDT efficacy in many ENT indications, further randomized, controlled trials and standardized guidelines are required. Despite this, the unconventional duality of PDT treatment, with its recognized microbicidal effect makes PDT an attractive component of the future otorhinolaryngology strategies.

CONCLUSION

PDT is a novel mode of treatment in otorhinolaryngology. Increasing evidence suggests many clinical applications for its use. The available literature indicates that PDT has several distinctive strengths, such as the significant potential to target the biofilms of microorganisms, reduce bacterial and viral loads, and modify local inflammatory reactions. These mediators target fundamental pathophysiological aspects of various ENT disorders, especially diseases with chronic infectious, recurrent, or even persistent disease patterns following standard therapy.

PDT has demonstrated the ability to damage sinonasal biofilms and to relieve symptoms in patients with recalcitrant CRS. The evidence for chronic and recurrent tonsillitis also suggests lower microbial load, symptomatic improvements, and long-term benefits, including its role as a non-invasive solution to, or an adjunct for, treatment algorithms in some cases. Its role in recurrent respiratory papillomatosis (RRP) is promising, with studies indicating reduced lesion size and delayed recurrence, which adds supporting evidence to its use as an adjuvant to surgical debulking.

PDT is a new and exciting treatment modality capable of augmenting existing therapeutic protocols for infectious, inflammatory, or viral diseases in the upper aerodigestive tract. With further developments in technology and an increase in clinical data, PDT may play a more significant role in otorhinolaryngology practice.

1. Table 1. Key advantages, limitations, and future perspectives of photodynamic therapy in otorhinolaryngology

Main Advantages of PDT in ENT	• Effective against bacteria, viruses, and biofilms • Minimally invasive and well tolerated

	• Low risk of antimicrobial resistance • Can complement or reduce the need for surgery • Rapid onset of local therapeutic effect
Clinical Areas With the Greatest Potential	• Chronic rhinosinusitis resistant to standard therapy • Chronic and recurrent tonsillitis • Recurrent pharyngotonsillitis • Recurrent respiratory papillomatosis • Upper airway viral infections (e.g., SARS-CoV-2) • Oral cavity inflammatory conditions linked to ENT disorders
Technological Strengths	• Improved photosensitizers with higher precision • Nanocarrier-based delivery systems increase tissue penetration • Advanced light-delivery devices enable targeted illumination • Expanding adaptability to anatomically complex ENT areas
Limitations of Current Evidence	• Small sample sizes in existing studies • Lack of standardized treatment protocols • Heterogeneity in photosensitizers and light parameters • Limited long-term follow-up in most clinical applications
Future Research Priorities	• Large randomized controlled trials • Standardization of PDT protocols • Development of ENT-specific photosensitizers • Evaluation of cost-effectiveness compared

	to standard therapy • Integration with surgical and antimicrobial strategies
Overall Clinical Outlook	PDT is a promising adjunct or alternative therapy in ENT. With continued technological refinement and growing evidence, PDT shall become an increasingly relevant therapeutic tool.

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