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Dental Extraction After Head and Neck Radiotherapy: Does Timing Influence the Risk of Osteoradionecrosis?

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Abstract
Background: Dental extraction after head and neck radiotherapy remains difficult because radiation-related vascular, cellular and tissue-repair changes can impair healing and precipitate osteoradionecrosis (ORN). A universally safe post-radiotherapy waiting period has not been established.
Objective: To synthesise evidence concerning post-radiotherapy extraction timing, radiation dose, procedural and patient factors, and prevention and management of ORN.
Results: A 2021 meta-analysis of 21 studies and 37,805 patients reported pooled ORN incidence of 5.3% after post-radiotherapy extraction (95% CI 2.9–8.2%; substantial heterogeneity). A 2024 cohort of 1,608 patients reported ORN in 8.8%; no reliably safe post-radiotherapy intervention interval was identified. The 2024 ISOO–MASCC–ASCO guideline recommends reviewing the radiation plan and avoiding extraction in jaw regions receiving ≥50 Gy when reasonable alternatives exist. Evidence for hyperbaric oxygen (HBO), pentoxifylline–tocopherol (PENTO) and antibiotics is heterogeneous; the HOPON trial did not demonstrate a benefit from routine HBO.
Conclusion: Time since radiotherapy should not be used as the sole measure of extraction safety. The decision should be based on the dose and volume of jaw irradiated, the tooth's condition, the complexity and urgency of extraction, and patient-related risk factors.
Keywords: *dental extraction; head and neck cancer; radiotherapy; osteoradionecrosis; radiation dose; prevention; hyperbaric oxygen; pentoxifylline; tocopherol.*

I. Introduction

Osteoradionecrosis of the jaws is a serious late complication of head and neck radiotherapy. It may cause persistent exposed or necrotic bone, pain, infection, fistula, fracture and substantial impairment of oral function. Definitions vary, including the duration of exposed bone required for diagnosis, which complicates comparison between studies.

The mandible, particularly posterior sites receiving high doses, is often affected more frequently than the maxilla. Radiation-related injury impairs vascularity and cellular repair, while mucosal injury, salivary dysfunction, caries, periodontal disease and trauma may interact to create a chronic non-healing wound. Marx's hypoxic–hypocellular–hypovascular model remains influential, although ORN is now understood as multifactorial rather than simply infection-driven [1].

Extraction is a recognised precipitating event, but it is not the only pathway to ORN: spontaneous disease occurs, and extraction may be a marker of severe underlying dental pathology. A fixed waiting rule is therefore unlikely to answer every clinical case. The key variables include dose delivered to the actual extraction site, jaw volume receiving higher doses, tooth pathology, procedure-related trauma and patient-level healing factors.

This review focuses on extraction after completion of radiotherapy. Pre-radiotherapy extraction evidence is mentioned only where needed to clarify the distinction between pre- and post-treatment timing.

II. Review approach

This narrative evidence review synthesises selected clinical studies, systematic reviews, a randomised trial and current multidisciplinary guidance relevant to dental extraction after head and neck radiotherapy. Priority was given to studies directly addressing post-radiotherapy extraction timing, radiation dose and volume, preventive adjuncts, and management of osteoradionecrosis (ORN). Quantitative estimates are reported as

published by the original studies or evidence syntheses; no new pooled estimate or formal risk-of-bias assessment was undertaken.

The evidence base is heterogeneous in design, patient selection, radiation exposure, ORN definition and follow-up. Evidence about extractions before radiotherapy is considered only as context and is not treated as direct evidence for the post-radiotherapy waiting interval. Studies of medication-related osteonecrosis and laboratory or animal studies are outside the scope of this review.

The primary clinical question is whether a particular interval after radiotherapy can be considered safer for extraction. Related questions concern the importance of socket-level radiation dose, procedural and patient factors, and preventive or therapeutic adjuncts. Because study populations and outcomes are not sufficiently comparable, results are summarised narratively rather than statistically pooled.

