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Effects of Radiotherapy to the Jaws 2: Potential Solutions.

S. Eliyas*, R. Porter†, P. Briggs‡ and R.R. Patel§

Abstract - *Dental maintenance and rehabilitation of head and neck cancer care is becoming more important as the outcome of cancer treatment improves. The management of these patients can be very difficult for a number of reasons as discussed in part one of this two-part series. This second part attempts to suggest possible solutions for the management of the major oral health problems encountered by these patients during and after their cancer treatment.*

KEYWORDS: Head and neck oncology, cancer, radiotherapy, oral health risk assessment and management

INTRODUCTION

When considering the ideal pathway for head and neck cancer patients, a relatively short period of time exists between diagnosis and commencement of oncology treatment. Where radiotherapy is required, planning is the rate-limiting factor. This translates to a very short period of time available for 'dental assessment' and more importantly treatment.

Any decision-making is multidisciplinary, including head and neck surgeons, reconstructive surgeons, maxillofacial surgeons, oncologists, radiologists, pathologists, restorative dentists, maxillofacial prosthodontists, dental hygienists/therapists, specialist nurses, speech and language therapists, dieticians, community services, occupational health, social services, general medical practitioners, general dental practitioners (GDPs) and multidisciplinary team coordinators[1-5]. Clear communication is critical for optimal care of the patient.

The ideal solution is prevention with measures to shape cultural norms that determine individual lifestyles and shaping behaviour to influence disease risk at a population level[6]. Although there may be merit in exerting effort to find the 'high-risk' patients within any group, large numbers of people exposed to a small risk may generate many more cases than a small number exposed to a high-risk[7]. There must be a change in ideology from finding and treating the 'high-risk person' to finding the 'root of the risk' that can be addressed at a national level with public health policy[6]. The expected result is the reduction of the entire population's disease risk, hence reducing the number of 'high-risk' persons as well.). To a small degree this can be achieved for head and neck cancer patients thereby reducing the number of patients facing complications following radiotherapy and hence improving the cost efficiency of managing this group.

ORAL HEALTH RISK ASSESSMENT AND MANAGEMENT

Dental assessment and management may be better described as Oral Health Risk Assessment and Management (OHRAM) as speech, phonetics, swallowing and eating are included as well as the hard and soft tissues surrounding the dentition. OHRAM begins prior to oncology treatment, carries on throughout oncology treatment, followed by dental rehabilitation and then continues for the lifetime of the patient. The management strategy must reflect the patient's quality of life and the resources available. Oral care is not always possible with the patient's GDP and a Restorative Specialist with experience in maxillofacial prosthodontics and implant therapy may be required to oversee a holistic pathway of care. OHRAM involves consideration of numerous factors (Figure 1).

When dental assessments have been carried out prior to radiotherapy, post-radiotherapy dental needs are lower. If seen for pre-radiotherapy OHRAM, 35.5% fewer patients required restorations, 30.2% fewer patients required root canal treatment and 20.7% fewer patients required dental extractions post-radiotherapy in a group of 357 patients[8]. It is worth noting that 77.2% of those who had pre-radiotherapy dental examinations required complete dentures compared to 43.3% of those who did not receive pre-radiotherapy dental assessments[8], which may be reflective of aggressive treatment planning to reduce future problems.

Sennhenn-Kirchner et al (2009) compared the pathway of 37 oncology patients in 1993 and 36 oncology patents in 2005. In this time the pathway changed, oral hygiene improved, the number of edentulous patients reduced from 54% to 25%, the number of missing teeth reduced and the residual teeth with caries reduced from 20.6% to 10.8%[9]. This positive change is important in highlighting the role played by the restorative team pre, during and post-radiotherapy. Protocols for the dental management of these patients have been suggested, however the oncology prognosis is not always taken into consideration[10].

* BDS, MFDS RCS Eng, MRD RCS Eng, FDS (Rest Dent) RCS Eng, PGCertHE
† BDS, BSc, MFDS RCS, FDS (Rest Dent) RCS, AHEA
‡ BDS(Hons), MSc, MRD, FDS RCS(Eng)
§ BDS, LDSRCS(Eng), MSc, FDSRCPS (Glasgow)

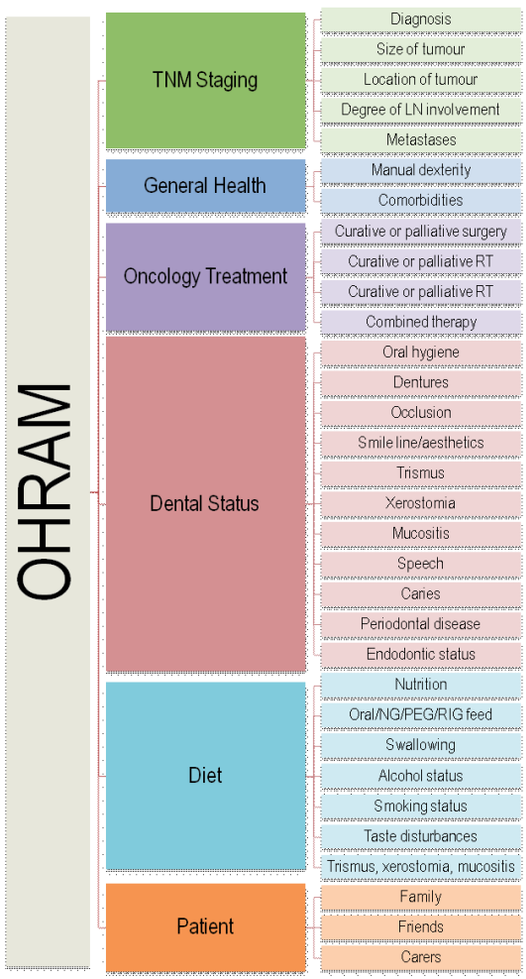


Figure 1. *Factors to consider in OHRAM*

PRE-RADIOTHERAPY OHRAM

The time prior to radiotherapy commencing should be utilised to full effect although this is a difficult time for the patient to be receptive to dental advice. At the earliest stage patient motivation, anxiety and dental awareness must be assessed. This together with oncological prognosis helps to tailor treatment planning to the individual. It is important to also repeat and offer written patient-specific oral health education advice to a family member/carer[5]. Advice needs to be consistent, repeated and supported by the whole team managing the patients and having continuity with at least one individual in the dental team can be a positive influence.

