Dental Management of the Head and Neck Cancer Patient Treated with Radiation Therapy

By Carol Anne Murdoch-Kinch, D.D.S., Ph.D., and Samuel Zwetchkenbaum, D.D.S., M.P.H.

Approximately 36,540 new cases of oral cavity and pharyngeal cancer will be diagnosed in the USA this year; more than 7,880 people will die of this disease.[1] The vast majority of these cancers are squamous cell carcinomas. Most cases are diagnosed at an advanced stage: 62 percent have regional or distant spread at the time of diagnosis.[2] The five-year survival for all stages combined is 61 percent.[1] Localized tumors (Stage I and II) can usually be treated surgically, but advanced cancers (Stage III and IV) require radiation with or without chemotherapy as adjunctive or definitive treatment.[1] See Table 1.[3] Therefore, most patients with oral cavity and pharyngeal cancer receive head and neck radiation therapy (RT) as part of their treatment.

The oral complications of head and neck RT result from radiation injury to the salivary glands, oral mucosa and taste buds, oral musculature, alveolar bone, and skin. They are clinically manifested by xerostomia, oral mucositis, dental caries, accelerated periodontal disease, taste loss, oral infection, trismus, and radiation dermatitis.[4] Some of these effects are acute and reversible (mucositis, taste loss, oral infections and xerostomia) while others are chronic (xerostomia, dental caries, accelerated periodontal disease, trismus, and osteoradionecrosis.) Chemotherapeutic agents may be administered as an adjunct to RT. Patients treated with multimodality chemotherapy and RT may be at greater risk for oral mucositis and secondary oral infections such as candidiasis. The oral complications of therapy for head and neck cancer can significantly impair quality of life.[5]

Table 1 — TNM Staging for Head-and-Neck Cancer

Stage	Tumor	Nodes	Distant Metastases
0	T_{is}	N_0	M_0
I	T_1	N_0	M_0
II	T_2	N_0	M_0
III	T_3	N_0	M_0
	T_1	N_1	M_0
	T_2	N_1	M_0
IVA	T_4	N_0	M_0
	T_4	N_1	M_0
	Any T	N_2	M_0
IVB	Any T	N_3	M_0
IVC	Any T	Any N	M_1

T_{is}: in situ
T_1: < 2 cm
T_2: > 2 cm and < 4 cm
T_3: > 4 cm
T_4: Invades adjacent structures
N_0: No nodal involvement
N_1: Ipsilateral, < 3 cm
N_{2a}: Ipsilateral > 3 cm and < 6 cm
N_{2b}: Ipsilateral, multiple, < 6 cm
N_{2c}: Bilateral/contralateral, < 6 cm
N_3: > 6 cm
M_0: No metastases
M_1: Distant metastases

Adapted from Brandwein-Gensler and Smith.[3]

The oral health care team serves a vital role in the prevention and management of short- and long-term oral complications of cancer treatment. Hospital-based dentists specially trained in oral oncology treat some of these patients, but currently in North America most long-term dental care is provided by general dentists in private practice.[6-8] Depending on available health care resources, the patient may rely on his local dentist for pre-treatment oral care and supportive care during cancer treatment, as well as continued oral health care to manage the long-term oral complications of cancer therapy. It is essential that all health professionals caring for the cancer patient be knowledgeable about the diagnosis, prevention and management of oral complications of therapy and their sequelae, in order to work together as a team to minimize the impact of these toxicities on the patient's life.

This article provides an overview of oral complications of RT for head and neck cancers, with a particular emphasis on caries, periodontal disease, and osteoradionecrosis of the jaws, and guidelines for the dental management of the head and neck cancer patient treated with RT.

Oral Complications of Head and Neck RT

a. Xerostomia and salivary gland hypofunction: Xerostomia is the most common oral complication of head and neck RT. In fact, up to 64 percent of patients treated with conventional head and neck RT still experience a moderate to severe degree of permanent xerostomia when assessed up to 22 years after radiation therapy.[9] The most severe complaints occur in patients treated for cancer of the nasopharynx and oropharynx, most likely due to the close proximity of the field to the parotid glands.

