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Photodynamic Therapy for Oral Lesions: An Overview of Clinical Applications

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Abstract: Photodynamic therapy (PDT) is a minimally invasive treatment modality that uses photosensitizers, specific wavelengths of light, and oxygen to selectively destroy pathological tissues. This therapeutic approach has demonstrated efficacy in multiple oral conditions, including potentially malignant disorders, benign mucosal lesions, and infectious diseases. PDT offers advantages such as selective tissue targeting, functional preservation, reduced morbidity, and favorable cosmetic outcomes. Despite promising clinical results, challenges remain in terms of protocol standardization, photosensitizer selection, and long-term efficacy assessment. This review examines the current evidence on PDT applications in oral medicine and identifies future research directions.

Keywords: Photodynamic Therapy, Oral Lesion, Potentially Malignant Disorders.

Review Paper

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INTRODUCTION

The management of oral lesions presents significant challenges for dental clinicians because of the diversity of pathological conditions affecting the oral cavity and the limitations of conventional treatments. Photodynamic therapy (PDT) has emerged as a treatment modality that demonstrates efficacy in curative and palliative applications for head and neck squamous cell carcinoma and other oral lesions [1]. The therapeutic mechanism involves the interaction between a photosensitizing agent, appropriate wavelength of light, and molecular oxygen, generating cytotoxic reactive oxygen species that induce selective cell death [2]. This review provides a concise summary of the current evidence on PDT applications in oral medicine for dental practitioners.

Mechanism and Principles of Photodynamic Therapy

The fundamental mechanism of PDT requires three essential components: a photosensitizer, light of a specific wavelength, and oxygen. Upon light activation, photosensitizers undergo energy transfer reactions, producing reactive oxygen species through Type I and Type II photochemical pathways [2]. Common photosensitizers used in oral applications include aminolevulinic acid, methylene blue, toluidine blue, and chlorin-e6. Wavelengths between 585-660 nm have been most frequently utilized, with power densities ranging from 100-150 mW/cm² [3]. The selective accumulation of photosensitizers in pathological tissues, combined with precise light delivery, enables targeted therapeutic effects while minimizing damage to surrounding healthy structures.

Photodynamic Therapy for Oral Potentially Malignant Disorders

Oral potentially malignant disorders, particularly leukoplakia and erythroplakia, carry a significant risk of malignant transformation, necessitating effective management strategies. Systematic reviews have demonstrated that PDT achieves complete response rates of approximately 50% and partial response rates of 42% in oral leukoplakia [4]. A recent meta-analysis revealed that lesion size decreased by 1.38 cm² following PDT, with an overall complete response of 0.52 and a partial response of 0.82. Twenty percent aminolevulinic acid demonstrated superior efficacy compared to other photosensitizers,

achieving a complete response of 0.68 and a partial response of 0.88 [5]. A clinical evaluation of 50 patients with oral leukoplakia receiving topical 5-aminolevulinic acid PDT revealed an overall response rate of 68%, with 12% complete and 56% partial responses [6]. Recurrence rates following PDT range from 13-36% depending on the lesion characteristics and treatment protocols [4].

Applications in Inflammatory and Benign Oral Lesions

Topical PDT has been effective in managing benign oral soft tissue lesions, is well tolerated, and is easy to perform [7]. Oral lichen planus, a chronic inflammatory condition affecting 0.5-2% of the population, represents a significant application area for PDT. Systematic review evidence indicates that PDT has demonstrated significant clinical remission in oral potentially malignant disorders, although at low to very low certainty of evidence [8]. Studies evaluating PDT for symptomatic oral lichen planus have demonstrated a reduction in lesion size, pain scores, and quality of life improvements [9]. The response to PDT varies by lesion location, with the lining mucosa showing a 57.6% reduction compared to a 30.0% reduction in the masticatory mucosa [10].

Antimicrobial Photodynamic Therapy

Antimicrobial photodynamic therapy (aPDT) utilizes light and photosensitizers to eliminate biofilms and achieve bone formation or tissue regeneration in periodontal diseases [2]. The emergence of antibiotic-resistant bacteria has necessitated the exploration of alternative therapeutic approaches, with aPDT showing promise for localized and superficial oral infections [11]. Clinical studies have demonstrated the effectiveness of aPDT in treating oral fungal infections, with methylene blue, toluidine blue, and porphyrin derivatives serving as commonly used photosensitizers [12]. Systematic review evidence indicates that aPDT may provide similar clinical improvements in probing depth and clinical attachment level compared to conventional periodontal therapy. However, the comparative differences remain modest, typically less than 1 mm [13].

Treatment efficacy is influenced by multiple factors, including the photosensitizer type and concentration, light source characteristics, application duration, and lesion pathology [4]. Side effects are generally mild and transient, including temporary pain, local ulceration, and photosensitivity, and occur in approximately 50% of patients [6].

Emerging Technologies and Future Directions

Nanotechnology-based photosensitizer delivery systems address the limitations of photosensitizer water solubility and tissue penetration. Nanostructured drug delivery systems, including gold nanoparticles, liposomes, micelles, and dendrimers, enhance photosensitizer bioavailability and enable targeted delivery to pathological tissues [14]. The potential role of PDT in managing premalignant and malignant oral lesions warrants further investigation through large-scale randomized controlled trials [15]. Future research should focus on protocol standardization, biomarker identification for patient selection, and combination therapy to enhance therapeutic outcomes.

CONCLUSION

Photodynamic therapy represents a versatile treatment modality for diverse oral lesions, offering the advantages of selective targeting, functional preservation, and favorable patient acceptance. Evidence supports PDT efficacy for potentially malignant disorders, inflammatory conditions, and infectious diseases, although long-term outcomes and standardized protocols require further investigation through rigorous clinical trials to establish definitive treatment guidelines for routine clinical practice.

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