III. Results and synthesis

3.1 Incidence of ORN after post-radiotherapy extraction

Beaumont and colleagues included 21 studies with 37,805 patients, of whom 6,030 underwent extraction after radiotherapy. The pooled ORN incidence after post-radiotherapy extraction was 5.3% (95% CI 2.9–8.2%), with substantial heterogeneity (I^2 approximately 80%) [2]. Their overall comparison did not demonstrate a statistically significant difference between pre- and post-radiotherapy extraction groups. This pooled incidence is not an individual risk estimate: dose distribution, case mix, diagnostic criteria and follow-up varied.

A systematic review by Lajolo and colleagues included nine studies and 462 patients, reporting ORN in 41 patients (5.8%; 95% CI 2.3–9.4%)[3]. An earlier systematic review by Nabil and Samman also highlighted variability in the reported incidence and prevention of ORN after extraction in irradiated patients[4]. The small evidence base and variable methods limit precision. Similar pooled values around 5–6% do not imply stable risk across all radiation doses and anatomical sites.

In a prospective pilot study, 30 of 50 patients underwent extraction at a median of 64.5 days after radiotherapy (range 13–152 days), while 20 declined extraction. At two years, cumulative incidence of any exposed alveolar bone was 40% after extraction (95% CI 22–58%) and 7% among those not extracted (95% CI 0–22%). Eight patients had confirmed ORN [5]. Exposed bone is not identical to confirmed ORN, and the sample was small, but the study cautions against assuming early post-radiotherapy extraction is benign.

3.2 Does a safe waiting interval exist?

In a retrospective cohort of 1,608 patients, 141 (8.8%) developed ORN. Median time from radiotherapy to ORN onset was nine months overall, 6.5 months for intervention-associated ORN and eight months for spontaneous ORN. The investigators did not identify a reliably safer time for dental intervention [6]. The longer median interval reported after mandibulectomy (15 months) is a subgroup finding and should not be generalised to all irradiated patients.

A nationwide population-based cohort of 7,394 oral cancer patients found that exodontia performed 1–3 months after radiotherapy was associated with increased ORN risk (HR 2.63). The study also examined other dental interventions and treatment-related factors, so this association should not be interpreted as proof of a universal extraction-specific waiting threshold [7]. As an observational study, it remains vulnerable to confounding by dental disease severity, treatment selection and administrative outcome coding.

Taken together, these findings do not mean that timing is irrelevant; rather, time since radiotherapy is only one part of the decision. Waiting may allow acute mucositis and soft-tissue injury to settle, but it does not reverse established radiation damage or make a high-dose mandibular site equivalent to unirradiated bone.

3.3 The proposed early “golden period” versus delayed extraction

A longstanding school of thought recommends completing necessary extractions during the first 3–6 months after radiotherapy, based on the hypothesis that progressive microvascular injury, hypocellularity and fibrosis may make later surgery less favourable. This view is associated with the radiobiological framework described by Marx and Johnson, who distinguished osteoradionecrosis related to early trauma, late trauma and spontaneous disease [8]. The framework is biologically influential, but it should not be mistaken for proof that extraction within a specific early interval reduces clinical ORN incidence.

The competing position is that early extraction occurs in tissue still recovering from acute mucosal injury and can itself precipitate non-healing. Waiting may allow acute inflammation and mucositis to settle, but does not reverse radiation injury; conversely, later fibrosis does not establish that every later extraction is more dangerous. These mechanisms can coexist, and neither alone determines the optimal time for intervention.

The most direct prospective test of the early-window approach is Ward et al. (2024). Their single-centre pilot recommended planned extractions as soon as feasible, ideally within four months of radiotherapy. Thirty patients underwent extraction at a median of 64.5 days (range 13–152 days). At two years, cumulative incidence of any exposed alveolar bone was 40% (95% CI 22–58%) among those extracted and 7% (95% CI 0–22%) among

those who declined extraction; eight patients had confirmed ORN. Because this was a small non-randomised pilot and exposed bone was the primary endpoint, the estimates are imprecise and subject to selection and competing-risk bias. Nonetheless, it does not support assuming that the early window is safe [5].