Paradoxically, for such highly differentiated tissues, salivary glands are very sensitive to radiation. There is a sharp decrease in the salivary flow rate during the first week of RT with conventional fractionation (2 Gy/day). The decrease in flow rate continues throughout the treatment period, especially when both parotids are irradiated.[5,10] This correlates to the dose and duration of RT. There is immediate serous cell death accompanied by inflammatory cell infiltration, and then continuous reduction of salivary flow rates. Patients often complain of thick, ropy saliva and a sensation that there is too much saliva because it is difficult to swallow. The exact mechanism of radiation-induced damage to the salivary glands is not currently well understood.[11]

With conventional RT, xerostomia is permanent. Salivary gland-sparing techniques using intensity modulated radiation therapy (IMRT) have been pioneered at the University of Michigan.[12-15] IMRT is rapidly emerging as the standard of care for head and neck cancer.[16] Salivary gland-sparing IMRT is associated with gradual recovery of salivary flow over time, and improved quality of life as compared to conventional RT.[12-15,17-20] Residual salivary flow can be stimulated by sialogogues such as pilocarpine[21-22] or cevimeline, and/or use of sugarless gum and buffered citric acid tablets[23] (Numoisyn™, Align Pharmaceutical, Berkeley Heights, N.J.) Salivary substitutes provide transient symptomatic relief.[21,24-27]

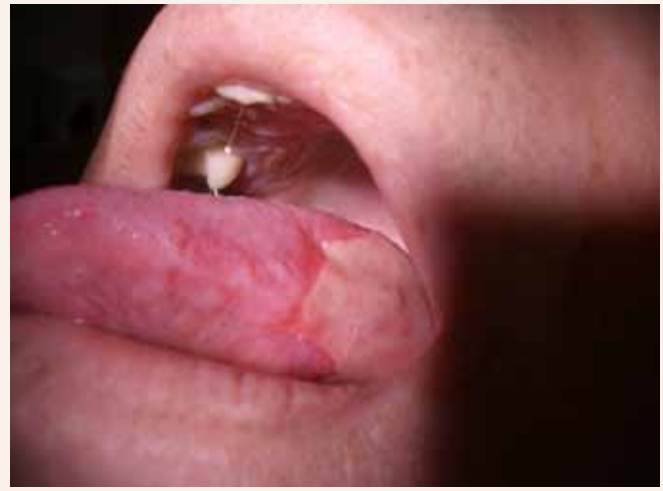

Figure 1 — Xerostomia and radiation mucositis in patient one month after the end of radiotherapy. Saliva is thick and sticky. Mucositis is painful and interferes with eating.

Figure 2 — Silicone mucosal guards. These custom-made guards cover metallic restorations with 5 mm of silicone impression material, to prevent heating of the metal and backscatter of radiation in contact with the mucosa.

b. Radiation mucositis: Mucositis is an important common acute short-term complication of head and neck RT. It is a dose-limiting toxicity and may be more severe in patients receiving multimodality therapy for head and neck cancer. It is characterized by ulceration in the oro-esophageal and gastrointestinal mucosa, resulting in significant pain and dysphagia.[28-31]

Mucositis initially presents clinically as erythema after 4-5 days of therapy, corresponding to cumulative doses of 10 Gy to the head and neck. The patient often complains of oral burning or intolerance to spicy food. As the mucositis progresses after cumulative radiation doses of 30 Gy (approximately two weeks), ulcers develop. (Figure 1). Radiation-induced mucositis can involve any radiation-exposed area, including the hard palate. It may be worse in tissue in direct contact with metallic restorations. Radiation-in-

duced mucositis peaks at two weeks post RT of 60-70 Gy. This ulcerative phase may last for up to 5-7 weeks following RT, with gradual healing. Chronic mucositis is a rare occurrence following RT.[29,32-33]

Mucositis has a significant health and economic impact on cancer patients. It is one of the most common reasons for a break in the administration of RT.[32] Measures specifically designed to prevent and treat oral mucositis can be provided by the patient's oncology team. The dentist can assist by providing basic oral care consisting of patient education, disease control, and oral hygiene instruction. These measures can decrease the microbial load in the oral cavity and prevent other complications associated with therapy. In addition, patients who have heavily restored teeth may benefit from the use of silicone mucosal guards worn during RT (Figure 2) to reduce the severity of mucositis associated with scatter of radiation off metal restorations.[34-36]

c. Oropharyngeal candidiasis (OPC): This is a very frequent complication of cancer therapy; up to 27 percent of patients undergoing RT present with evidence of OPC.[37] It may present as a pseudomembranous candidiasis (thrush), with thick white plaques that wipe off (Figure 3), or as generalized erythema and burning discomfort. Clotrimazole has been shown to be more effective than nystatin for treatment of OPC; clotrimazole 10 mg troches administered five times per day are effective in treating mild to moderate OPC.[38] Some topical preparations have a high sucrose content that may contribute to caries risk in the xerostomic patient. Fluconazole 50-100 mg daily has been associated with clinical recovery in 80 percent of patients within 10 days, or within five days with 200 mg daily. Complete mycologic cure is difficult to achieve. Resistance to fluconazole is associated with non-albicans yeast such as *Candida glabrata* and *C. krusei*.[39] A recent systematic review of this topic failed to find strong enough evidence to support one drug over another in the treatment of OPC in this population.[40-41] Although initially encountered during RT, it also can present a long-term problem in patients with xerostomia. Antifungal prophylaxis may be beneficial in high-risk patients; the oncology team should make this decision.