Frank discussion with clinical oncologists will be able to provide vital information regarding the possible prognosis and five-year survival rates for these patients. The knowledge of whether the patient is having curative or palliative radiotherapy and better understanding of poor oral function predictors will leave a profound impression on the OHRAM decision making and could be ascertained using a proforma (Figure 2). Careful planning with the surgical/oncological team simplifies future treatment[11].

Information regarding oncology diagnosis, staging and prognosis should be recorded, as should alcohol and smoking status with details of the quantity and frequency. A thorough examination of the dentition and the supporting structures is essential and should include plaque scores, dental pathology, mouth opening and existing dental prostheses. Clear records will allow planning and future audit of treatment outcome.

Patients should be made aware of the limitations of rehabilitative treatment and maintenance requirements. For example, obturators may affect speech; function will be different and adaptation will take time. Removable implant retained prostheses allows easier access for the monitoring of oral cancer recurrence. An essential part of OHRAM is reassuring the patient and family/carers that the dental team will be there to help and support the patient during and beyond cancer treatment.

Prevention of dental disease

As ever prevention is better than cure, a large proportion of which is oral health education and promotion[12-21]. Advice and support regarding alcohol consumption and smoking cessation should not be overlooked and appropriate counselling services offered. In multidisciplinary care it is easy to assume that other members of the team are covering certain aspects of care. Avoiding assumptions and asking the patient directly if their needs are being met ensures completeness of care. The deficiencies in the care pathway should not be perceived negatively but as an opportunity to improve the patient's journey.

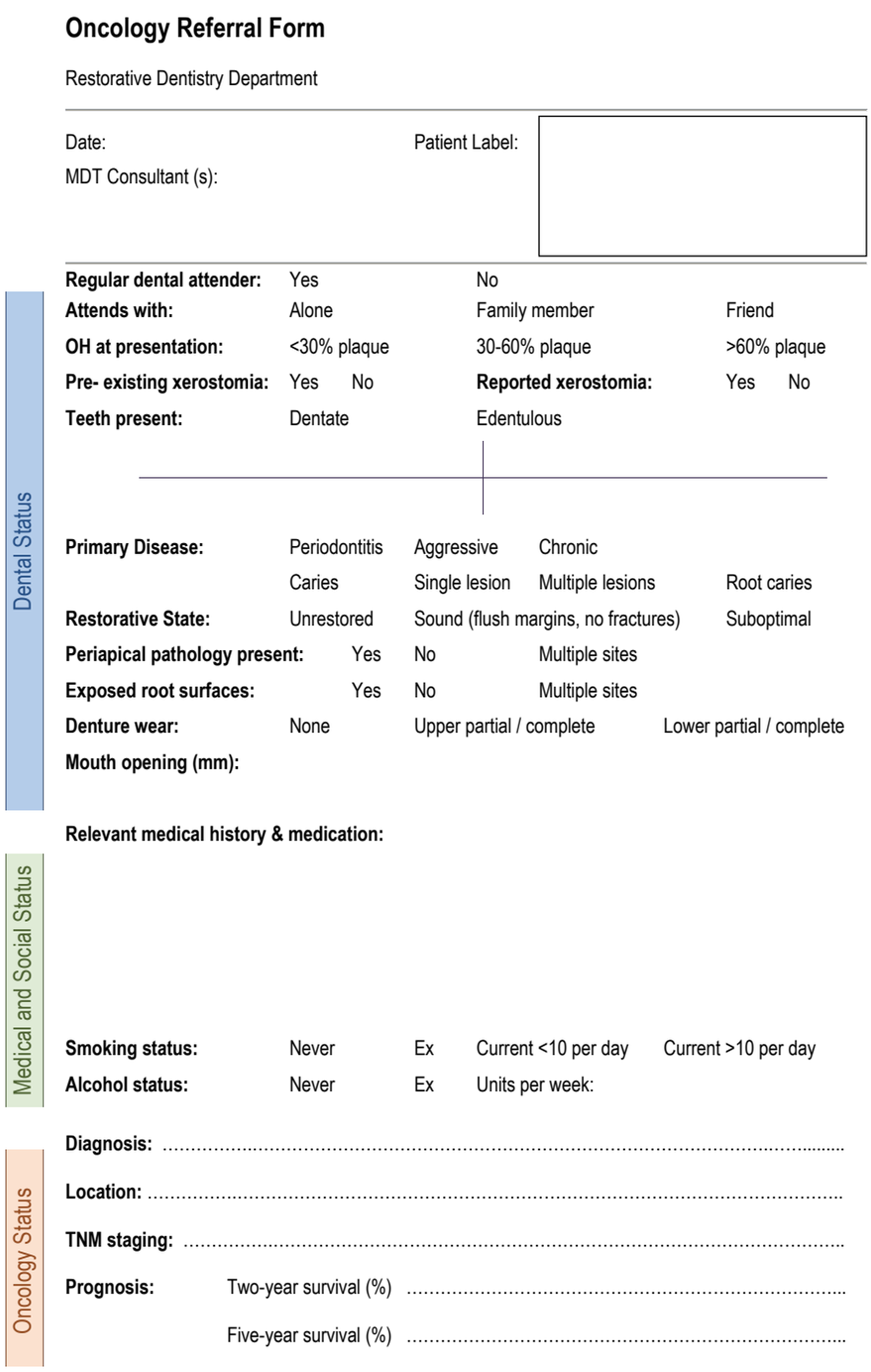
Oral Hygiene

This group of patients will require support from a dental hygienist on a regular basis throughout the patient journey. The patient's psychological state and perception of the importance of simple measures may pose a significant barrier to behavioural change. Perceptions of oral health and oral health related quality of life has been associated with numerous factors including depression, self-rated general health, education and low income[22,23]. It is important to relay to patients that it is often small changes that have the most significant impact.

