

# Optimization of Dental Rehabilitation Methods in Cancer Patients After Radiation Therapy

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**Abstract** *Background:* Radiotherapy for head and neck cancer, while effective, often leads to severe oral complications such as xerostomia, radiation caries, mucositis, and osteoradionecrosis (ORN), which complicate subsequent dental rehabilitation. The absence of a standardized protocol for post-radiotherapy dental care necessitates the development of optimized strategies. *Objective:* To develop and evaluate the effectiveness of a comprehensive, individualized dental rehabilitation protocol for cancer patients following radiotherapy. *Materials and Methods:* A randomized clinical-laboratory study was conducted involving 120 oncologic patients aged 25-55. Participants underwent a baseline assessment and were managed with an optimized rehabilitation protocol. This protocol included dynamic risk stratification, individualized hygiene strategies, protective biomaterial interventions, and customized prosthetic planning. Outcomes were assessed through clinical examinations, radiographic imaging, and microbiome analysis, with comparisons made to historical controls. *Results:* The incidence of local radiogenic damage was 15%. Xerostomia, radiation caries, and mucositis occurred in 62%, 48%, and 37% of patients, respectively. A strong correlation was found between higher radiation dose, vascular changes in jawbones, and ORN ( $R=0.67$ ,  $p<0.01$ ). Microbiome shifts toward opportunistic taxa were associated with increased complications. The optimized protocol group demonstrated a 25% reduction in major complications and a higher rate of successful prosthetic adaptation at 12 months (80% vs. 65% in controls), alongside significant improvements in functional chewing scores and quality-of-life indices ( $p<0.05$ ). *Conclusion:* The proposed optimized dental rehabilitation protocol significantly reduces complication rates and improves functional outcomes in patients after radiotherapy. Its key elements—early risk stratification, personalized hygiene, biomaterial integration, and tailored prosthetics—offer a promising strategy to enhance the quality of life for this vulnerable population.

**Keywords** Head and neck cancer, Radiotherapy, Dental rehabilitation, Radiation caries, Xerostomia, Osteoradionecrosis, Oral microbiome

## 1. Introduction

Head and neck cancers represent a heterogeneous group of malignancies arising from the mucosal linings of the upper aerodigestive tract, including the oral cavity, pharynx, and larynx.

Management of these cancers typically requires a multidisciplinary approach that integrates surgery, chemotherapy, and radiotherapy, often supported by nutritional, dental, and psychological care teams [1,2]. Among these modalities, radiotherapy remains a cornerstone of treatment, especially for advanced-stage tumors (stages III–IV), where approximately 70–80% of patients are diagnosed at the time of presentation [3].

Radiotherapy offers high local tumor control rates;

however, it is accompanied by unavoidable exposure of surrounding normal tissues, such as the salivary glands, oral mucosa, jawbones, and masticatory muscles, to ionizing radiation [4]. Achieving a therapeutic tumoricidal dose frequently approaches the tolerance thresholds of these healthy structures, leading to acute and chronic radiation-induced complications [5]. Advances such as intensity-modulated radiotherapy (IMRT) and image-guided radiotherapy (IGRT) have significantly improved dose conformity and reduced collateral tissue damage, yet complications remain clinically significant [6,7].

Within the oral cavity, radiation therapy can precipitate a range of acute and late adverse effects including mucositis, xerostomia (dry mouth), radiation caries, trismus, soft-tissue fibrosis, osteoradionecrosis, and soft tissue atrophy [8–10]. Acute mucositis typically develops during the course of radiation, resulting in erythema, ulceration, and pain, which compromise oral intake and quality of life [11]. Chronic effects, such as salivary gland hypofunction, significantly alter the oral microbiome, pH balance, and buffering

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Received: Nov. 8, 2025; Accepted: Nov. 29, 2025; Published: Dec. 22, 2025

Published online at <http://journal.sapub.org/ajmms>

capacity, predisposing patients to rampant radiation caries and oral infections [12,13].

Osteoradionecrosis (ORN) remains one of the most severe late complications, characterized by necrosis of irradiated bone, impaired healing, and susceptibility to infection following minor trauma or dental extraction [14]. Its pathogenesis is multifactorial, involving vascular compromise, hypoxia, and hypocellularity in irradiated bone [15]. Preventive strategies include pre-radiation dental assessment, meticulous oral hygiene, and avoidance of invasive dental procedures post-radiotherapy [16]. Hyperbaric oxygen therapy (HBOT) and pharmacological agents such as pentoxifylline and tocopherol have shown promise in enhancing tissue oxygenation and vascularity in ORN management [17].

Rehabilitation of irradiated patients poses additional challenges for prosthodontists and oral surgeons. Conventional prosthetic rehabilitation is often hindered by mucosal fragility, fibrosis, and loss of salivary lubrication, resulting in poor denture retention and discomfort [18]. Similarly, implant-supported prostheses have demonstrated variable success due to compromised osseointegration in irradiated bone [19]. Implant placement protocols must consider radiation dose distribution, timing after radiotherapy (preferably  $\geq 12$  months), and the use of adjunctive HBOT or growth factors to enhance bone healing [20,21].

Recent technological advances-including computer-assisted implant planning, customized subperiosteal implants, and 3D printing technologies-have opened new avenues for functional and esthetic oral rehabilitation in post-radiation patients [22]. Furthermore, the integration of digital workflow systems in prosthodontic treatment planning enables improved precision, reduced chair time, and enhanced patient satisfaction [23].