Khoo et al. (2021) provide an apparently contrasting observation. In their retrospective series of 73 patients, 16 developed ORN. Extraction more than five years after radiotherapy was associated with lower adjusted odds of ORN (OR 0.06, 95% CI 0.01–0.25), while surgical extraction was associated with higher odds (OR 6.50, 95% CI 1.37–30.91). This finding suggests that risk may vary with time and procedural complexity, but the small, selected cohort and residual confounding preclude interpreting five years as a protective threshold [9].

Kovarik et al. retrospectively examined 1,608 patients, of whom 141 (8.8%) developed ORN. Median time from radiotherapy to ORN diagnosis was nine months overall, 6.5 months for intervention-associated ORN and eight months for spontaneous ORN. The study did not identify a reliably safe interval for dental intervention. These are times to ORN onset rather than comparative extraction-specific risks at each time point, so they should not be interpreted as proof that extraction at a given month is more hazardous [6]. Beaumont et al.'s systematic review likewise did not establish a dependable optimal post-radiotherapy extraction interval, with substantial heterogeneity across studies [2].

A separate retrospective multicentre study reported a longer mean interval from radiotherapy to extraction in the ORN group than in the non-ORN group (41.2 versus 28.2 months). Its observational design and limited number of affected cases cannot establish that waiting caused the higher risk [10]. Together, these studies show why neither "extract early before fibrosis" nor "the longer one waits, the safer it becomes" should be presented as an evidence-based universal rule.

Table 1. Comparison of the competing timing hypotheses

Issue	Early-window hypothesis (first 3–6 months)	Delayed-extraction hypothesis
Proposed mechanism	Operate before progressive fibrosis and microvascular damage become established.	Allow acute mucositis and soft-tissue inflammation to resolve; defer surgery until recovery.
Main supporting evidence	Historical radiobiological model; early extraction recommended in some older protocols.	Some retrospective cohorts report lower ORN odds after very long intervals; clinical recovery from acute toxicity may help.
Key evidence against a universal rule	Ward et al. reported 40% two-year exposed-bone incidence after extraction at a median of 64.5 days.	Radiation injury can persist; other cohorts do not identify a safe interval, and waiting does not guarantee reduced risk.
What the evidence can establish	A biologically plausible hypothesis, not a validated safe window.	A possible association in selected cohorts, not proof that delay itself reduces risk.
Clinical implication	Do not extract early solely because the patient is within a supposed golden period.	Do not delay necessary treatment solely to reach an arbitrary later date.

Interpretation: The evidence does not establish that either school of thought is universally correct. A fixed calendar interval should not substitute for assessment of the dose delivered to the actual extraction site, dental pathology, extraction complexity, urgency and patient-specific risks. The 2024 ISOO–MASCC–ASCO guideline recommends avoiding extraction in jaw regions receiving ≥50 Gy when reasonable alternatives are available, rather than endorsing a universal post-radiotherapy waiting period [11].

3.4 Radiation dose and volume

The 2024 ISOO–MASCC–ASCO guideline recommends review of the radiotherapy plan with the radiation oncologist and risk assessment based on the dose and volume received by the jaw at the planned intervention site. Extractions and implants in mandibular or maxillary regions receiving ≥50 Gy should be avoided when other therapeutic options are available [11]. This is a risk-management recommendation, not an absolute prohibition in every clinical circumstance.

Dose-volume parameters matter because the prescription dose to the primary tumour may not equal the dose delivered to the extraction socket. Mean mandibular dose and the volume receiving at least 50 Gy (V50) have been associated with ORN. Dose distribution, fractionation, re-irradiation and the proximity of the socket to high-dose regions should be considered when records are available. Knowing the actual site dose is more useful than relying only on a broad statement such as "the patient received 66 Gy."

The ≥50 Gy threshold should trigger caution and consideration of alternatives, not be used as a standalone prediction model. Risk is modified by local and patient factors. Dose mapping should be interpreted clinically rather than as a rigid geometric boundary.