Advice must be on an individual basis. Factors such as a deep overbite and trismus/scarring of oral aperture or limitation of hand/arm/shoulder activity can make oral hygiene difficult or impossible. Often the oral cavity is uncomfortable and only the use of a soft brush or mouth sponges may be possible. Some have suggested the gentle swabbing or oral structures with saline or chlorohexidine mouthwash[24]. If few teeth remain, a modified single tufted brush can be helpful (Figure 3). Various cleaning agents have been recommended including salt, bicarbonate of soda, saline and water[25]. There is no clear evidence that one agent is better than another and therefore the selection is determined by the patient's preference and comfort.

Diet

Patients should be informed of the adverse effects of high frequency sugar consumption. The drinking of flavoured waters and the use of high sugar lozenges to relieve oral discomfort should be discouraged. Some salivary substitutes may also contain flavourings and sugar. When recommending reduction/cessation of alcohol consumption and smoking, appropriately trained staff within the



Oncology Referral Form

Restorative Dentistry Department

Date:

MDT Consultant (s):

Patient Label:

Dental Status

Regular dental attender: Yes No

Attends with: Alone Family member Friend

OH at presentation: <30% plaque 30-60% plaque >60% plaque

Pre- existing xerostomia: Yes No **Reported xerostomia:** Yes No

Teeth present: Dentate Edentulous

Primary Disease: Periodontitis Aggressive Chronic

Caries Single lesion Multiple lesions Root caries

Restorative State: Unrestored Sound (flush margins, no fractures) Suboptimal

Periapical pathology present: Yes No Multiple sites

Exposed root surfaces: Yes No Multiple sites

Denture wear: None Upper partial / complete Lower partial / complete

Mouth opening (mm):

Medical and Social Status

Relevant medical history & medication:

Smoking status: Never Ex Current <10 per day Current >10 per day

Alcohol status: Never Ex Units per week:

Oncology Status

Diagnosis: .....

Location: .....

TNM staging: .....

Prognosis: Two-year survival (%) .....

Five-year survival (%) .....

Figure 2. *Proforma (Page 1 of 2) to collect minimum data for decision-making*

team are beneficial. Consideration must be given to the patient's overall prognosis and advice tailored accordingly for patients having palliative care, where comfort may be more important than long term preservation of the teeth.

Fluoride

Since the introduction of fluoride, the reduction in caries rates in the general population is well documented[26]. In head and neck oncology patients, a daily rinse of 0.42% or 0.05%NaF has been shown to reduce the development of radiation caries[18, 21]. Topical fluoride may be in the form of mouthwashes, pastes or gels. Pastes and gels can be directly applied onto tooth structure using a brush or finger or in customised trays. Fluoride trays are vacuum form silicone trays with reservoirs to hold a small amount of fluoride gel or toothpaste[27]. These can be constructed using casts poured up from alginate impressions in stock trays prior to surgery. The success of this treatment is very much dependent on patient compliance and as can be seen from Figure 4 despite the use of various fluoride regime, caries post radiotherapy still occurs.

There are numerous toothpastes and oral rinses available (Figure 5). Stannous fluoride has been shown to have three times the effectiveness of sodium fluoride at reducing the solubility of enamel in dilute acids[28]. Stannous fluoride

Oncology Treatment Plan

Treatment planned: Surgery Chemotherapy Radiotherapy

Surgical plan: .....

Date of Planned Chemotherapy commencement: .....

Date of Planned Radiotherapy commencement: .....

Planned Radiation Dose: .....

Radiation Field / Level .....

Is prolonged xerostomia likely (12 months or longer)? Yes No

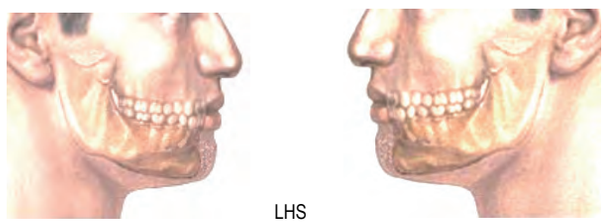
Is trismus likely? Yes No

Tissues in primary beam of radiation: Mandible: Anterior dentition Posterior dentition

Maxilla: Anterior dentition Posterior dentition

Salivary glands: Parotid L Parotid R Submandibular

Oral cavity and dentition exposed to radiotherapy:



RHS LHS

Details/ Complications/ Comments:

Signature: ..... **Print Name:** .....

Ward ..... **Ext**..... **Bleep**..... **E-mail**.....

