

PROPHYLACTIC PHOTOBIMODULATION IN ORAL MUCOSITIS IN PATIENTS WITH HEAD AND NECK CANCER: IMPACT ON ENTERAL NUTRITION AND ORAL COMPLICATIONS

FOTOBIMODULAÇÃO PROFILÁTICA NA MUCOSITE ORAL EM PACIENTES COM CÂNCER DE CABEÇA E PESCOÇO: IMPACTO NA NUTRIÇÃO ENTERAL E NAS COMPLICAÇÕES ORAIS

FOTOBIMODULACIÓN PROFILÁCTICA EN LA MUCOSITIS ORAL EN PACIENTES CON CÁNCER DE CABEZA Y CUELLO: IMPACTO EN LA NUTRICIÓN ENTERAL Y EN LAS COMPLICACIONES ORALES

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ABSTRACT

Introduction: Photobiomodulation (PBM) has emerged as a promising intervention for mitigating oral mucositis (OM) in individuals receiving radiotherapy. However, OM can precipitate serious consequences and increase patient health risks. Objective: The aim of this prospective cohort study was to investigate the manifestation of oral mucositis and determine the degree of need for enteral nutritional support in patients with head and neck cancer who underwent combined radiotherapy and chemotherapy while receiving preventive PBM. Additionally, we sought to identify other oral conditions that could arise in these patients. Materials and methods: Sociodemographic, clinical, treatment, oral mucositis and pain data, as well as enteral nutrition use, were collected. Statistical analysis used frequency distributions, mean, median, standard deviation, and Pearson's chi-square and Fisher's exact tests. Results: The study sample comprised 22 individuals, predominantly male and self-identified as brown, and the most common diagnosis was squamous cell carcinoma. The data revealed that 21 patients developed OM throughout their oncological therapeutic course, with grades 2 (31.8%) and 3 (45.5%) representing the most severe stages. Notably, only 4 participants required enteral tube feeding, and all of them had OM grade

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greater than 2. Among the various oral complications observed, fungal infection, specifically pseudomembranous candidiasis, was the most common, affecting 17 patients. Conclusion: In summary, the preventive application of PBM suggests significant potential for minimizing dependence on enteral nutrition in patients with head and neck cancer undergoing radiotherapy and chemotherapy. This approach is crucial to avoid potential interruptions in oncological therapy and to prevent a decline in the overall clinical status of these patients.

Keywords: Stomatitis. Drug Therapy. Radiotherapy. Laser Therapy.

RESUMO

Introdução: A fotobiomodulação (FBM) tem se destacado como uma intervenção promissora para atenuar a mucosite oral (MO) em indivíduos submetidos à radioterapia. Contudo, a MO pode desencadear consequências graves e aumentar os riscos à saúde dos pacientes. **Objetivo:** O objetivo deste estudo de coorte prospectivo foi investigar a manifestação da mucosite oral e determinar o grau de necessidade de suporte nutricional enteral em pacientes com câncer de cabeça e pescoço submetidos a radioterapia e quimioterapia concomitantes, recebendo profilaxia com FBM. Além disso, buscou-se identificar outras condições orais que poderiam surgir nesses pacientes. **Materiais e métodos:** Foram coletados dados sociodemográficos, clínicos, terapêuticos, de mucosite oral, dor e uso de nutrição enteral. A análise estatística incluiu distribuições de frequência, média, mediana, desvio-padrão, além dos testes qui-quadrado de Pearson e exato de Fisher. **Resultados:** A amostra do estudo foi composta por 22 indivíduos, em sua maioria do sexo masculino e autodeclarados pardos, sendo o diagnóstico mais comum o carcinoma de células escamosas. Os dados revelaram que 21 pacientes desenvolveram MO ao longo do tratamento oncológico, sendo os graus 2 (31,8%) e 3 (45,5%) os mais frequentes. Apenas 4 participantes necessitaram de alimentação por sonda enteral, todos com MO superior ao grau 2. Entre as complicações orais observadas, a infecção fúngica, em especial a candidíase pseudomembranosa, foi a mais prevalente, acometendo 17 pacientes. **Conclusão:** Em síntese, a aplicação profilática da FBM apresenta potencial significativo para reduzir a dependência da nutrição enteral em pacientes com câncer de cabeça e pescoço em tratamento radioterápico e quimioterápico, evitando possíveis interrupções da terapia oncológica e o comprometimento do estado clínico geral.

