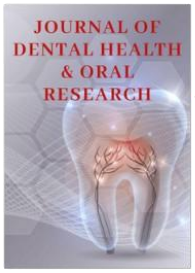

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The Dental Practitioner's Role in Head and Neck Radiation Oncology: A Narrative Review of Oral Complications and Evidence-Based Management Across the Treatment Continuum

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Abstract

Head and neck cancer remains a significant global health burden, with radiotherapy playing a central role in its management. Despite advances in treatment precision, the oral cavity is frequently included within the radiation field, resulting in a spectrum of complications that affect patient function and quality of life. Oral mucositis, xerostomia, candidiasis, radiation caries, trismus, dysgeusia and osteoradionecrosis represent the most clinically significant of these sequelae, occurring across a continuum from the acute phase of treatment through long-term survivorship. This narrative review examines the pathophysiology, clinical presentation and evidence-based management of each complication, emphasizing the dentist's indispensable role within the multidisciplinary oncology team. Pre-radiation dental evaluation, structured in-treatment monitoring and lifelong post-radiation follow-up are presented as an integrated clinical framework. Current gaps in literature and emerging therapeutic directions, including photobiomodulation, aquaporin-1 gene therapy and artificial intelligence-assisted early detection, are also discussed.

Keywords: Head and Neck Cancer; Radiotherapy; Oral Complications; Oral Mucositis; Oral Candidiasis; Xerostomia; Salivary Gland Dysfunction; Osteoradionecrosis; Dental Management; Multidisciplinary Care

Introduction

Head and neck cancer represents one of the most common malignancies worldwide and continues to be a major public health problem. Approximately 90% of cases are squamous cell carcinoma, which primarily affects the oral cavity, pharynx and larynx [1]. Tobacco and alcohol consumption remain among the primary risk factors associated with the development of this disease and in recent years, a well-documented increase in cases linked to the Human Papillomavirus (HPV), particularly HPV-16, has been observed in oropharyngeal cancers across the United States and Europe [2]. Current treatment options for localized disease include surgery and radiotherapy, with five-year survival rates ranging between 70% and 90% depending on tumor stage and anatomical location [3].

Radiotherapy remains one of the cornerstones in the management of head and neck cancer, used either as a definitive modality or as adjuvant therapy following surgical resection [4]. Modern techniques such as Intensity-Modulated Radiotherapy (IMRT) and proton therapy have improved treatment precision and reduced collateral damage to surrounding healthy structures; however, given the complex anatomy of this region, the oral cavity is frequently encompassed within the radiation field [1,4]. As a result, many patients develop significant oral complications during and after treatment, the severity of which depends on total radiation dose, fractionation scheme, treatment duration and the specific anatomical areas irradiated [5].

The spectrum of oral complications associated with head and neck radiotherapy is broad and clinically meaningful. Oral mucositis produces painful ulcerations that impair eating, drinking and speaking; xerostomia, caused by radiation-induced damage to the salivary glands, significantly affects oral health and quality of life; dysphagia compromises nutrition and swallowing function; and in some cases, these acute complications become severe enough to delay or interrupt oncological treatment [5,6]. Late sequelae including radiation caries, trismus, dysgeusia and osteoradionecrosis can persist for months or years after the completion of therapy and carry lasting functional and psychosocial consequences [4,7,8]. Table 1 provides a structured overview of each complication, its onset, pathophysiological mechanism and management approach.

Ionizing radiation damages rapidly proliferating tissues through direct DNA strand breaks and the generation of reactive oxygen species, leading to cellular death, mucosal barrier disruption and subsequent inflammatory cascades [8]. These mechanisms underlie the pathogenesis of most acute oral complications. Radiotherapy also alters the composition of the oral microbiota, creating a dysbiotic environment that favors opportunistic pathogens, particularly Candida species, which further contributes to oral morbidity [9].

The impact of oral complications extends well beyond physical symptoms. Difficulties with speaking, eating, swallowing and maintaining adequate oral hygiene, as well as changes in facial appearance, can impair nutrition, social interaction and emotional well-being. [10] For this reason, early detection and appropriate clinical management of these complications are fundamental throughout the course of cancer care [11].

The dentist occupies a critical position within the multidisciplinary team responsible for managing patients with head and neck cancer [12]. A dental evaluation performed prior to the initiation of radiotherapy enables the identification of active foci of infection, periodontal disease and other local risk factors that could amplify subsequent complications. During active treatment, regular dental follow-up supports management of mucositis, xerostomia and oral infections [13]. Following the completion of therapy, ongoing monitoring is essential to minimize late sequelae and support the patient's oral function and quality of life throughout survivorship [11].