Figure 2. *Proforma (Page 2 of 2) to collect minimum data for decision-making*

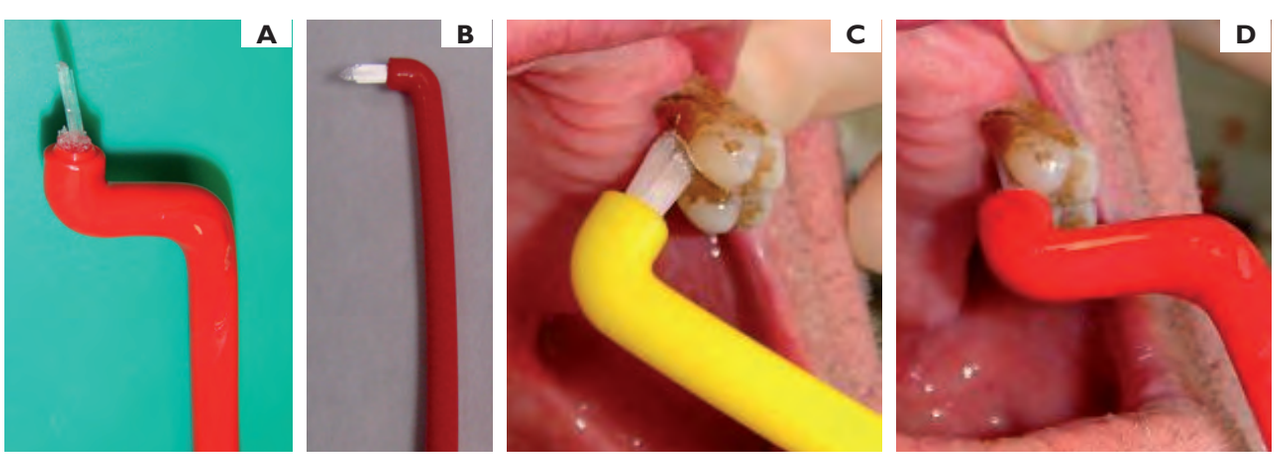


Figure 3. *Modified single tufted brush*

Study	Type of radiation	No of pts	Follow up time	Fluoride regime	Outcome
Wang et al 2008[27]	linear accelerator based radiotherapy	181	3-12months	1.23% APF or 2% NaF in custom trays daily for 4 minutes	Mean number of carious lesions during and post radiotherapy was 7.18+/-7.10 and that pre-radiotherapy was 2.45+/-2.85
Jham et al 2008[47]	Cobalt (51%) Linear accelerator (53%) 50-72Gy	207	90-1005 days	1% sodium fluoride for 1min	Radiation caries found in 12 patients (6%)
Hariot et al 1983[16]	Not stated	935	1-10 years	Fluoride trays with 1% fluoride gel 450ppm F or toothpaste (1350 ppm F) given to wear for min 5mins per day	Diffuse caries occurred in 4% (36 patients) Primarily failure occurred in patients with poor compliance to prescribed dental regime Patients divided into poor, fair or good dentitions (needed fair or good to keep the teeth but some patients who refused extractions also kept their teeth and were included in the study). In second part of study patients who kept their teeth were randomised to Fluoride gel vs. toothpaste) 3% of those on fluoride gel developed caries compared to 11% on fluoride toothpaste.

Figure 4. *Development of caries despite fluoride regimes used for oncology patients post radiotherapy*

Product	Manufacturer	Stannous/Sodium fluoride	Concentration of fluoride
Colgate regular	Colgate –Palmolive Co., New York, NY	Sodium fluoride	1100ppm fluoride
Fluorigard mouthwash	Colgate –Palmolive Co., New York, NY	0.05% Sodium fluoride	225ppm fluoride
Gelkam gel	Colgate –Palmolive Co., New York, NY	0.4% Stannous fluoride	970ppm fluoride
Gelkam oral rinse	Colgate –Palmolive Co., New York, NY	0.63% stannous fluoride for dilution to 0.1% stannous fluoride	
Duraphat 2800 toothpaste	Colgate –Palmolive Co., New York, NY	0.619% Sodium fluoride	2800ppm fluoride
Duraphat 5000 toothpaste	Colgate –Palmolive Co., New York, NY	1.1% Sodium fluoride	5000ppm fluoride
MI Paste Plus	Recaldent, GC America Inc, Illinois	Patented form of fluoride	900ppm

Figure 5. *Familiar fluoride products*

has a more protective effect than sodium fluoride due to the combined effect of the stannous and fluoride ions[29-31].

Different patients may prefer different products due to the flavouring and the sensitivity of their mucosa. The important point is to ensure that the patient is using a topical application of a high fluoride product numerous times on a daily basis. It may be appropriate to avoid agents containing sodium lauryl sulphate, due to possible mucosal irritation and risk of carcinogenicity[32].

Normally saliva is saturated with calcium and phosphate which may be very much reduced or non-existent in patients following radiation damage. Both calcium and phosphate have been shown to improve tooth remineralisation and increase fluoride uptake when given as supplements in toothpaste or mouth rinse[33]. New developments include agents that deliver bio-available amorphous calcium phosphate and casein phosphopeptide (GC Tooth Mousse by Recaldent™, GC America Inc, Illinois). Manufacturers recommended that these pastes be applied topically brush-

ing and left in place for several minutes on a daily basis. There are no clinical studies available on the outcome of using these pastes and a fluoride paste/gel/oral rinse.

Newer arrivals are products containing Novamin (NovaMin Technology Inc. GlaxoSmithKline, USA). Novamin constitutes a bioactive glass, which breaks down in water to release sodium, calcium and phosphorus. These then form hydroxycarbonate apatite[34]. It is recommended that these products be applied in addition to fluoride toothpaste due to the lack of or low levels of fluoride available within the product themselves. Figure 6 highlights the variety of preventative regimes recommended[24, 25, 35-36].

Dental extractions

The authors have seen numerous patients present years post-radiotherapy, with crumbling and painful teeth. Managing these teeth can be very challenging. In the anterior segments, even with trismus access is usually possible. Predictable restoration of carious posterior teeth can be very difficult as access is often complicated by trismus and/or a reduction in the size of the oral aperture.