Palavras-chave: Estomatite. Quimioterapia. Radioterapia. Laserterapia.

RESUMEN

Introducción: La fotobiomodulación (FBM) se ha consolidado como una intervención prometedora para mitigar la mucositis oral (MO) en individuos sometidos a radioterapia. Sin embargo, la MO puede ocasionar consecuencias graves y aumentar los riesgos para la salud de los pacientes. **Objetivo:** El objetivo de este estudio de cohorte prospectivo fue investigar la manifestación de la mucositis oral y determinar el grado de necesidad de soporte nutricional enteral en pacientes con cáncer de cabeza y cuello sometidos a radioterapia y quimioterapia concomitantes, recibiendo profilaxis con FBM. Además, se buscó identificar otras condiciones orales que podrían presentarse en estos pacientes. **Materiales y métodos:** Se recopilaron datos sociodemográficos, clínicos, terapéuticos, de mucositis oral, dolor y uso de nutrición enteral. El análisis estadístico incluyó distribuciones de frecuencia, media, mediana, desviación estándar, así como las pruebas de chi-cuadrado de Pearson y exacta de Fisher. **Resultados:** La muestra del

estudio estuvo compuesta por 22 individuos, en su mayoría hombres y autodeclarados mestizos, siendo el diagnóstico más común el carcinoma de células escamosas. Los datos mostraron que 21 pacientes desarrollaron MO durante el tratamiento oncológico, siendo los grados 2 (31,8%) y 3 (45,5%) los más frecuentes. Solo 4 participantes requirieron alimentación por sonda enteral, todos con MO superior al grado 2. Entre las complicaciones orales observadas, la infección fúngica, particularmente la candidiasis pseudomembranosa, fue la más común, afectando a 17 pacientes. Conclusión: En resumen, la aplicación profiláctica de la FBM demuestra un potencial significativo para reducir la dependencia de la nutrición enteral en pacientes con cáncer de cabeza y cuello sometidos a radioterapia y quimioterapia, evitando posibles interrupciones en la terapia oncológica y el deterioro del estado clínico general.

Palabras clave: Estomatitis. Quimioterapia. Radioterapia. Laserterapia.



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INTRODUCTION

Head and neck cancer (HNC) encompasses tumors in the oral cavity (most common, ~40%), pharynx, larynx, salivary glands, and thyroid. It affects oral functions, leading to weight loss and reduced quality of life, and its treatment may include surgery, chemotherapy, radiotherapy, or a combination of these modalities (DÖBROSSY, 2005; MORETI *et al.*, 2018).

Regarding oncological treatments, oral mucositis (OM) is a frequent complication that compromises speech, mastication, and swallowing. The National Cancer Institute (NCI) classifies OM into grades: 0 (absence), 1 (minimal symptoms, erythema, solid diet tolerated), 2 (pain, modified diet, ulcers/pseudomembranes), 3 (inability to eat orally, confluent ulcers/pseudomembranes, easy bleeding), and 4 (severe, life-threatening symptoms, necrosis, spontaneous bleeding) (FIGUEIREDO *et al.*, 2013).

OM impairs oral hygiene, increases susceptibility to infections, and complicates mastication and swallowing. This may intensify the need for feeding tubes, directly affecting patient nutrition. The treatment or mitigation of OM complications is crucial, as they can lead to modifications or even interruption of oncological therapy (SHU *et al.*, 2020).

Prevention and management strategies for OM include oral hygiene, cryotherapy, and photobiomodulation (PBM), with emphasis on a multidisciplinary approach. Pharmacological interventions, such as topical agents and mouthwashes, aim for symptomatic relief with

antimicrobial, analgesic, anti-inflammatory, and anesthetic properties (CAMPOS *et al.*, 2020; PAULI *et al.*, 2021).

Photobiomodulation (PBM) emerges as a promising non-pharmacological therapy for OM prevention and treatment. It modulates inflammation, reduces pain, and accelerates lesion healing through tissue biomodulation, without mutagenic or photothermal effects (MEDEIROS; MAIA; FERREIRA, 2017; ZADIK *et al.*, 2019).