3.5 Tooth and procedure-related factors

Available studies do not support a reliable numerical ranking of simple versus surgical extraction, flap elevation, bone removal or multiple adjacent extractions because reporting is inconsistent and confounder-adjusted comparisons are scarce. In practice, both the expected trauma and the consequences of retaining the tooth matter. An infected tooth may sustain ongoing inflammation, while extraction can create a wound with impaired healing.

Before extraction, assess restorability, endodontic feasibility, periodontal prognosis, periapical disease and whether conservative treatment can control symptoms without exposing irradiated bone. If extraction is unavoidable, review the radiation plan and minimise tissue trauma. Primary mucosal closure may be desirable when achievable without excessive periosteal stripping or tension; closure should not be forced at the cost of additional injury.

3.6 Preventive adjuncts

A 2024 systematic review included 29 studies and 1,520 patients: four randomised trials, four prospective studies and 21 retrospective observational studies. Reported pooled ORN prevalence was 4.6% with HBO, 3.4% with PENTO, 3.8% with antibiotics and 17.6% in control groups [12]. These pooled prevalence values are not direct head-to-head causal comparisons. Eleven of 25 observational studies were judged at serious risk of bias, and antibiotic regimens varied.

The HOPON phase III randomised trial enrolled patients requiring mandibular extraction or implant placement in sites exposed to >50 Gy. Both arms received antibiotics and chlorhexidine; the HBO arm received 30 dives. Among 100 patients analysed for the primary endpoint, six-month ORN incidence was 6.4% with HBO and 5.7% without HBO (OR 1.13, 95% CI 0.14–8.92; P=1.00) [13]. Routine HBO did not show a preventive advantage, although attrition and wide confidence intervals limit certainty.

Antibiotics may be appropriate according to infection, procedure and patient risk, but evidence does not establish a universal agent, dose or duration for every irradiated patient. Chlorhexidine is used in local protocols but should not be portrayed as independently proven to prevent ORN. PENTO may be considered in selected high-risk cases under specialist protocols after review of contraindications and interactions; supporting evidence is largely observational and regimens vary. Platelet-rich fibrin and photobiomodulation remain insufficiently standardised for universal recommendation.

Prevention should therefore begin with appropriate case selection and radiation-plan review, not reliance on a single adjunct. Routine HBO should not be presented as mandatory. Decisions about PENTO, antibiotics and other adjuncts should reflect evidence quality, contraindications, local protocols and availability.

3.7 Management when ORN develops

Management depends on extent, symptoms, infection, fracture risk and response to conservative care. Assessment should exclude recurrent malignancy when indicated and document exposed bone, mucosal breakdown, fistula, trismus, pain and radiographic change. Imaging may include panoramic radiography, CT or cone-beam CT; contrast CT or MRI may be needed when soft-tissue extension, recurrence or deep infection is suspected.

Limited disease may be managed with oral hygiene optimisation, saline or antiseptic rinses, analgesia, treatment of secondary infection when present, removal of loose sequestra where appropriate and close follow-up. Antibiotics are for clinically indicated infection, not a substitute for definitive management of necrotic bone. PENTO-based regimens are used in selected cases, but the evidence and optimal regimen remain unsettled. HBO may be considered selectively, but should not be assumed necessary for every patient.

Progressive disease, persistent symptoms, full-thickness necrosis, cutaneous fistula, pathological fracture or failure of conservative care warrants specialist surgical evaluation. Options include sequestrectomy, debridement, marginal or segmental resection and reconstruction with vascularised tissue according to extent. Advanced mandibular disease may require segmental resection and free-flap reconstruction. Treatment should be coordinated by an experienced head-and-neck multidisciplinary team.