In view of these difficulties, the question arises: should potentially problematic teeth or those that would be impossible to treat should trismus occur be extracted prior to radiotherapy? If so, which teeth? How long must the healing period be prior to the commencement of radiotherapy? Will the extraction of teeth lead to fewer complications in the long term? Or will there be other problems such as the need for the provision of fixed or removable prostheses to restore aesthetics and function? Will these then lead to other problems such as Osteoradionecrosis (ORN) due to trauma from denture or failure of oral implants as a result of poor quality bone? Is the better option preserving as many teeth as possible and finding ways of maintaining good health of these teeth during and post radiotherapy? Or is the risk of developing ORN too great to take the risk of leaving teeth in situ? These are questions that are difficult to answer using the available literature.

There has been tendency towards extracting potentially problematic ('questionable) teeth with a view to preventing future complications. This approach maybe considered problematic in itself as survival rates and patient expectation increase. Decisions appear to be based on clinical judgement stemming from expertise and experience. Questionable prognosis has been described to include:

- teeth with advanced caries lesions (more than half of the root circumference involved)[10, 20, 37, 38, 39, 41, 42, 45, 46, 50, 53, 54]
- teeth with questionable pulpal status or pulpal involvement (with or without periapical lesions)[10, 37, 38, 39, 42, 46, 53]
- extensive periapical lesions (>3mm in size)[10, 15, 20, 37, 39, 45, 46, 53, 54]

Publication	Recommendation
Meurman & Scully 2012[35]	Fluoride toothpaste used 2x daily Daily use of 0.05% sodium fluoride solution Weekly application of 0.2% fluoride gel in mouthguards or professionally applied fluoride varnish for selected patients Calcium phosphate containing tablets or lozenges or casein phosphopeptide preparations used daily Xylitol containing gum or high content xylitol containing products daily Chlorhexidine mouthwash used daily or more frequently 1% chlorhexidine gel in mouthguards for those who have salivary mutans streptococci assays of >106cfu/ml saliva
Joshi 2010[36]	Brush after each mean with soft brush and fluoride containing toothpaste preferably 5000ppm or bicarbonate based toothpaste can also reduce acidic pH Chlorhexidine mouthwash 2-3x daily when brushing is not possible Water irrigating systems to remove debris 500ppm fluoride toothpaste in mouthguards daily for 5 minutes Alternatives: warm dilute solution of sodium bicarbonate or salt and bicarbonate every 2 hours
Siddal et al 2012[24]	Soft toothbrush and fluoride toothpaste 2x daily Fluoride mouthwash, gel and amorphous calcium phosphate and casein phosphopeptide Aqueous chlorhexidine mouthwash
Barclay & Turani 2010[25]	Brush 4x daily with 5000ppm fluoride and use interdental brushes 2x daily 1% Sodium fluoride gel o 0.4% stannous fluoride gel in mouthguards daily for 5 minutes 0.12% – 0.2% Alcohol free CHX mouthwash daily (avoid use concurrently with fluoride) Chew xylitol or sorbitol containing gum Amorphous calcium phosphate & casein phosphopeptide to be applied when demineralisation seen Alternatives: Dilute sodium bicarbonate solution to buffer acidity

Figure 6. *Preventative regimes recommended in the literature*

- internal or external root resorption[46]
- moderate to advanced periodontal disease (spontaneous gingival bleeding, >5-6mm pockets , >6mm gingival recession, mobility > 2mm, +/- furcation involvements)[10, 15, 20, 37, 38, 39, 40, 41, 42, 43, 45, 46, 50, 53, 54]
- residual root tips not fully covered by alveolar bone or showing radiolucency[10, 37, 45, 46, 54]
- non functional molars to prevent food trapping following over eruption which may lead to root caries that may be difficult to manage[45, 46, 53, 54]
- second molars unless the patient is keen to (and has demonstrated the ability to) maintain meticulous oral hygiene[15]
- teeth with associated pathology such as follicular cysts[46]
- third molars except those that are completely covered by bone without associated pathology[37, 38, 44, 45, 54]
- all molars in patients with unsatisfactory oral hygiene who are unlikely to change their attitudes towards oral health[15, 45, 46]
- impacted or incompletely erupted teeth, especially 8s in contact with oral environment[46]
- teeth within radiation field[15, 46]
- teeth close to the tumour[10, 20, 37, 46]
- teeth in radiation field in patients with medical history preventing HBO therapy if future extractions needed post radiotherapy[50]

Dental planning in a patient soon to undergo radiotherapy to the head and neck region is unique in that there may be extraction of teeth that would otherwise be treated conservatively[47, 48] with more aggressive extraction strategies for patients less motivated to maintain adequate levels of oral hygiene[37, 46, 49]. Radiation site, dose, volume, modality, urgency and general state and prognosis should also influence pre-radiotherapy decision making[37,43]. Radiation doses above 55Gy, molars in the radiation field, teeth in close proximity to the tumour and time between dental extractions and radiotherapy have been identified as pre-treatment risk factors for high risk of oral complications following cancer therapy[46]. The ability to predict which patients will develop trismus following radiotherapy would be most beneficial to decision making[51].

An international survey using judgment analysis questionnaires sent to 54 oral-maxillofacial surgeons and hospital based dentists in North America, Australia and Europe (response rate 81%) found that dental conditions such as periodontal/endodontic conditions and impacted teeth played the largest role in decision-making. Radiotherapy had a relative importance of 10% and tooth functionality had a relative importance of 6%. Tooth location (upper vs. lower jaw) did not significantly contribute to the decision-making[52]. Bruins commented that much of the decision-making is opinion and experience based and produced a model for dental decision-making[52, 53].