Recommended PBM protocols consider parameters such as wavelength, treatment area, dose, application time, energy per point, and cumulative energy per session. Evidence indicates that intraoral PBM (630–660 nm) is effective in preventing OM and associated pain. MASCC recommends its use for OM prevention in patients with HNC undergoing radiotherapy (EL MOBADDER *et al.*, 2019).

This study aimed to determine the incidence of oral mucositis and the need for enteral nutrition in patients with HNC treated with radiotherapy and chemotherapy who received preventive photobiomodulation. Additionally, it sought to identify other oral complications in these patients.

THEORETICAL FRAMEWORK

Head and neck cancer (HNC) treatments, particularly chemoradiotherapy, often lead to severe and debilitating oral complications, with oral mucositis (OM) being one of the most prevalent and impactful (AKAIKE *et al.*, 2024). OM is a debilitating inflammatory condition of the oral mucosa that can lead to intense pain, difficulty swallowing (dysphagia), and compromised nutrition, significantly impairing the patient's quality of life (ZADIK *et al.*, 2019; LEE & YANG, 2021). The severity of OM can lead to treatment interruptions, which may negatively affect oncological outcomes (BAKUŁA & STAWARZ-JANECZEK, 2025).

In recent years, photobiomodulation (PBM) has emerged as a promising non-pharmacological therapy for the prevention and management of OM in this patient population. PBM, which involves the use of low-level light in the red and near-infrared spectrum, exerts its therapeutic effects by modulating cellular activities, promoting tissue repair, and reducing inflammation and pain (LEGOUTÉ *ET AL.*, 2019). Several meta-analyses and randomized controlled trials published in the last five years have provided robust evidence supporting its efficacy. A systematic review by Campos *et al.* (2020) and clinical guidelines from the

Multinational Association of Supportive Care in Cancer/International Society of Oral Oncology (MASCC/ISOO) strongly recommend PBM for the prevention of OM in HNC patients undergoing radiotherapy.

The clinical benefits of PBM extend beyond direct symptom relief. By mitigating the severity of oral mucositis, PBM helps to maintain oral intake, thereby reducing the need for enteral nutrition (LEGOUTÉ *et al.*, 2019). Malnutrition is a common issue in HNC patients, and the requirement for a feeding tube can add to the patient's physical and psychological burden. Studies have shown a direct correlation between the severity of OM and the need for artificial nutritional support (SHU *et al.*, 2020). Therefore, a prophylactic PBM approach can be a crucial strategy for preserving the patient's nutritional status and improving their overall treatment tolerance.

Furthermore, PBM has shown potential in mitigating other oral complications associated with cancer therapy. The use of PBM may reduce the incidence of complications like xerostomia (dry mouth), dysgeusia (altered taste), and oral candidiasis, which often coexist with OM and further compromise the patient's well-being (AKAIKE *et al.*, 2024; PORPORATTI *et al.*, 2024). These additional benefits reinforce the value of incorporating PBM into a comprehensive, multidisciplinary oral care protocol for HNC patients, with the ultimate goal of improving treatment outcomes and enhancing their quality of life.

MATERIALS AND METHODS

Type of Study and Study Population

This prospective cohort study was conducted with patients who were diagnosed with head and neck cancer and were indicated for simultaneous treatment with radiotherapy and chemotherapy.

Location and Infrastructure

The research was conducted in the Clinical Dentistry sector of the Pernambuco Cancer Hospital. Data collection took place between November 2022 and August 2023.

Inclusion and Exclusion Criteria

Inclusion criteria

Be a registered patient at the Pernambuco Cancer Hospital, diagnosed with head and neck cancer; Have an indication for curative radiotherapy and concomitant chemotherapy; The radiotherapy treatment field must include the oral cavity.

Exclusion criteria

Refusal to receive photobiomodulation treatment; Clinical or surgical impediment to accessing the oral cavity for the application of photobiomodulation, due to the presence of solid tumors; Indication of palliative radiotherapy.

Data Collection

After the informed consent form, researchers collected data on individual records, including sociodemographic information (age, gender, race), oncological diagnosis (location, histological type), treatment details (radiotherapy: type, dose, fractionation; chemotherapy: drugs, cycles, frequency), oral changes (mucositis, infections), mucositis grading, nasogastric tube use (start date and return to oral feeding), photobiomodulation sessions (quantity, frequency), and oral pain. Assessments and records were performed weekly, from the beginning to the end of oncological treatment, the period during which photobiomodulation was administered.