Given the high prevalence and clinical impact of oral complications associated with radiotherapy in head and neck cancer patients, this narrative review aims to analyze the main oral complications arising in this context and to present current evidence-based strategies for their prevention and management within a multidisciplinary framework [6]. The review is organized to follow the clinical sequence of these complications, beginning with the acute inflammatory toxicities of mucositis and candidiasis, continuing through salivary gland dysfunction, addressing the chronic sequelae of radiation caries, trismus and dysgeusia, examining the pathophysiology and management of osteoradionecrosis and concluding with an integrated pre-, peri- and post-radiation dental protocol [3,4].

Complication	Onset	Pathophysiological Mechanism	Clinical Consequences	Management Approach
Oral Mucositis	Acute (week 1-2)	DNA damage to rapidly proliferating epithelium; inflammatory cascade	Painful ulcerations; impaired eating, swallowing, speaking	Oral hygiene protocols; photobiomodulation; palifermin; analgesics
Candidiasis	Acute	Mucosal disruption; salivary hypofunction; immunosuppression	Oral discomfort; burning; dysgeusia; worsening pain	Fluconazole; nystatin; oral hygiene; denture disinfection

Xerostomia	Acute → Chronic	Acinar cell loss; fibrosis; parasympathetic denervation of salivary glands	Dry mouth; dysphagia; increased caries and infection risk	Pilocarpine; cevimeline; saliva substitutes; IMRT sparing
Radiation Caries	Chronic (months-years)	Hyposalivation; altered pH; microbiota shift; enamel structural damage	Rapid cervical and smooth-surface decay	High-fluoride trays; chlorhexidine; CPP-ACP; diet counseling
Trismus	Subacute → Chronic	Fibrosis of pterygoid muscles and infratemporal space	Restricted mouth opening; impaired hygiene, nutrition and airway access	TheraBite/Dynasplint devices; physiotherapy; botulinum toxin
Dysgeusia	Acute → may persist	Direct radiation damage to taste receptor cells and progenitors	Altered taste; reduced appetite; malnutrition risk	Zinc supplementation; dietary modification; time
Osteoradionecrosis	Late (months-years)	Vascular injury; fibrosis; impaired bone remodeling (fibroatrophic model)	Exposed non-healing bone; pain; fistula; disfigurement	PENTOCLO; surgery (sequestrectomy to free-flap); prevention is key
CPP-ACP = casein phosphopeptide-amorphous calcium phosphate; IMRT = intensity-modulated radiotherapy; PENTOCLO = pentoxifylline + tocopherol ± clodronate; RT = radiotherapy. Supporting references by complication: oral mucositis [8,9]; candidiasis [10,12]; xerostomia [13,14]; radiation caries [21,22]; trismus [25,26]; dysgeusia [23]; osteoradionecrosis [28,29]. The table represents a narrative synthesis of the cited literature; no standardized questionnaire or primary data collection was used to derive these parameters.				

Table 1: Overview of oral complications associated with head and neck radiotherapy: onset, mechanism, clinical consequences and management approach.

Oral Mucositis and Candidiasis: Acute Inflammatory Complications and Their Clinical Management

Among the oral complications associated with head and neck radiotherapy, oral mucositis and candidiasis are the two most prevalent acute conditions affecting patients during active treatment [9]. Both can significantly interfere with eating, speaking and swallowing, making it difficult to maintain adequate oral hygiene and ultimately affecting treatment tolerance and quality of life. Clinical data consistently demonstrate a high prevalence of these toxicities in patients receiving radiotherapy alone or in combination with systemic chemotherapy [10,11].

Oral mucositis develops as a consequence of radiation-induced damage to the rapidly proliferating epithelium of the oral mucosa and the inflammatory response that follows. The pathogenesis of this process has been described through a multiphase model proposed by Sonis, encompassing initiation, upregulation and message generation, signaling and amplification, ulceration and healing [12]. Clinically, patients present with erythema, edema, ulceration, pain, dysphagia and odynophagia. Severity is commonly graded using the World Health Organization (WHO) scale or the National Cancer Institute Common Terminology Criteria for Adverse Events (NCI-CTCAE); both systems are presented side by side in Table 2 for clinical reference [13]. In more severe cases, mucositis may compromise nutritional intake and hydration to a degree that necessitates opioid analgesics or enteral support and it may also contribute to interruptions or dose modifications in the oncological treatment schedule, with direct consequences for tumor control [8].