The Model for pre-radiotherapy Dental Decision Support (MDDS) is a method where clinicians can use available evidence in consultation with the patient to arrive at the best decision to suit the patient. It involves a set of decision-making steps and a decision tree. Each aspect of the patient from motivation and cooperation to the specifics of periodontal and pulpal disease was given risk weightings. Then the question was asked whether dental extraction or dental treatment should be used to eliminate the dental risk factor to optimise the oral outcome with respect to a malignancy related risk factor. The process is complicated with the need for probability estimations, outcome values and expected value of each decision alternative. Even then, in some cases, there were uncertainties as to what is the optimal decision. The limitations of using this case based analysis tool was built in judgment biases and the instability of the estimations over time (as there may be changes in cancer therapy, patient compliance and prognosis). The tool has been tested in simulations and as yet there is little evidence on the effectiveness in a clinical setting[53].

A variety of statements related to extractions and ORN have been made in the literature such as pre-irradiation extractions, when performed and timed correctly do not significantly increase the overall risk of ORN[37]. Recommended healing times of 14-21days prior to initiation of radiotherapy[12, 37, 40, 53]. Other suggestions have been to give 'sufficient' time for initial healing and to allow the tissues to support radiation without compromising the oncology treatment[55]. The size of the socket left by the extracted tooth may have an influence on the healing as an increased area of bone exposed to the oral cavity requires potentially longer to granulate. It is difficult to ascertain from the literature whether achieving primary closure necessarily protects against ORN.

Following completion of radiotherapy there is a 5-6 month window of tissue repair and healing prior to the onset of irradiation-induced fibrosis and loss of vascularity[56]. Some say this healing phase is a much safer time to undertake necessary extractions and hyperbaric oxygen is usually not needed[37]. Extraction during radiotherapy is strongly discouraged and antibiotic cover is strongly recommended[37]. Minimising or delaying extractions until at least 9-12 months after the end of radiotherapy has also been recommended as dental extractions shortly before, during or after radiotherapy increased the risk of ORN[57]. Others recommend avoiding dental extractions even many years after radiotherapy has been completed[58].

As seen in part one of this series of articles the incidence of ORN attributed to dental extractions is low and is based on low quality evidence. A Cochrane review found no randomised controlled trials looking at timing of dental extractions and post-radiotherapy dental complications[59]. Over-prescription of extractions in this group of patients is not recommended as it is unsupported by the literature. New trials are established and running to ascertain the use of hyperbaric oxygen therapy in preventing ORN in patients needing surgery to the mandible following radiotherapy (HOPON trial[60,61]).

The use of intensity modulated radiotherapy (IMRT) to calculate the radiation dose to each area of the mouth with special consideration being given to the parotid glands and is thought to assist the whole saliva experience of the patient[62, 63]. The major salivary glands (parotid, submandibular and sublingual) contribute to 90% of saliva production. The rest is produced by the minor salivary glands, making a significant contribution to lubricating the

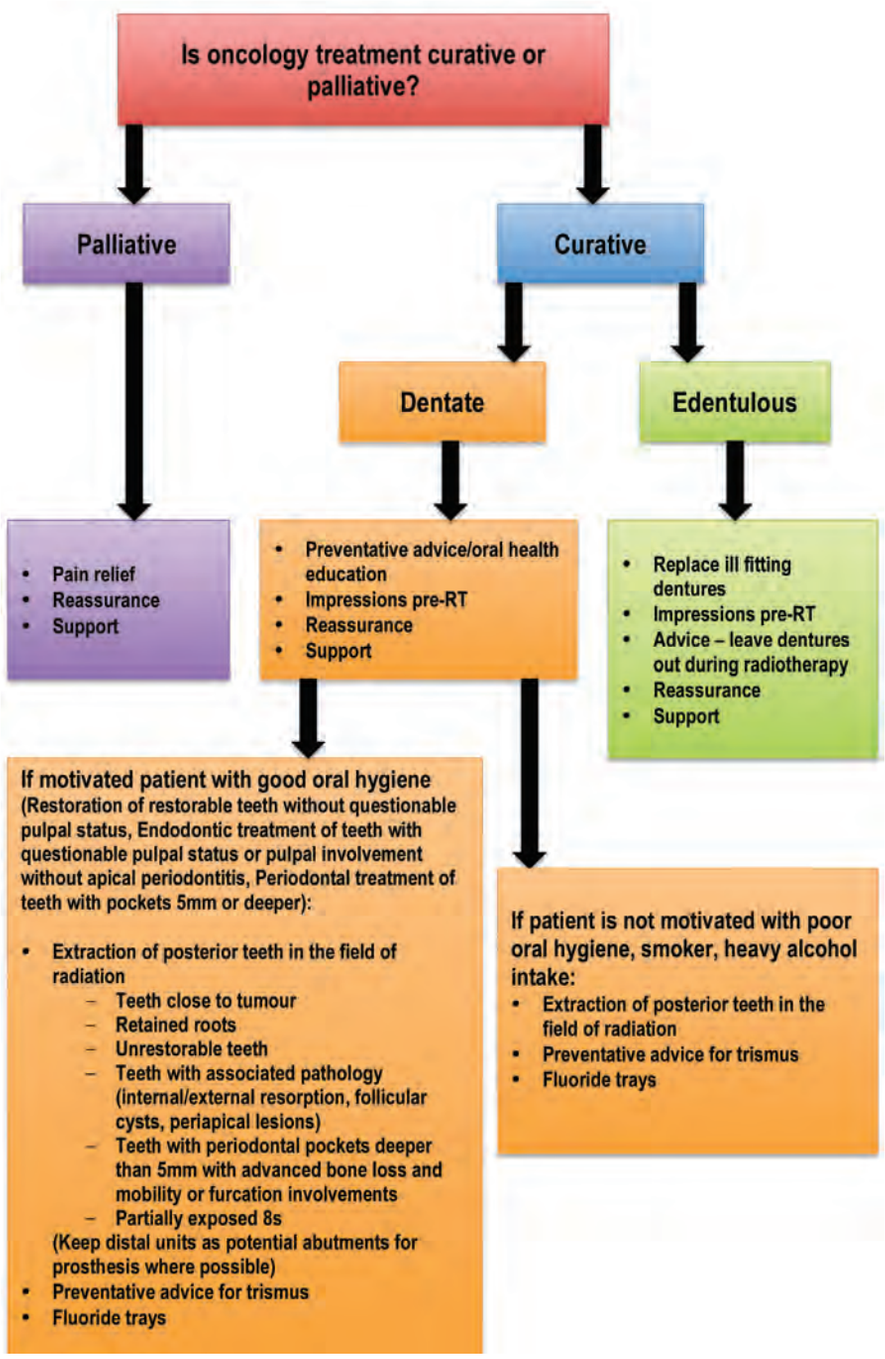


Figure 7. *Simplified approach to extractions as part of pre-radiotherapy oral health management*