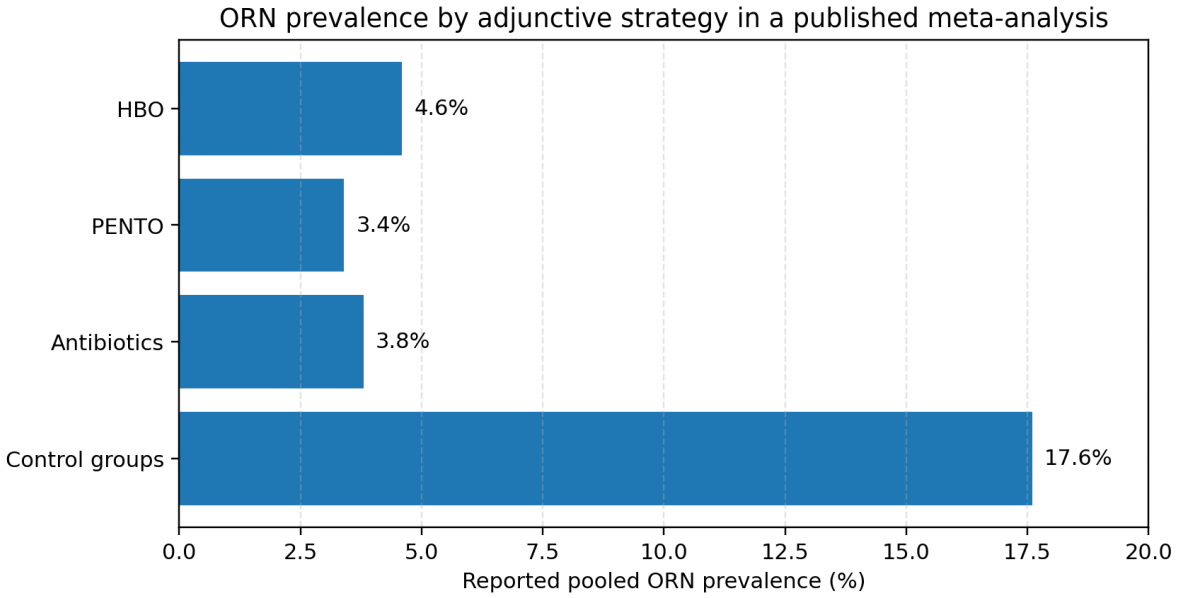
IV. Quantitative summary

Table 2 summarises key quantitative findings from selected studies and evidence syntheses. These estimates should not be combined into a single pooled estimate because outcomes, populations and study designs differ.

Table 2. Quantitative findings from key studies and evidence syntheses

Study / design	Sample	Outcome	Reported result	Caution
Beaumont et al., 2021; systematic review/meta-analysis	21 studies; 37,805 patients; 6,030 post-RT extractions	ORN after post-RT extraction	5.3% (95% CI 2.9–8.2%); I^2 ≈80%	High heterogeneity; not individual risk

Review of extractions during/after RT, 2021	9 studies; 462 patients	ORN incidence	41/462; 5.8% (95% CI 2.3–9.4%)	Small evidence base
Ward et al., 2024; prospective pilot	50 enrolled; 30 extracted at median 64.5 days	Any exposed bone at 2 years	40% after extraction vs 7% without	Exposed bone is not identical to confirmed ORN
Kovarik et al., 2024; retrospective cohort	1,608 patients; 141 ORN cases	Incidence / onset	8.8%; median 6.5 months for intervention-associated ORN	Single-centre cohort
Quah et al., 2024; systematic review/meta-analysis	29 studies; 1,520 patients	Pooled prevalence by adjunct	HBO 4.6%; PENTO 3.4%; antibiotics 3.8%; controls 17.6%	Mostly observational; not direct ranking
HOPON, 2019; randomised trial	144 randomised; 100 analysed	ORN at 6 months	HBO 6.4% vs control 5.7%; OR 1.13 (95% CI 0.14–8.92)	Wide CI; attrition



Source: Quah et al. (2024). Heterogeneous pooled prevalence estimates; not direct randomized comparisons.

Figure 1. Illustrative summary of pooled ORN prevalence estimates for selected adjunctive strategies reported by Quah et al. (2024)[12]; values are reproduced from the published review and are not a new meta-analysis or a direct comparison between interventions.

V. Clinical synthesis: decision-making

The evidence supports a risk-based rather than calendar-based decision. No fixed waiting period can be recommended as universally safe after radiotherapy. A practical assessment should determine: (1) the dose to the intended extraction site; (2) whether the tooth can be retained or treated non-surgically; (3) the urgency and expected morbidity of retaining it; and (4) which precautions and follow-up are feasible if extraction is undertaken.