Current management of oral mucositis is primarily directed toward symptom control, preservation of oral function and reduction of secondary complications. Recommended supportive measures include structured oral hygiene protocols, saline or sodium bicarbonate rinses, adequate pain management, nutritional support and regular dental follow-up throughout the treatment course [14]. Photobiomodulation therapy, commonly referred to as low-level laser therapy, has gained increasing

support in the literature as a non-pharmacological adjunct for reducing mucositis severity and promoting mucosal healing and it is now incorporated into several institutional guidelines [9]. Palifermin, a recombinant human keratinocyte growth factor, has demonstrated efficacy in reducing severe oral mucositis in specific patient populations, although its use remains limited by cost and indication. Cryotherapy during chemotherapy infusion has also been explored as a preventive measure, though its applicability in the radiotherapy setting is more constrained [15].

Radiotherapy also alters the oral environment in ways that promote opportunistic fungal infections, particularly oropharyngeal candidiasis. Several interacting factors contribute to this susceptibility, including mucosal barrier disruption, radiation-induced salivary hypofunction, impaired immune defenses, denture use, reduced oral intake and the frequent concurrent use of systemic antibiotics or corticosteroids [16]. Oropharyngeal candidiasis has been associated with increased oral discomfort, burning sensation, dysgeusia and worsening pain during radiotherapy. The most common clinical presentations are pseudomembranous candidiasis, erythematous candidiasis and angular cheilitis, each of which may occur in isolation or concurrently [17].

Management of oropharyngeal candidiasis in this population relies on early clinical diagnosis, prompt initiation of antifungal therapy, reinforcement of oral hygiene practices and appropriate denture disinfection when applicable. Fluconazole is generally preferred as a first-line systemic antifungal agent given its bioavailability and tolerability, while nystatin suspension remains an option for milder presentations, though its efficacy may be limited in patients with significantly reduced salivary flow [18]. In immunocompromised patients or those with fluconazole-resistant strains, alternative agents such as itraconazole or voriconazole may be required [19]. Persistent Candida colonization in this population is closely linked to ongoing salivary hypofunction, which underscores the importance of addressing xerostomia as a contributing factor even when managing acute fungal infections [20].

The dentist's role during the active treatment phase encompasses regular clinical monitoring of both mucositis and candidiasis, reinforcement of oral hygiene, proactive communication with the oncology team regarding symptom severity and timely initiation or adjustment of supportive therapies. Structured oral care protocols implemented from the onset of radiotherapy have been shown to reduce the overall burden of acute oral complications and improve patient tolerance to the treatment regimen [20,21].

Grade	Severity	WHO Criteria	NCI-CTCAE v5.0 Criteria	Clinical Implications
0	None	No mucositis	No mucositis	No intervention required
1	Mild	Erythema; soreness	Erythema; minimal symptoms	Oral hygiene; saline rinses
2	Moderate	Erythema; ulcers; can eat solids	Patchy ulceration (< 1.5 cm); moderate pain	Soft diet; topical analgesics; close monitoring
3	Severe	Ulcers; liquid diet only	Confluent ulceration (> 1.5 cm); severe pain; cannot eat	Systemic analgesics; nutritional support; may delay RT
4	Life-threatening	Alimentation not possible	Life-threatening; tissue necrosis	Parenteral nutrition; hospitalization; treatment interruption
NCI-CTCAE = National Cancer Institute Common Terminology Criteria for Adverse Events; RT = radiotherapy; WHO = World Health Organization. The grading criteria are reproduced from the WHO oral toxicity scale and the NCI-CTCAE version 5.0 classification; the clinical implications column represents a narrative synthesis of the cited literature [8,11].				

Table 2: Comparative grading of oral mucositis severity: WHO scale versus NCI-CTCAE version 5.0 criteria with clinical implications.

Xerostomia is defined as the subjective sensation of oral dryness and is commonly associated with hyposalivation, also defined as a measurably reduced or absent salivary flow rate. Saliva production is regulated primarily through adrenergic and cholinergic neurotransmission and plays a critical role in maintaining oral health and protecting against oral infections [22]. The major salivary glands, namely the parotid, submandibular and sublingual glands, together with numerous minor salivary

glands, are collectively responsible for approximately 90% of total saliva production [13,14]. The parotid gland predominantly secretes serous saliva and contributes mainly to stimulated salivary flow, whereas the submandibular and sublingual glands produce mixed seromucous secretions that are essential for basal lubrication and protection of the oral mucosa [24]. Collectively, saliva forms a protective barrier against microorganisms and is indispensable for mastication, swallowing, taste and the maintenance of mucosal integrity [25].

Radiotherapy to the head and neck severely impairs salivary gland function due to the high radiosensitivity of glandular tissue, particularly the serous acinar cells [16]. The parotid glands are considered the most radiosensitive because of their predominantly serous composition and high secretory activity; radiation doses exceeding approximately 25 to 30 Gy have been associated with significant and often irreversible reductions in salivary flow [26]. The submandibular and sublingual glands, while relatively more radioresistant, are also frequently compromised depending on the radiation field [14]. Over time, radiation-induced changes lead to progressive acinar cell loss, fibrotic replacement of glandular parenchyma and disruption of parasympathetic innervation, resulting in persistent salivary hypofunction that may be permanent [15,27].