Application of Photobiomodulation

Photobiomodulation (PBM) was applied three times a week, on alternate days, from the beginning to the end of radiotherapy, using a 660 nm DMC Therapy XT laser. The application was direct to specific points in the oral cavity (jugal mucosa, lips, soft palate, edges and dorsum of the tongue, and floor of the mouth - Figure 1 - Predetermined points in the oral cavity), with parameters of 100 mW of power, 1 J per point (10 seconds/point, 35 J/cm², 10 cm long silica

optical fiber and a 0.028 cm² spot). The procedure included disinfection, a plastic barrier, and the use of protective eyewear.

Evaluation of Oral Mucositis

Mucositis present in patients was classified according to the National Cancer Institute (NCI) table (Table 1).

Table 1 - Classification table of mucositis grades.

Degree	0	1	2	3	4
NCI Function and symptom	No change	Minimal symptoms, solid food	Presence of pain and modified diet	Oral feeding is not possible	Symptoms associated with risk of death
NCI Clinical Examination	No change	Presence of erythema	Presence of ulcers or pseudomembranes	Confluent ulcers or pseudomembranes, bleeding with mild trauma	Necrosis, spontaneous bleeding, risk of death

Source: Prepared by the author (2025).

Subjective Assessment of Pain

The pain of oral mucositis caused by cancer treatment was measured using the Wong-Baker Faces Scale (0 = no pain; 2.4 = mild; 6 = moderate; 8 = severe; 10 = unbearable). Patients self-assessed their pain before oral evaluation and/or laser therapy, and the researchers recorded it on a form.

Statistical Analysis

For statistical analysis, categorized data were presented in absolute and relative frequency distributions and then subjected to appropriate statistical tests. Continuous data were described by mean, median, and standard deviation. The study adopted a significance level of 5% (p-value < 0.05). SPSS 28.0 software was used for the analyses, and data entry was performed in Microsoft Excel.

Ethical Aspects

The research project was submitted to and approved by the Human Research Ethics Committee of the Pernambuco Cancer Hospital. All necessary terms and procedures were followed, ensuring compliance with current ethical and legal aspects, in accordance with Resolution 466/2012 . The opinion that authorized data collection is number 5,777,332.

RESULTS AND DISCUSSION

The study included 22 patients, predominantly men (77.9%), mixed race (81.8%) and in their sixth decade of life. The most common diagnosis was squamous cell carcinoma (95.5%), located mainly in the oral cavity (50%) (Table 2).

Table 2 - Characterization of the sample studied.

Variable	Category	n	%
Age (decades of life)			
	2nd decade of life	1	4.54
	3rd decade of life	1	4.54
	4th decade of life	4	18,18
	5th decade of life	5	22.72
	6th decade of life	7	31.81
	7th decade of life	4	18,18
Gender			
	Masculine	17	77.3
	Feminine	5	22.7
Race			
	White	2	9.1
	Indigenous	1	4.5
	Brown	18	81.8
	Black	1	4.5
Diagnosis			
	Squamous cell carcinoma	21	95.5
	Other (Adenoid cystic carcinoma)	1	4.5
Tumor location			
	Oral Cavity	11	50
	Larynx	3	13.6
	Oropharynx	7	31.8
	Other (Rhinopharynx)	1	4.5
Source: Research data, 2025.			

Source: Prepared by the author (2025).

Among the 22 patients, the degree of oral mucositis (OM) was common, with grades 2 and 3 predominating. The majority (81.6%) did not require a tube, and all received preventive photobiomodulation. Pain varied, with moderate and severe being the most reported (Table 3).

Table 3 - Variables related to oral health conditions and cancer treatment.

Variable	Category	n	%
Radiotherapy Dose			
	66 Gy	12	54.5%
	70 Gy	9	40.9%
	Others	1	4.5%
Fractionation (FX)			
	Average 32.3		
	Median 33		
	Standard deviation 2.607	22	100%
	Minimum 27		
	Maximum 35		
Chemotherapy Cycles			
	Up to 4 cycles	9	40.9%
	5 or more	13	59.1%
Frequency of Chemotherapy			
	21 days	9	40.9%
	Weekly	13	59.1%
Xerostomia			
	No	21	95.5%
	Yes	1	4.5%
Fungal Infection			
	No	5	22.7%
	Yes (Pseudomembranous candidiasis)	17	77.3%
Herpes			
	No	20	90.9%
	Yes	2	9.1%
Mucositis			
	No	2	9.1%
	Yes	20	90.9%
Degree of Mucositis			
	Grade 0	2	9.1%
	Grade 1	2	9.1%
	Grade 2	7	31.8%
	Grade 3	10	45.5%
	Grade 4	1	4.5%
Pain (Numerical scale)			
	0	4	18.2%
	4	1	4.5%
	6	8	36.4%
	8	6	27.3%
	10	3	13.6%
Use of Enteral Tube			
	No	18	81.6%

	Yes	4	18.6%
Source: Research data, 2025.			