Table 3. Practical risk-adapted approach to extraction after radiotherapy

Clinical situation	Preferred approach	Key precautions
Restorable tooth in a site receiving ≥50 Gy	Prefer non-surgical management when prognosis is reasonable	Endodontics, restoration and periodontal control
Non-restorable tooth in a site receiving ≥50 Gy	Multidisciplinary decision; extract if alternatives unsuitable	OMFS/radiation oncology consultation, dose review, informed consent
Dose to site uncertain	Obtain RT plan or dose information before elective invasive care	Do not rely only on tumour prescription dose or elapsed time
Urgent infection/source control	Treat urgency while coordinating care	Individualise antimicrobial therapy, technique and follow-up
Extraction unavoidable in irradiated bone	Minimise trauma and optimise soft-tissue healing	Atraumatic technique; limit periosteal stripping and bone removal; closure without tension if feasible
Persistent exposed bone, fistula, fracture or progression	Refer to an experienced ORN/head-and-neck team	Assess extent, exclude recurrence where indicated, stage and consider surgery

The detailed study-level evidence and principal limitations are summarised in Table 4.

Table 4. Selected studies and evidence syntheses relevant to post-radiotherapy extraction and ORN

Study	Design / sample	Main finding relevant to this review	Limitations / interpretation
Beaumont et al. (2021) [2]	Systematic review/meta-analysis; 21 studies, 37,805 patients	Pooled ORN incidence after post-RT extraction 5.3% (95% CI 2.9–8.2%); $I^2 \approx 80\%$.	Marked heterogeneity; pooled incidence is not an individual risk estimate.
Lajolo et al. (2021) [3]	Systematic review; 9 studies, 462 patients	41 ORN cases; pooled incidence 5.8% (95% CI 2.3–9.4%) for extraction during/after RT.	Small evidence base; definitions and follow-up varied.
Shaw et al. (2019), HOPON [13]	Randomised trial; 100 analysed for primary endpoint	Six-month ORN 6.4% with HBO vs 5.7% without HBO; no demonstrated benefit.	Both groups received antibiotics and chlorhexidine; wide confidence interval.
Marx et al. (1985) [14]	Randomised prospective trial; irradiated mandibles	ORN 5.4% with HBO vs 29.9% with penicillin in a high-risk population.	Older treatment era and protocols; contrasts with later HOPON findings.
Huang et al. (2020) [7]	Nationwide population-based cohort	Nationwide cohort; exodontia 1–3 months after RT was associated with ORN (HR 2.63); multiple dental interventions were assessed.	Observational administrative data; not a definitive comparison of extraction timing alone.
Shih et al. (2024) [15]	Nationwide cohort; pre-RT extraction timing	Examined the interval between extraction and RT initiation.	Pre-RT question; should not be pooled with post-RT waiting intervals.
Lee et al. (2023) [16]	Observational cohort	Examined pre-radiotherapy extraction and subsequent ORN risk.	Pre-RT exposure; indirect to the primary question.
DeLuke et al. (2022) [17]	Retrospective matched study; 56 patients (27 ORN, 29 controls)	V50/V65 dose-volume variables predicted ORN better than total dose alone (AUROC 0.90 vs 0.76).	Small selected sample; prediction requires external validation.
Samani et al. (2022) [18]	Retrospective cohort; 219 patients, 1,079 extractions	With PENTO adherence, ORN was 3.4% at patient level vs 11.5% in controls; tooth-level 1.0% vs 3.5%.	Non-randomised; control group included patients with contraindications, allowing confounding.
Lombardi et al. (2023) [19]	Clinical audit; 29 patients	Four patients developed ORN in a small PENTO clinical audit; use the study's stated denominator when quoting a rate.	Small uncontrolled audit; denominator differs by patient, procedure and tooth.
PENTO systematic review (2023) [20]	Systematic review; 4 studies, 387 patients, 1,871 teeth	12 patients developed ORN (3.1% patient level); 0.9% tooth-level rate.	Few studies, varying regimens and no strong comparative evidence.
Quah et al. (2024) [12]	Systematic review/meta-analysis; 29 studies, 1,520 patients	Pooled prevalence: HBO 4.6%, PENTO 3.4%, antibiotics 3.8%, controls 17.6%.	Mostly observational; pooled prevalence across arms is not a causal head-to-head ranking.
Kovarik et al. (2024) [6]	Retrospective cohort; 1,608 HNC patients	141 ORN cases (8.8%); median onset 6.5 months for intervention-associated ORN; no safe interval identified.	Single-centre retrospective cohort.
Ward et al. (2024) [5]	Prospective pilot; 50 enrolled, 30 extracted	Two-year exposed-bone incidence 40% after post-RT extraction vs 7% in those declining extraction; 8 confirmed ORN cases.	Small pilot; exposed bone is not equivalent to confirmed ORN.
Predictive modelling study (2025) [21]	Retrospective case-control; 298 patients	20 ORN cases (6.7%); mandibular V50 and post-RT extraction were associated with ORN (HR 1.05 and 2.51, respectively, as reported).	Single-centre model; requires external validation and is not an extraction-timing trial.