Radiation-induced salivary gland dysfunction produces a wide range of oral and functional consequences that substantially affect patients' daily lives [28]. Reduced salivary flow impairs oral lubrication, making swallowing, chewing and speaking more difficult. Many patients experience dysphagia and speech alterations, which can contribute to inadequate nutrition and reduced well-being [29]. Furthermore, diminished saliva disrupts the normal oral environment by reducing its buffering capacity and antimicrobial properties, thereby increasing the risk of enamel demineralization, radiation-associated dental caries and periodontal complications [30]. The reduction of protective salivary proteins also creates conditions favorable to opportunistic infections such as oral candidiasis. Taste disturbances, including dysgeusia, are an additional frequent consequence and may contribute to reduced appetite and inadequate nutritional intake [14,31].

Clinical assessment of radiation-induced xerostomia relies on both objective and subjective measures [32]. Objective evaluation is primarily accomplished through sialometry, which measures unstimulated and stimulated salivary flow rates; salivary scintigraphy can provide additional functional information regarding glandular secretory capacity [33]. Subjective assessment typically relies on validated patient-reported questionnaires including the European Organization for Research and Treatment of Cancer Quality of Life Head and Neck Module (EORTC QLQ-H&N35) and the Xerostomia Questionnaire (XQ) [34]. It is clinically important to use both types of measures, as the correlation between perceived xerostomia and objectively measured salivary flow is frequently limited [35].

Management of radiation-induced xerostomia focuses on functional improvement, symptom relief and the prevention of downstream oral complications [36]. Pharmacological sialogogues such as pilocarpine and cevimeline act on muscarinic receptors to stimulate residual glandular secretion and are typically employed when functional glandular tissue remains [37]. Saliva substitutes and oral moisturizing agents help alleviate discomfort in patients with more severe glandular damage. Preventive approaches, particularly IMRT with contralateral parotid-sparing techniques, have demonstrated meaningful reductions in xerostomia rates and represent the current standard of care when anatomically feasible [38]. Acupuncture has been explored as an adjunctive approach, with some evidence suggesting benefit in patients with mild to moderate xerostomia [39,40]. Emerging therapeutic strategies focus on restoring salivary gland function through gene-based and regenerative approaches. Aquaporin-1 (AQP1) gene therapy has demonstrated encouraging results in preclinical and early clinical studies, showing improved salivary secretion in previously irradiated glands [19]. Stem cell-based therapies are also under active investigation, given their potential to restore salivary tissue architecture; however, available evidence remains predominantly preclinical [35]. Submandibular gland transfer, in which the gland is surgically repositioned outside the radiation field prior to treatment, represents an established preventive surgical option for selected patients treated with unilateral radiotherapy [41]. While these approaches hold promise, most regenerative strategies continue to require clinical validation before widespread implementation [42].

Radiation Caries, Trismus and Dysgeusia: Chronic Sequelae Affecting Oral Function and Nutritional Status

Definitive or adjuvant radiotherapy for head and neck cancer carries a substantial risk of inducing chronic oral sequelae that persist well beyond the active treatment phase. Among these, radiation caries, trismus and dysgeusia represent three interrelated complications that directly compromise oral function, nutritional intake and the patient's capacity for social and rehabilitative

engagement [43]. Pain and functional impairment from these conditions hinder daily activities such as speaking, eating and swallowing, with compounding negative effects on quality of life [44].

Radiation caries is a localized, destructive process affecting dental hard tissues and represents one of the most frequent and clinically significant dental consequences of head and neck radiotherapy [21,22]. Its pathogenesis is multifactorial. Radiation-induced degeneration of salivary gland acini and interstitial fibrosis reduce salivary flow and alter saliva composition, creating a more acidic oral environment with diminished buffering capacity and antimicrobial proteins [45]. Simultaneously, direct radiation effects on the dental hard tissues include changes in the structure of enamel prisms, odontoblast degeneration and obliteration of dentinal tubules, which render the tooth more susceptible to demineralization [46]. The resulting caries typically exhibits a characteristic pattern of cervical and smooth-surface involvement, affecting sites not commonly susceptible in non-irradiated patients and progresses rapidly without preventive intervention. Systematic review data indicate that approximately 29% of patients develop post-radiotherapy dental caries, with higher radiation exposure correlating with greater incidence [21,47].