mucosa. At rest the submandibular glands produce two-thirds and sublingual glands produce 1-2% of the saliva. Upon stimulation the parotid glands produce half of the total volume of saliva[63]. More recently submandibular gland transfer to the sublingual space instead of removal during neck dissection has shown promising results in reducing xerostomia and improving quality of life[64].

The availability of exact dose and tissue volumes affected by IMRT and use of this information in OHRAM will be a positive step in determining the required dental treatment. This can mean more conservative dental treatment and fewer extractions[65]. Future use of genetic screening is also likely to identify the patients most likely to develop ORN[66, 67].

Isodose charts are unlikely to be available for pre-radiotherapy OHRAM and dental extractions must be carried out as soon as possible to allow the maximum time for healing prior to radiotherapy. As IMRT planning is complex[68], isodose charts will only be available once radiotherapy planning is complete, at which point the patient is ready to receive radiotherapy, which cannot be delayed on account of dental treatment. A simple protocol to follow for extraction of teeth is shown in Figure 7 however must be adapted to the individual needs of the patient. If

the patient is seen for a dental assessment at the time of diagnosis, dental extractions can be planned and carried out at the time of primary surgery, which often allows approximately six weeks of healing prior to radiotherapy commencement[61].

Trismus

It is sensible to make a record of the inter-incisal distance at maximum opening prior to surgery and/or radiotherapy commencing. Jaw exercises, including stretching of the masticatory muscles using numerous wooden spatulas placed with flat edges towards the occlusal surfaces of posterior teeth, or devices to stretch the muscles pre, during and post-radiotherapy can be useful. The patient must be shown how to use these devices. Care must be taken in a patient who presents with widespread demineralisation of the teeth, dental neglect or radiation caries as the increased forces of using these devices can lead to tooth fracture[69] or soft tissue trauma in those who have one dentate jaw and an opposing edentulous jaw. The use of pentoxifylline for the treatment of radiation-induced trismus has been discussed recently however further evidence regarding the benefits have been called for[70, 71].

The practical maintenance of a shortened dental arch[72] may be very much easier in a patient with trismus or reduced oral aperture, from the patient's and dental professional's perspective. In patients with a deep overbite, the lack of posterior teeth may be beneficial in allowing toothbrush access to lingual/palatal aspects of the remaining anterior teeth. Impressions taken pre-surgery/radiotherapy may be necessary for future treatment planning, construction of surgical obturators and construction of fluoride slips/spacers for radiotherapy. Once trismus has developed impression taking can be exceedingly difficult.

OHRAM DURING RADIOTHERAPY

This may be a very difficult time for the patient and their families/carers. Both parties are likely to need comfort and reassurance. Mucositis, xerostomia and taste disturbances are normal responses to radiotherapy. It is important to stress that some of these are transient but may take months or years to return and others may never return to normal following cancer treatment.

Mouthwashes

A number of agents have been used to prevent the development of mucositis in this patient group however, no single intervention has been found to prevent mucositis[73, 74]. Chlorohexidine mouthwashes have been used to treat mucositis in the past with variable results[75]. Benzydamine hydrochloride has been shown to reduce mucositis and pain in head and neck cancer patients[76, 77]. Ice chips, honey (for edentulous patients only), homemade mouthwashes with a teaspoon (10ml) of salt and a teaspoon (10ml) of bicarbonate of soda mixed in 250ml of water[49], saline mouthwashes, soluble aspirin and simple analgesia can also be beneficial.

New attempts to reduce discomfort from mucositis have been the development of Caphosol® (EUSA Pharma (Europe) Ltd, Oxford, UK), a mouthwash prepared by mixing two separately packaged aqueous solutions (a phosphate and a calcium solution) which when combined created a supersaturated solution of calcium and phosphate ions. This electrolyte solution is marketed for moistening and lubricating the oral cavity in hose with a dry mouth. Other mucosal protectants are Gelclair® (Alliance Pharmaceuticals Ltd, England) and Zilactin® (Blairex Laboratories Inc. Columbus, IN).

Diluting mouthwashes help as strong flavours can exacerbate the symptoms. Patient comfort and allergies may determine which mouthwashes are used.

Salivary Substitutes

Xerostomia can exacerbate the symptoms of mucositis, as the protective lubricating effect of saliva is absent. Avoidance of dry foods, and regular sipping of soft, sugary drinks should be advised. Frequent sipping of plain, still water is recommended. Available agents have been summarised in other publications[36, 69]. Note that Glandosane® (Fresenius Kabi Ltd) is not recommended for dentate patients due to the acidic pH[5, 69, 78]. Xerostomia can be a lifelong complication and it is important for the patient to be aware of this as adjustments to oral hygiene, diet and fluoride regimes will need to be maintained for life.