VI. Discussion

The central conclusion is that elapsed time after radiotherapy cannot independently define a safe extraction window. Published cohorts describe ORN at varying intervals, and a substantial retrospective series did not identify a reliably safe period for intervention. The risk is better understood as an interaction between radiation injury, local dental disease, surgical trauma and patient-level healing factors.

Radiation dose is particularly actionable. The 2024 ISOO–MASCC–ASCO guideline advises avoiding extraction in jaw sites receiving ≥50 Gy when reasonable alternatives exist and emphasises review of the actual dose distribution. This supports obtaining the radiotherapy plan rather than relying on the prescribed tumour dose alone, and prioritising endodontic or restorative alternatives when a tooth can predictably be retained.

Published pooled estimates require caution. A pooled ORN incidence around 5% may conceal substantially higher risk in selected high-dose or complex cases and lower risk in less-irradiated sites. Heterogeneity in diagnostic criteria, follow-up and extraction indications prevents derivation of a universal risk calculator. The high exposed-bone incidence in the 2024 pilot is concerning but should not be equated directly with confirmed ORN.

Evidence for preventive adjuncts remains uncertain. Pooled prevalence estimates suggest lower ORN rates with HBO, PENTO and antibiotics than controls, but confounding, protocol variation and differences in baseline risk limit causal inference. HOPON did not show a benefit from routine HBO when both arms received antibiotics and chlorhexidine. A pragmatic pathway prioritises radiation-plan review, suitable alternatives, careful technique, infection control and follow-up, with adjuncts selected individually.

This review has limitations. It is a narrative synthesis of selected accessible evidence rather than a reproducible systematic review with independent screening, comprehensive full-text retrieval, formal study-level risk-of-bias assessment and extraction of comparable data. It should not be interpreted as a completed systematic review or a new meta-analysis. The conclusions are therefore intended to guide interpretation of the available evidence, not to provide a definitive pooled estimate of risk.

Future studies should prospectively record socket-level radiation dose, dose-volume metrics, tooth pathology, extraction type, closure technique, antimicrobial and adjunctive regimens, smoking, comorbidities and standardised ORN outcomes. Time should be modelled continuously where possible rather than only in arbitrary month-based categories.

VII. Conclusions

A universally safe waiting period for dental extraction after head and neck radiotherapy has not been established. Time since treatment should not be used in isolation. Decisions should consider the dose and volume of irradiated jaw, tooth prognosis, urgency, extraction complexity and patient factors. In sites receiving ≥50 Gy, extraction should be avoided when reasonable alternatives exist. When extraction is unavoidable, multidisciplinary planning, atraumatic technique, appropriate infection control and structured follow-up are essential. Evidence for adjunctive prevention is promising but insufficient to justify one universal regimen; routine HBO is not supported by the HOPON trial.

Declarations

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