Prevention of radiation caries relies heavily on fluoride therapy. Systematic review evidence supports that various fluoride formulations, including high-concentration fluoride varnishes and custom fluoride trays, can reduce the incidence of radiation caries by up to 70% when used consistently [48]. Chlorhexidine gluconate rinses serve as an adjunct to reduce cariogenic bacterial load and Casein Phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP) preparations have been proposed as remineralizing agents, though evidence for the latter in this specific population remains limited [22]. Dietary counseling to reduce cariogenic food intake and reinforce oral hygiene practices is an essential complement to these preventive strategies. Custom fluoride trays should ideally be fabricated prior to the start of radiotherapy and used daily for life [48,49].

Trismus, defined as a restriction in maximal mouth opening, results from fibrosis and contracture of the muscles of mastication and the surrounding soft tissues within the radiation field, particularly the pterygoid muscles and the infratemporal space [25,26]. The prevalence of clinically significant trismus increases progressively with time after radiotherapy; one prospective study reported a prevalence of 24.4% at baseline, rising to 37.1% at six months post-treatment, with prevalence of 27.9% at week three and 41.9% at week six during active radiotherapy [50]. The concurrent use of chemotherapy appears to further increase the risk of trismus development [51]. Clinically, trismus impairs mastication, oral hygiene, speech and access for dental examination or treatment; in severe cases, it may also complicate anesthetic airway management [52].

Management of trismus must be initiated early, as evidence consistently indicates that early intervention yields greater improvement in interincisal opening than treatment initiated after contracture is established [25]. Mechanical jaw-stretching devices, including the TheraBite system and the Dynasplint Trismus System, are among the most commonly used and best-supported interventions; these devices apply progressive, sustained force to gradually increase the range of mandibular motion. Physical therapy including manual stretching exercises, heat application and myofascial release techniques is an important component of rehabilitation. Botulinum toxin injection into hypertonic masticatory muscles has been explored as an adjunctive measure, with some evidence of short-term benefit [53,54].

Dysgeusia or taste disturbance, is a radiation-induced alteration resulting from direct damage to taste receptor cells on the fungiform, foliate and circumvallate papillae, as well as from eradication of rapidly proliferating progenitor cells responsible for taste cell renewal [55]. Changes in taste perception can be evident within the first weeks of radiotherapy and may persist for months to years after treatment completion. One study of patients with oropharyngeal cancer documented severe dysgeusia in 50% of patients at one-month post-treatment, with progressive improvement over time: 40% at three months, 22% at six months and 23% at twelve months [56]. Given its impact on appetite and oral intake, dysgeusia is an underrecognized contributor to malnutrition in this patient population [27]. Management options remain limited; zinc supplementation has been studied with inconsistent results and most patients rely on time and general supportive measures including flavor enhancement strategies and dietary modification [57].

The interrelationship among radiation caries, trismus and dysgeusia creates a compounding clinical burden. Restricted mouth opening limits access for dental hygiene and professional care, while reduced salivary flow accelerates caries progression; simultaneously, altered taste and swallowing difficulty reduce oral intake and poor nutrition impairs tissue repair and immune

competence [58]. Because these alterations collectively increase the risk of malnutrition, the dentist plays a meaningful role in identifying patients at nutritional risk and collaborating with dietitians and oncology teams to implement appropriate supportive interventions. Early preventive programs targeting all three conditions must be established before radiotherapy begins and maintained throughout the post-treatment survivorship period [59].

Osteoradionecrosis of the Jaws: Pathophysiology, Prevention and Current Management Paradigms

Osteoradionecrosis (ORN) of the jaws represents the most severe and potentially disfiguring late complication of head and neck radiotherapy. By current diagnostic criteria, ORN is defined as exposed, non-healing bone within a previously irradiated field that persists for more than three months in the absence of residual or recurrent tumor [60]. This distinction is essential for accurate diagnosis and to avoid confusing ORN with local tumor recurrence or other bone pathologies. Unlike the acute toxicities discussed previously, ORN reflects a chronic failure of irradiated bone to maintain homeostasis in the face of progressive vascular compromise, fibrosis and impaired remodeling capacity [28,29].

The pathophysiology of ORN has evolved significantly in its conceptualization over recent decades. Marx's classical model emphasized hypovascularity, hypoxia and hypocellularity resulting from radiation-induced obliterative endarteritis as the central mechanism of non-healing necrotic bone. More recent evidence has shifted toward the radiation-induced fibroatrophic model proposed by Delanian and Lefaix, which highlights chronic oxidative stress, fibroblast dysregulation, microvascular compromise and progressive tissue fibrosis as the dominant pathological processes [61]. In practical terms, both frameworks underscore that irradiated bone exists in a state of profound biological fragility, in which even minor trauma, infection or dental intervention may precipitate ORN [62].