Diet

Patients undergoing oncology treatment may be of a low nutritional and psychological state. An example of an area needing clear communication between oncologists, dietitians and the dental team is during and post radiotherapy where nutrition is concerned. The medical team and dietitians will want to maintain the nutrition levels and weight, however frequent meals with a high sugar level can be detrimental to the dentition (especially if they are sticky foods and there is hyposalivation). At this point survival of the patient is the priority (although the patients long term quality of life will influence treatment decisions). Therefore it is essential to have support from the hygienist for motivation to maintain adequate oral hygiene and fluoride use during this short period where there may be no option than to increase high sugar food intake. In some units around the world a dental hygienist sees the patient daily during their radiotherapy[79]. Where present percutaneous endoscopic gastrostomy (PEG) tubes can be used for high sugar supplements to spare the dentition.

Spacers to reduce the radiation to certain structures[80] and stents to prevent backscatter of metal restorations in posterior teeth[81] could be beneficial to patients.

POST-RADIOTHERAPY OHRAM

Although this next stage is rehabilitation, assessment and clear recording of the oral hygiene, smoking, alcohol, caries and periodontal status is still important. Additionally, mucositis, xerostomia, maximum mouth opening, the need for dental extractions and any associated complication should be recorded. Clear recording of information prior to and post-radiotherapy can form help inform future changes to OHRAM.

Pre-RT OHRAM	OHRAM during radiotherapy	Post-RT OHRAM	Long term OHRAM
Secondary Care 1. Discussions at MDT: diagnosis, staging, prognosis, surgical treatment plan, radiotherapy treatment plan 2. Clinical and radiographic assessment 3. Giving the patient information about the effects of surgery and radiotherapy: what to expect and reassurance 4. Impressions of the oral cavity and storage of models 5. Palliative care or Stabilisation: restore teeth with good prognosis and removal of teeth that may pose potential problems in the future 6. Oral health education: 7. Construction of transitional prostheses such as surgical plates and interim obturators 8. Preventative advice regarding trismus	**Secondary Care** 1. Management of oral problems: mucositis, xerostomia, taste disturbances 2. Preventative advice: mucositis and xerostomia may mean difficulties brushing, difficulty using flavoured toothpastes and mouthwashes due to soreness 3. Relining and adjustment of transitional prostheses 4. Preventative advice regarding trismus	**Secondary Care** 1. Information to patients in relation to the limitations of rehabilitative treatment and the maintenance requirements 2. Palliative care or definitive restoration: restoring function and improving the quality of life 3. Preventative advice 4. Construction of definitive prostheses 5. Preventative advice regarding trismus 6. Provision of soft bite guards or smoothing of sharp edges of teeth and restorations to protect the mucosa from trauma (protective lubricating effect of saliva may be absent)	**Primary Care** 1. Routine follow up 2. Oral health education 3. Routine restorations **Secondary Care** 1. Atraumatic extraction of problematic teeth 2. Replacement obturators 3. Implant placement and management of complex complications

Figure 8. *Oral health management on head an neck oncology patients at various stages*

The patient's quality of life must be considered and once again advice on oral hygiene, diet, fluoride, mouthwashes and salivary substitutes tailored to each patient's needs. The presence of non keratinised mucosa in place of keratinised mucosa can be very painful to brush, hence soft cloths/sponges and brushes may be required.

At this point the patient may be coming to terms with their survival or long-term prognosis and highly concerned with 'late effects' such as their oral health and teeth following oncology treatment[82]. Rehabilitation may include maintenance of the remaining dentition, a removable prosthesis, a fixed prosthesis or an implant retained prosthesis. The decision-making is on a case-by-case basis, depending on the oncology treatment and needs of the patient. The details of each treatment modality are beyond the remit of this paper.

LONG-TERM ORAM

All of these patients will require maintenance and surveillance for the duration of their lives. A shared care approach between primary and secondary care may be necessary for maintenance of rehabilitations using implant supported restoration or complex maxillofacial prosthodontics. It is reasonable to expect primary care to provide regular supportive care during regular recall visits following rehabilitation and stabilisation of the dentition. If complications arise in relation to complex rehabilitating prostheses, the patient can be referred back to secondary care for specific items of treatment.

One of the problems of managing this group of patients is dental phobias, anxiety and loss of patients to follow up[61]. Even where careful protocols are in place it is difficult to ensure that patients turn up for appointments and comply with recommendations. It is therefore important to have a supportive dental team who can ensure continuity and motivation.

Figure 8 outlines the authors' recommendations in relation to the oral health management of these patients by the dental team at various stages of their treatment. Details of the dental treatment are available in previously published protocols[10, 37].

CONCLUSIONS

In the absence of evidence to suggest that leaving healthy teeth in the field of radiation during radiotherapy causes marked detrimental effects, it may be possible to consider the following as standard practice:

1. Information regarding tumour location, expected overall prognosis and chance of 5year survival for each patient to be sent to dental team for planning of extractions
2. Oral Health Risk Assessment and Management (OHRAM) made on available evidence
3. IMRT isodose bar charts for all radiotherapy patients be available prior to pre-radiotherapy extraction planning (and given to patient to keep for life to aid future treatment such as dental implants)
4. Extractions and dental treatment within 3 days of initial diagnosis therefore allowing for maximum healing time prior to radiotherapy (or at the time of primary surgery)
5. Possible shields and spacers to reduce scatter/unnecessary radiation of adjacent structures
6. An universal approach within the team for pre, during and post radiotherapy preventative advice, support and dental maintenance
7. Detailed data bases to be held by all centres for all head and neck cancer patients

The aim of OHRAM should be to reduce the risk of potential future oral complications while maintaining the quality of life. Collect data regarding treatment, clinical outcomes and patient related outcomes will inform and drive forward improvement in the patient journey and quality of care provided via national and international audits.

ADDRESS FOR CORRESPONDENCE

Shiyana Eliyas, Department of Restorative Dentistry, Charles Clifford Dental Hospital, Wellesley Road, Sheffield. S10 2SZ, UK. E-mail: shiyanaeliyas@hotmail.com

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