Source: Prepared by the author (2025).

Table 4 details the relationship between different variables and the degree of mucositis, using P values (statistical probability) to indicate the existence of a significant association.

Statistically Significant Associations

Oral mucositis (OM) was significantly associated with gender, predominantly affecting women (80%) and men (82.4%) with grade 2 or higher. Xerostomia also showed a significant association, with all affected patients presenting with grade 1 or lower OM, while the majority (85.7%) without xerostomia developed higher grades (Table 4).

Absence of Statistically Significant Associations

The variables that did not show a statistically significant association with the degree of oral mucositis (OM) include: age (similar proportions of OM grade 2+ between adults and elderly), pain intensity (no significant relationship), fungal infection (percentage difference without statistical significance), herpes (100% of OM grade 2+ with herpes vs. 80% without, without significance), use of tube (all with tube had OM grade 2+ vs. 77.8% without tube, without significance), number of chemotherapy cycles and chemotherapy frequency (Table 4).

Table 4 - Analysis of the degree of mucositis with independent variables.

Variable	Mucositis grade up to 1	Mucositis grade 2 or more	P-value
Gender			
Feminine	1 (20.0%)	4 (80.0%)	0.014*
Masculine	3 (17.6%)	14 (82.4%)	0.014*
Age			
Adult	1 (9.1%)	10 (90.9%)	0.293*
Elderly	3 (27.3%)	8 (72.7%)	0.293*
Pain			
Moderate	3 (23.1%)	10 (76.9%)	0.450**
Intense	1 (11.1%)	8 (88.9%)	0.450**
Fungal infection			

Yes	2 (11.8%)	15 (88.2%)	0.210**
No	2 (40.0%)	3 (60.0%)	0.210**
Xerostomia			
Yes	1 (100.0%)	0 (0.0%)	0.030**
No	3 (14.3%)	18 (85.7%)	0.030**
Herpes			
Yes	0 (0.0%)	2 (100.0%)	0.662**
No	4 (20.0%)	16 (80.0%)	0.662**
Probe use			
Yes	0 (0.0%)	4 (100.0%)	0.418**
No	4 (22.2%)	14 (77.8%)	0.418**
Number of QT cycles			
Up to 4	2 (22.2%)	7 (77.8%)	0.550**
5 or more	2 (15.4%)	11 (84.6%)	0.550**
Periodicity			
21 days	2 (22.2%)	7 (77.8%)	0.683
Weekly	2 (15.4%)	11 (84.6%)	0.683
Source: Research data, 2025.			

* Person's Chi-square

** Fisher's Exact Test

Values in bold were statistically significant at the 5% (0.05) level.

Source: Prepared by the author (2025).

The individuals most affected by oral mucositis (OM) in our study were males in their sixth decade of life. Patients who received preventive photobiomodulation (PBM) reported lower severity of OM and reduced pain. These results are consistent with Zanin *et al.* (2010), who also investigated the efficacy of preventive laser therapy. In their study with 72 head and neck cancer patients divided into a control group (C; n=36) and a laser group (L; n=36), participants in group L generally reported reduced OM symptoms and pain, while all patients in group C developed OM with severe pain. The authors concluded that laser therapy was effective in preventing and treating the adverse oral effects of radiotherapy and chemotherapy, contributing to improved quality of life. Figueiredo *et al.* (2013) corroborated these findings, emphasizing the significant preventive role of laser therapy against OM in cancer patients.