Several well-established risk factors for ORN have been identified. Radiation doses exceeding 60 Gy, mandibular location, pre-existing periodontal disease, alcohol and tobacco use and particularly post-radiation dental extractions are consistently implicated [63]. Although IMRT and proton therapy have reduced high-dose exposure to surrounding structures compared with conventional radiotherapy; current cohort data confirm that these modalities do not eliminate ORN risk; cases continue to be reported even in proton therapy series [30,32]. The mandible is by far the most commonly affected site, given its anatomical position within typical radiation fields and its relatively limited collateral blood supply compared with the maxilla. Dental implants placed in previously irradiated bone carry substantially higher failure rates, particularly when cumulative doses exceed 50 to 60 Gy [64,65].

Several staging systems guide clinical management. The Marx classification, the Notani system and the criteria issued by the American Association of Oral and Maxillofacial Surgeons (AAOMS) each distinguish disease severity based on the extent of bone exposure, presence of orocutaneous fistulae and response to conservative treatment [65]. Table 3 presents these systems in a comparative format to assist clinical decision-making. These classifications assist clinicians in determining whether conservative medical management, limited surgical debridement or definitive resection with reconstruction is indicated [66].

Medical management is primarily applicable to early-stage ORN. Pentoxifylline combined with tocopherol (vitamin E), with or without clodronate, constitutes the PENTOCLO protocol, which targets the fibroatrophic mechanism through vasodilation, reduction of oxidative stress and inhibition of fibroblast activation. This regimen has demonstrated favorable outcomes in early and moderate ORN in several case series, though randomized controlled trial evidence remains limited [67]. Hyperbaric Oxygen (HBO) therapy, once widely used based on Marx's hypoxia model, has not demonstrated consistent benefit in prospective trials and is no longer recommended as a routine component of ORN management, though it continues to be used in some centers as an adjunct to surgical care [31].

Surgical intervention is required for advanced ORN that fails to respond to conservative measures. Options include sequestrectomy and debridement for limited disease, marginal resection for moderate cases and segmental resection with microvascular free-flap reconstruction for severe or refractory ORN [68]. Fibula free flaps remain the most commonly employed reconstruction option for segmental mandibular defects and offer favorable long-term outcomes in terms of bone continuity and functional rehabilitation. A staged approach, progressing from conservative medical therapy to definitive surgical reconstruction based on clinical response, is supported by the available evidence [28,32].

Prevention of ORN begins with thorough dental evaluation before radiotherapy. Teeth with advanced periodontal disease, deep caries, periapical pathology or questionable long-term prognosis should be extracted with adequate healing time, generally a minimum of two to three weeks before the initiation of radiation, when the oncological timeline permits [69]. Completion of basic periodontal therapy, resolution of active infections and placement of definitive restorations for teeth intended to be maintained are all components of a comprehensive pre-radiation dental clearance [32]. Communication with the radiation oncology team to optimize field design and minimize mandibular dose exposure is an additional preventive measure within the dentist's scope. Post-radiation dental extractions, when unavoidable, should be performed with antibiotic prophylaxis, meticulous atraumatic technique and primary wound closure, with close postoperative monitoring given the significantly elevated risk of ORN in this context [31,70].

Grade	System Equivalents (Marx / Notani / AAOMS)	Clinical and Radiographic Features	Disease Extent	Recommended Management
I	Stage I / Grade I / Stage I	Superficial cortical bone involvement only; minimal soft tissue involvement	Limited disease; responds to conservative care	Oral hygiene; PENTOCLO; antibiotics; close monitoring
II	Stage II / Grade II / Stage II	Cortical and medullary bone involvement; no pathological fracture or fistula	Moderate disease; may require minor surgery	PENTOCLO; sequestrectomy; debridement
III	Stage III / Grade III / Stage III	Full-thickness bone necrosis; pathological fracture and/or orocutaneous fistula	Advanced disease; requires surgery	Segmental resection; microvascular free-flap reconstruction (fibula preferred)
—	Marx Stage 0 (precursor)	Exposed bone < 3 months; no confirmed ORN	Early at-risk lesion	Observation; PENTOCLO; eliminate local irritants
AAOMS = American Association of Oral and Maxillofacial Surgeons; HBO = hyperbaric oxygen therapy; PENTOCLO = pentoxifylline + tocopherol ± clodronate. The staging categories are reproduced from the Marx, Notani and AAOMS classification systems [28,33]; management recommendations by grade are synthesized from the cited literature: grade I [29]; grade II [28]; grade III [28]; Marx stage 0 [28]. No standardized questionnaire or primary data collection was used.				

Table 3: Comparative staging of osteoradionecrosis of the jaws: Marx, Notani and AAOMS classification systems with corresponding management recommendations.

