



Incidence of Osteoradionecrosis and Dosimetric Distribution Utilization in Treatment Planning for Head and Neck Cancer Patients: A Literature Review

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Introduction

Radiotherapy plays a critical role in managing various malignancies, particularly in the head and neck region. However, one of the significant complications associated with radiotherapy is osteoradionecrosis (ORN), a condition characterized by the necrosis of bone tissue in irradiated areas.¹ The teeth, soft tissue, salivary glands, and muscles can be affected by the side effects or complications of ORN.^{2,3}

Both radiologists and prosthodontists can employ various strategies to minimize radiation exposure to areas surrounding the target region during radiotherapy by employing high-precision radiotherapy techniques and intraoral protective devices, as outlined below:

High-Precision Radiotherapy Techniques:

- Radiologists use techniques like Intensity-Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT), and Stereotactic Body Radiation Therapy (SBRT) to target radiation precisely at tumors while minimizing damage to healthy tissues.⁴

Intraoral Protective Devices:

- Prosthodontists can fabricate intraoral devices, including lead protective stents, tongue depressing devices, and positioning devices, to provide additional protection for non-targeted areas during radiotherapy.⁵

In addition to efforts to minimize radiation exposure to healthy tissues, factors such as the risk of ORN post-radiotherapy and the timing of dental extractions must be carefully planned to reduce ORN risk without compromising oncological outcomes. Dosimetry involves mapping and calculating radiation doses to evaluate the prescribed dose delivered to regions surrounding the tumor site after radiotherapy.⁶

To Develop Dosimetry:

- Computerized treatment plans utilize axial CT scans to contour the mandible, maxilla, and teeth.¹⁴
- Cumulative doses for each jaw sextant are calculated to create dose-volume histograms, which facilitate the determination of mean and maximum radiation doses for each jaw sextant—anterior teeth, left and right premolars, and left and right molars.¹⁴

By assessing the risk of ORN after tooth extraction post-radiotherapy and using dosimetric contouring to map radiation doses to specific jaw regions, clinicians can create a precise treatment plan, even for patients who have received a total radiation dose exceeding 60 Gy. Additionally, a thorough understanding of dosimetric distribution for different types of head and neck cancers will assist clinicians in making informed decisions during treatment planning.

Objectives

This review seeks to summarize the findings related to the risk of osteoradionecrosis (ORN) following extractions in patients who have undergone radiotherapy and the dosimetric distribution of radiation in patients with various types of head and neck cancer. By using this information, dental professionals can make informed decisions about treatment planning, including extractions, for patients with a history of head and neck cancer who have undergone radiotherapy.

Methods

A PubMed search using the terms "radiotherapy and dental extraction" and "radiotherapy and dosimetric distribution," limited to publications from 2010 to 2024, initially identified 1,148 citations. Focusing on randomized controlled trials, clinical trials, meta-analyses, and systemic reviews narrowed the results to 132 relevant studies. After excluding articles based on title, abstract, and duplicates, 10 articles were selected for final review.

Results

Author	Type of study	Dose delivered	Time after radiotherapy	Sample size	Incidence of ORN	Conclusions
Lajolo et al. 2021 ⁷	Systemic review	Mean dose: 50 - 68 Gy	15 - 32.4 months	462 patients	5.8%	- Average radiation dose for ORN patients: 68 Gy. 3 of 41 ORN patients had ORN in the maxilla.
Nabil et al. 2011 ⁸	Systemic review	29 patients < 60 Gy 230 patients > 60 Gy	Extraction within 1 yr to after 5 yrs included in the study	828 patients 2766 teeth	7%	- Patients with > 60 Gy radiation and dental extractions were at highest risk for ORN. - Highest ORN incidence was 2-5 years post-radiotherapy.
Kuo et al. 2016 ⁹	Retrospective cohort study	> 50Gy (below 50 Gy were excluded)	Extraction < 0.5 yr (19.7%) Extraction > 0.5 yr (80.3%) Mean: 2.7 yrs	495 patients	5.5%	Tooth extractions performed < 6 months and involving < 5 teeth were associated with a significantly reduced incidence of ORN.
Saito et al. 2022 ¹⁰	Retrospective cohort study	62.0 Gy in ORN group 37.6 Gy in Non-ORN group	Mean: 41.2 months for ORN group Mean: 28.2 months for Non-ORN group	32 patients 99 teeth	12.1%	- Threshold dose for ORN risk: 58 Gy. - Risk of ORN increases with tooth extraction > 35 months after radiation.
Khoo et al. 2021 ¹¹	Retrospective cohort study	Median dose: 70 Gy	3 months - 1 yr (3.3%) 1 - 5 yrs (26.5%) > 5 yrs (70.2%)	73 patients 389 teeth	8.5%	- Dental extractions > 5 years post-radiotherapy showed lower ORN incidence. - All 22 ORN cases had ≥ 60 Gy radiation.

Table 1. Incidence of osteoradionecrosis (ORN) after extraction following radiotherapy