In a case study exploring the effectiveness of laser therapy in treating OM, Medeiros, Maia, and Ferreira (2017) reported that no mucositis lesions developed during chemotherapy in patients who underwent laser therapy prior to treatment. Based on these findings, they recommended low-level laser therapy as an essential approach for the prevention and treatment of OM. Reolon *et al.* (2017) demonstrated a substantial improvement in quality of life indicators,

especially pain perception and milder degrees of mucositis, in patients who had previously undergone laser therapy. In contrast, Lima *et al.* (2010) found that, even with the use of low-level laser therapy during cancer treatment, all patients developed OM by the end of therapy. Patients with OM often need to modify their diet or even discontinue radiotherapy or chemotherapy due to the severity of the condition. Ottaviani *et al.* (2013) confirmed that preventive PBM was effective in reducing the intensity of OM and associated pain, as well as shortening the recovery time from OM.

Melo *et al.* (2022) reported that preventive PBM reduced the risk of severe OM by 62%. Of the 158 patients who received preventive PBM, only 25 presented OM grade ≤ 2 seven days after onset. The prevalence of grade 2 OM aligns with findings from other researchers, such as Kuhn *et al.* (2009). Menezes *et al.* (2021), evaluating the prevention and treatment of OM using low-level laser therapy (630 nm, 2 J/cm²), analyzed 204 patients undergoing preventive PBM and observed that laser therapy reduced both the incidence and intensity of OM. Patients who received laser therapy manifested OM grades 1 and 2, with grade 1 being the most frequent.

Considering individual treatment protocols and OM occurrence, the application of laser therapy demonstrated a statistically significant reduction in OM manifestations compared to patients not treated with laser. Several studies have reported the beneficial effects of PBM in OM management (KUHN *et al.*, 2009; ZADIK *et al.*, 2019).

Difficulty swallowing and oral pain are common problems in individuals with OM prior to PBM (REOLON *et al.*, 2017). PBM has shown positive results in mitigating these issues. OM causes oral discomfort and negatively impacts patients' quality of life, leading to decreased food intake and contributing to malnutrition (SHU *et al.*, 2020; CAMPOS *et al.*, 2020). Shu *et al.* (2020) also noted that OM is often associated with severe pain, making chewing and swallowing difficult, which may increase the need for nasogastric or nasoenteric tubes.

The need for feeding tubes in cancer patients, which can reach 35%, occurs due to severe OM and pain when chewing or swallowing, and is determined individually based on these difficulties (SHU *et al.*, 2020). In a study with patients who received preventive PBM, it was shown that during chemotherapy, 91.2% (62 patients) maintained normal or solid food initially; however, by the end of treatment, 59.7% (37 patients) required enteral feeding as a supplement.

Enteral feeding via a tube can benefit patients with head and neck cancer by improving nutritional and functional health indicators during treatment (SHU *et al.*, 2020). Malnourished patients have a higher prevalence of oral problems, including discomfort and OM, which may be

compounded by fungal infections such as pseudomembranous candidiasis (SHU *et al.*, 2020). Treatment costs also tend to increase when patients experience eating difficulties due to pain, including procedures such as nasogastric tube insertion (CAMPOS *et al.*, 2020; PAULI *et al.*, 2021).

OM, xerostomia, and infections (fungal and viral) were identified, with OM being the most common across all sexes and ages. This highlights the importance of dentists in the multidisciplinary team for head and neck cancer patients, from diagnosis onward, to improve prognosis and reduce side effects. Preventive PBM can mitigate the effects of OM and may even prevent the need for enteral or parenteral nutrition (PAULI *et al.*, 2021). The present study reinforces previous findings that preventive PBM significantly improves the management of OM, despite the limited sample size, and underscores the need for further research to optimize preventive therapies.

CONCLUSION

This study provided a comprehensive overview of the oral health implications of patients undergoing intensive treatment for head and neck cancer. Oral mucositis (OM), a common and debilitating complication, has proven to be a significant challenge in this clinical setting. Preventive photobiomodulation (PBM) emerges as a promising strategy to prevent and mitigate the negative effects of OM, with the potential to significantly improve patients' quality of life and reduce the need for nasogastric tube use.

Limitations and Recommendations for Future Research: This study presents as its main limitation the small sample size, which restricts the generalization of the results. Furthermore, patient follow-up was limited to the period of oncological treatment, without considering medium- and long-term impacts. It is recommended that future research be conducted with larger samples, in different oncology reference centers, and with extended follow-up in order to validate the findings presented here. Comparative studies among different photobiomodulation protocols are also necessary to standardize clinical parameters and optimize therapeutic outcomes.

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