Pre-, Peri- and Post-Radiation Dental Protocols: A Multidisciplinary Management Framework and Future Directions

Patients receiving head and neck radiotherapy require structured dental management across all three phases of their oncological treatment, as oral complications can significantly affect nutrition, oral hygiene, speech and overall quality of life [34]. Effective care in this context depends on sustained communication between the dentist, radiation oncologist, medical oncologist and other members of the healthcare team. Early dental intervention, initiated before radiotherapy begins, has consistently been shown to reduce the burden of complications that would otherwise become difficult to manage once treatment is underway [70]. Table 4 presents an integrated three-phase dental management checklist for use as a clinical reference.

Pre-Radiation Phase

Before radiotherapy begins, every patient should undergo a thorough dental evaluation encompassing assessment of existing caries, periodontal status, periapical pathology, defective restorations and teeth with uncertain long-term prognosis [66]. The decision to extract or retain a tooth must weigh its restorative prognosis, periodontal condition, symptom status and position relative to the planned high-dose radiation field. Teeth with severe periodontal involvement, extensive decay or limited long-term viability are generally recommended for extraction before treatment; conversely, unnecessary extractions should be avoided, as they reduce dental support for function and prosthetic rehabilitation. When extractions are necessary, a healing period of at least two to three weeks before the start of radiotherapy is recommended, with some protocols accepting a minimum

of fourteen days when treatment timing is constrained [36]. In addition to extraction decisions, the pre-radiation appointment should include completion of basic periodontal therapy, reinforcement of oral hygiene instructions, dietary counseling and fabrication of custom fluoride trays for long-term preventive use [34]. Patient education is critical at this stage, as many patients are unaware that oral complications can persist for years after the completion of cancer treatment [58,60].

Peri-Radiation Phase

During active radiotherapy, dental care focuses on monitoring and supportive management rather than elective dental procedures. Oral mucositis is typically the most prominent and distressing acute complication during this phase and may make eating, swallowing and maintaining oral hygiene extremely uncomfortable [49]. Xerostomia, dysgeusia, dysphagia, oral pain and increased mucosal sensitivity are also commonly reported from the early weeks of treatment onward [37,38]. Frequent dental follow-up visits during this period are important, as many patients progressively reduce oral hygiene efforts as discomfort increases, creating conditions favorable for secondary infections and accelerated dental disease. Management during this phase includes reinforcement of oral hygiene protocols, adequate hydration, saliva substitutes and pain management through topical rinses, anesthetic agents or systemic analgesics as appropriate to symptom severity [22]. Nutritional support, including soft-diet counseling, nutritional supplementation or referral for formal nutritional assessment, may become necessary in patients experiencing difficulty eating as a result of mucositis, dysphagia or pain. [43].

Post-Radiation Phase

After radiotherapy is completed, long-term dental follow-up remains necessary because several clinically significant complications may emerge or worsen in the months and years following treatment [34]. Xerostomia, radiation caries, trismus and osteoradionecrosis are among the most common long-term sequelae and require ongoing monitoring and proactive management [36,38]. Lifelong daily fluoride application using custom trays and frequent dental recall visits, typically every three to four months, are recommended for all irradiated patients [34,35]. Post-radiation dental extractions carry a substantially elevated risk of ORN and should be avoided whenever possible; when they are clinically necessary, they should be performed under antibiotic coverage and with meticulous surgical technique [36]. Prosthetic rehabilitation in irradiated patients presents additional complexity related to mucosal fragility, reduced salivary lubrication, fibrosis and limited mouth opening, all of which affect denture retention, comfort and tissue tolerability. These patients require more frequent adjustments, closer monitoring of tissue response, and, in many cases, modified prosthetic designs or reduced denture extension [38].

Phase	Dental Actions	Clinical Objectives	Assessment Tools
PRE-RADIATION (Before RT starts)	•Complete dental evaluation (caries, perio, periapical, restorations) •Extract teeth with poor prognosis; allow 2-3 weeks healing minimum • Complete basic periodontal therapy • Place definitive restorations on retained teeth • Fabricate custom fluoride trays • Oral hygiene instruction and dietary counseling • Communicate with radiation oncology team re: field design	•Reduce post-RT ORN risk •Eliminate foci of infection •Establish preventive baseline	•Dental radiographs (FMX/panoramic) •Periodontal charting •Fluoride tray impressions
PERI-RADIATION (During active RT)	•Monitor mucositis severity (WHO/NCI-CTCAE grading) •Reinforce oral hygiene at every visit •Prescribe saline/sodium bicarbonate rinses •Manage pain (topical anesthetics → systemic analgesics as needed) • Assess for oral candidiasis; treat promptly •Encourage hydration and use of saliva substitutes • Coordinate nutritional support with dietitian	•Preserve mucosal integrity •Maintain treatment schedule •Prevent secondary infections	•Mucositis scale assessment •Oral fungal cultures if candidiasis suspected •Body weight monitoring