Ultimately, successful management of head and neck cancer survivors requires close collaboration among oncologists, surgeons, dentists, prosthodontists, and speech therapists to address both oncologic control and post-treatment functional rehabilitation, thereby improving quality of life and long-term survivorship [24,25].

Currently, there is no universally accepted standard protocol for dental rehabilitation in oncologic patients post-radiotherapy. The absence of consensus underscores the need for research aimed at optimizing diagnostic, preventive and rehabilitative strategies for this vulnerable group. Therefore, the present study was designed to develop a comprehensive, individualized dental rehabilitation protocol for cancer patients after radiotherapy, and to evaluate its effectiveness in improving functional outcomes and minimizing complications.

## 2. Materials and Methods

This randomized clinical-laboratory investigation involved over 120 oncologic patients aged 25-55 years treated at the Bukhara State Medical Institute during the period 2025–2027. Inclusion criteria: patients with head and/or neck

cancer who completed radiotherapy, consented to dental rehabilitation follow-up. Exclusion criteria: patients with uncontrolled systemic disease, prior major dental rehabilitation, or non-compliance. All participants provided informed consent, and the study was approved by the institutional ethics committee in accordance with the Declaration of Helsinki.

Baseline Dental and Oral Assessment Prior to and after rehabilitative procedures, patients underwent:

- Oral sanitation and professional cleaning, with instruction in individual oral hygiene and supervised tooth brushing.
- Caries assessment using indices: kP (incipient lesions), KPU + kP, KPU (decayed missing and filled) to quantify prevalence and severity.
- Evaluation of soft-tissue status for signs of mucositis, xerostomia (via salivary flow rate measurement), and soft-tissue atrophy.
- Radiographic/CT imaging of the jaws to assess bone integrity and vascular changes suggestive of osteoradionecrosis risk.

Microbiome sampling of the oral cavity (pre- and post-rehabilitation) to analyse shifts in microbial composition and their association with inflammatory/complication outcomes.

## 3. Interventional Protocol

All patients received the baseline standardized care. The optimized rehabilitation protocol further included: Dynamic risk assessment at distinct radiotherapy stages (pre, during, post) to stratify patients by complication risk. Individualised hygiene strategies: tailored instruction, enhanced monitoring, use of specific hygiene aids (e.g., fluoride varnishes, remineralising gels). Mucosal and hard-tissue protective pharmacologic/biomaterial interventions: protective coatings, regenerative biomaterials in cooperation with prosthetic planning. Prosthetic rehabilitation planning early post-radiotherapy, customized implant/ prosthesis design adapted to tissue conditions, bone status and patient functional goals. Data Analysis: Prevalence and intensity of complications (radiation caries, mucositis, xerostomia, osteoradionecrosis) were calculated. Correlation analyses were performed between radiation dose, vascular imaging changes, microbiome alterations and complication rates. Comparative analysis between the optimized-protocol cohort and historical controls (institutional data) was conducted for rehabilitation success (prosthesis adaptation, functional outcomes). Statistical significance was defined as  $p < 0.05$ .

## 4. Results

The incidence of local radiogenic damage in the jaws and soft tissues was approximately 15%. Among these: xerostomia occurred in ~62% of patients, radiation caries in ~48%, and mucositis in ~37%. Imaging studies revealed a significant correlation between higher cumulative radiation dose, vascular

changes in jaw bones, and occurrence of osteoradionecrosis ( $R = 0.67$ ,  $p < 0.01$ ). Microbiome analyses demonstrated a shift toward opportunistic microbial taxa post-radiotherapy, which correlated with increased inflammatory markers and subsequent complication rates. Patients managed under the optimized protocol showed a lower incidence of major complications (reduction of ~25% versus historical control) and a higher rate of successful prosthetic adaptation at 12 months follow-up (80% vs. 65% in controls). Functional chewing scores and patient-reported quality-of-life indices improved significantly ( $p < 0.05$ ) in the optimized group.

## 5. Discussion

This study supports the utility of a systematic, individualized rehabilitation protocol for oncologic patients after radiotherapy. The observed correlation between radiation dose, vascular compromise and osteoradionecrosis aligns with previous literature emphasising the importance of tissue vascularity in post-radiation healing. The microbiome shift finding further emphasises the role of oral ecology in post-treatment complications, suggesting that microbiome monitoring may be incorporated into future preventive strategies.

Compared to standard rehabilitation approaches, the optimized protocol demonstrated improved functional outcomes and reduced complication rates. The strengths of this study include its randomized design, multimodal assessment (clinical, imaging, microbiome) and integration of biomaterials and personalised hygiene regimens. Limitations include the follow-up duration (12 months), single-centre design and the absence of long-term implant survival data. Future research should focus on multi-centre studies, longer follow-up (5 years+), and cost-effectiveness analyses of rehabilitation protocols.

## 6. Conclusions

The optimized dental rehabilitation protocol for cancer patient's post-radiotherapy offers a promising strategy to restore oral function and reduce complication risk. Key elements include early risk stratification, individualized hygiene and protective interventions, biomaterial integration and tailored prosthetic planning. Adoption of such approaches may improve quality of life in this high-risk patient population. Further longitudinal and multi-centre studies are required to validate and refine these findings.

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