Author	Type of radiation therapy	Locations of head and neck cancer studied	Conclusions
Bak et al. 2016 ¹²	IMRT	Base of tongue Tonsil Nasopharynx Hypopharynx	- BOT, tonsil, and hypopharynx cancers: highest doses to the posterior mandible. - Nasopharynx cancer: highest doses to the posterior maxilla.
Hansen et al. 2012 ¹³	IMRT	Base of tongue	A larger tumor size (i.e., T3-T4) impacted a larger area of the mandible.
Parahyba et al. 2016 ¹⁴	IMRT	Oropharynx Nasopharynx	- In oropharyngeal cancer, highest radiation dose: posterior mandible. - In nasopharyngeal cancer, highest radiation dose: posterior maxilla. *D_{mean} at sites ipsilateral to the tumor was higher than at those on the contralateral side.
Ma et al. 2022 ¹⁵	IMRT, VMAT	Oral Cavity Oropharynx Nasopharynx Larynx	- Nasopharyngeal cancer patients: *D_{mean} maxilla > *D_{mean} mandible. - Oral cavity, oropharyngeal, and laryngeal cancer patients: *D_{mean} mandible > *D_{mean} maxilla. - Molars received significantly higher doses than premolars and incisors.
Fregnani et al. 2016 ¹⁶	IMRT, 3DRT	Oral Cavity Oropharynx Nasopharynx Lateral border of tongue	- Both 3DRT and IMRT: *D_{mean} molars > *D_{mean} anterior teeth. - Generally, in IMRT, *D_{mean} maxilla < *D_{mean} mandible except for nasopharynx. - Ipsilateral teeth were exposed to higher doses than contralateral teeth with both techniques.

Table 2. Dosimetric distribution observed in patients with various types of head and neck cancer. *D_{mean} represents the average doses delivered to each anatomical region.

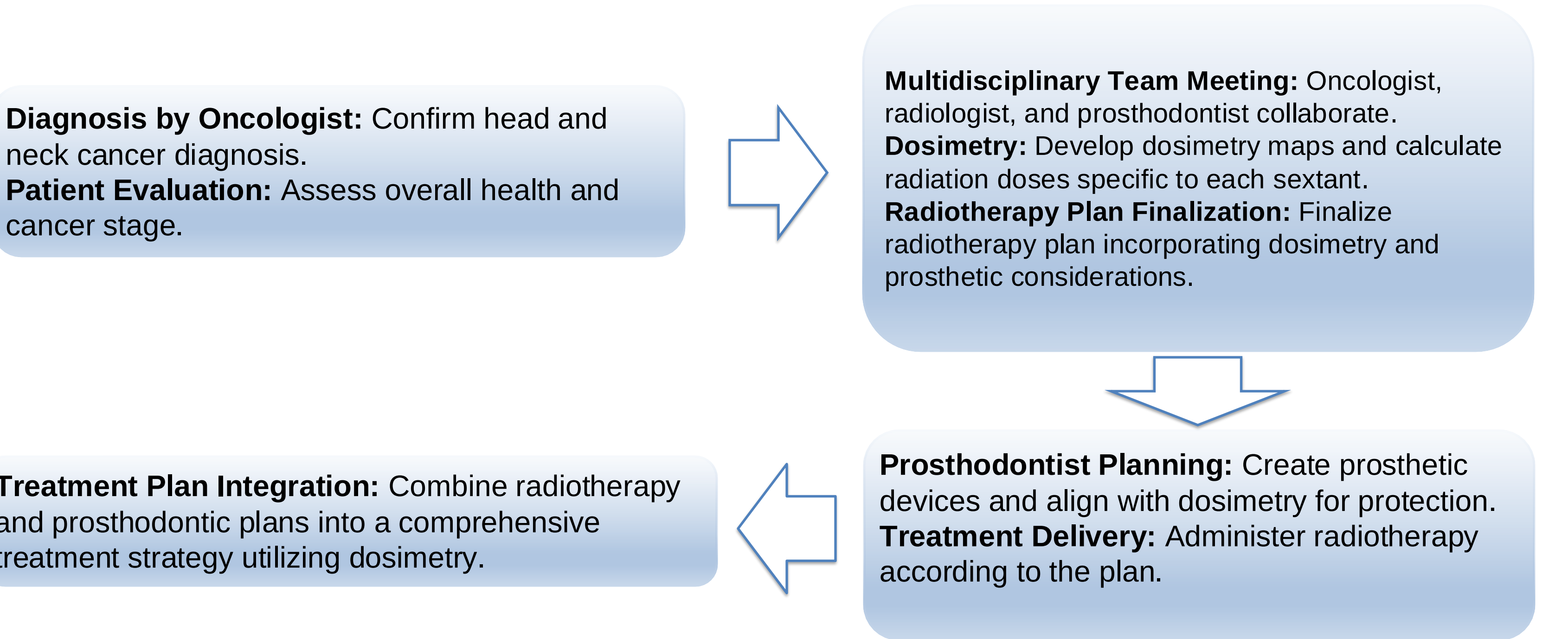


Figure 1. Flow chart outlining the steps to develop a prosthetic treatment plan using dosimetry.

Conclusions

From this literature review, the following conclusions were drawn:

Incidence of Osteoradionecrosis (ORN): Rates of ORN ranged from 5.5% to 12.1% for doses exceeding 50 Gy.⁷⁻¹¹ Most studies indicate an increased risk with doses above 60 Gy.^{7,8,10,11}

Variation in Studies: Different studies report varying outcomes based on the administered dose and timing of tooth extraction post-radiotherapy, with no consensus on optimal timing for extraction.

Impact of Tumor Location and Dental Arch: The tumor's location, the type of dental arch, and the position of teeth influence radiation doses. Typically, the tooth-bearing region nearest to the tumor receives the highest dose.^{13,14,16}

Specific Regional Exposure: For cancers like those of the base of the tongue, tonsil, hypopharynx, and oropharynx, the mandibular molar region ipsilateral to the tumor site receives the greatest radiation exposure.^{13,14} Nasopharyngeal cancer, however, results in higher doses to the maxillary molar region.^{12,14}

Posterior vs. Anterior Regions: Posterior regions generally receive more radiation than anterior ones, necessitating extra caution during surgery in these areas.¹²⁻¹⁶

Advancements in Radiotherapy Planning: Modern radiotherapy techniques, including targeted treatments and dosimetry, along with intraoral protective devices, enable prosthodontists to develop detailed treatment plans that reduce the risk of ORN by precisely analyzing dose distribution.

References