	•Communicate with oncology team if complications threaten RT continuity		
POST-RADIATION (Lifelong follow-up)	• Dental recall every 3-4 months (lifelong) • Daily fluoride tray use (lifelong) • Monitor for radiation caries; restore early • Initiate jaw exercises at first sign of trismus • Avoid post-RT extractions whenever possible • If extraction unavoidable: antibiotic prophylaxis, atraumatic technique, primary closure •Manage xerostomia (pilocarpine; saliva substitutes) •Prosthetic rehabilitation with modified designs as needed •Monitor for ORN: any non-healing wound > 3 months → urgent referral	•Prevent late sequelae •Maintain oral function •Detect ORN early •Support nutritional status and QoL	•Clinical oral exam •Panoramic radiograph annually •Salivary flow assessment •Patient-reported QoL measures
CPP-ACP = casein phosphopeptide-amorphous calcium phosphate; ORN = osteoradionecrosis; QoL = quality of life; RT = radiotherapy. Supporting references by phase: pre-radiation [34,35]; peri-radiation [37]; post-radiation [36,38]. The protocol represents a narrative synthesis of the cited guidelines and literature; no standardized questionnaire or primary data collection was used.			

Table 4: Integrated pre-, peri- and post-radiation dental management protocol for patients receiving head and neck radiotherapy.

Synthesis, Evidence Gaps and Future Directions

Across the continuum reviewed in this paper, mucositis, xerostomia, radiation caries and osteoradionecrosis remain the most prevalent and clinically impactful oral complications in patients receiving head and neck radiotherapy [37,38]. These conditions significantly affect speech, comfort, nutrition and quality of life across the treatment trajectory. Preventive dental care, structured patient education, fluoride therapy and sustained interdisciplinary collaboration provide the greatest cumulative long-term benefit for reducing these complications and improving patient outcomes [34,35].

Despite meaningful advances in supportive oncology care, important limitations remain in the evidence base. Many clinical recommendations continue to rely on observational data and expert consensus and randomized controlled trials are still lacking for several preventive and therapeutic interventions, including fluoride protocols for radiation caries, jaw-exercise programs for trismus and medical management strategies for ORN [36,39]. Heterogeneity in ORN diagnostic criteria and follow-up protocols across studies makes direct comparison difficult and patient-reported outcome measures in oncological dentistry remain underrepresented in the published literature [38].

Future research directions are promising. Photobiomodulation therapy has demonstrated growing evidence for reducing the severity of oral mucositis in cancer patients and is increasingly supported by clinical practice guidelines. [39] Aquaporin-1 gene therapy and stem cell-based approaches to salivary gland regeneration offer the possibility of restoring glandular function rather than merely compensating for its loss [19,20]. Artificial intelligence tools for early detection of oral complications, risk stratification for ORN and optimization of radiation dose planning may complement clinical judgment in the coming years. Stronger interdisciplinary care models, with the dentist formally integrated into the oncology team from the time of cancer diagnosis, represent a structural priority for improving outcomes in this population [34,38].

Conclusion

Nearly all patients undergoing head and neck radiotherapy experience at least one clinically significant oral complication, spanning acute mucositis and candidiasis through chronic xerostomia, radiation caries, trismus, dysgeusia and osteoradionecrosis. The acute toxicities are most effectively limited by photobiomodulation, structured oral hygiene protocols and prompt antifungal therapy, whereas radiation-induced hyposalivation, the principal driver of caries, candidiasis and dysgeusia, is best prevented through intensity-modulated radiotherapy with parotid sparing and managed with sialogogues

and saliva substitutes. Radiation caries, trismus and dysgeusia act synergistically to compromise oral function and nutrition; custom fluoride trays reduce caries incidence by up to 70% and early jaw mobilization yields greater functional gains than delayed intervention. Osteoradionecrosis remains largely preventable, with pre-radiation dental clearance, adequate healing time and avoidance of post-radiation extractions representing the most effective measures, while early disease responds to the PENTOCLO protocol and advanced disease requires microvascular free-flap reconstruction. Across the full spectrum of complications, a structured three-phase protocol comprising pre-radiation clearance, peri-radiation monitoring and lifelong post-radiation follow-up at three- to four-month intervals constitutes the current standard of care.

In summary, dental professionals play an indispensable role in the prevention, early detection and ongoing management of oral complications associated with head and neck radiotherapy. A proactive, structured approach across the pre-, peri- and post-radiation continuum, grounded in interdisciplinary collaboration and individualized patient care, offers the greatest potential to preserve oral function, reduce long-term morbidity and support quality of life throughout cancer survivorship.

Conflict of Interest
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Not applicable.

Authors' Contributions
All authors contributed equally to this paper.

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