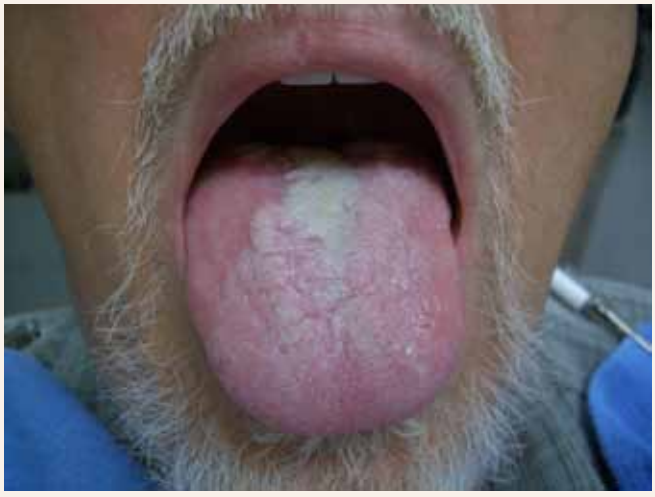

Figure 3 — Oral candidiasis in a head-and-neck cancer patient six months post-radiotherapy. These white plaques on the tongue dorsum could be wiped off. This infection responded to Nystatin suspension.

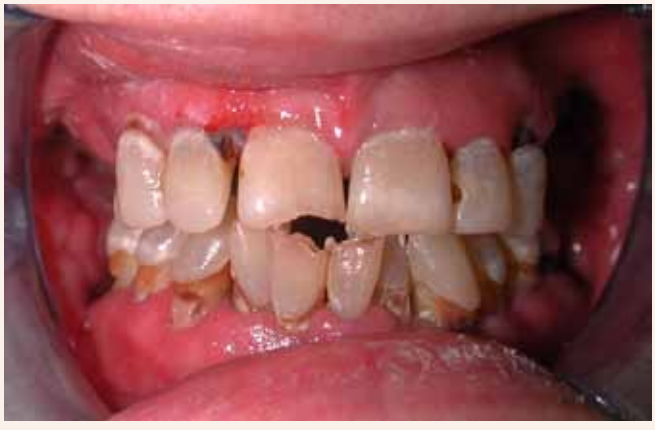

Figure 4 — Rampant dental caries post-radiotherapy.

d. Dental caries: After standard RT there is a profound shift in the oral microflora to a predominance of acidogenic microbes, primarily *Streptococcus mutans* and lactobacilli, coincident with a decrease in salivary flow, and an increase in caries risk.[42-44] Dental caries in irradiated patients may develop rapidly, as early as three months after RT. Lesions typically involve the cervical portions of the teeth (Figure 4); however, caries may affect any tooth surface, including those typically resistant to dental caries such as the incisal edges of the mandibular incisors.[45-46]

Prevention and treatment of dental caries. A strict daily oral hygiene regimen that includes fluoride and meticulous plaque removal has been shown to prevent the development of caries.[43,45] Chlorhexidine gel has also been shown to clinically reduce caries risk by lowering mutans streptococci and lactobacilli counts in patients undergoing RT.[47-48] Chlorhexidine gel is not currently available in the U.S.; however, chlorhexidine mouthrinse could provide similar benefits.[48] Alcohol-free formulations should be selected to reduce discomfort in patients with dry mouth. Caries lesions should be restored before RT to prevent progression of disease and reduce microbial load. Also, the patient will be more comfortable during treatment if the oral mucosa is intact. Patients should also receive diet counseling about cariogenic foods and their deleterious effects on the dentition.

Vissink and colleagues[49] concluded that a lifelong commitment to improved oral hygiene and home care should include meticulous oral hygiene and frequent self-applications of fluoride, either neutral NaF 1 percent gel applied at least every other day[46,50] in custom-made fluoride carriers or NaF 3 percent toothpaste twice per day.[45] The daily use of 4 percent stannous fluoride also is effective.[51-52] Presently, there is inadequate evidence to support one type of fluoride product over another for patients undergoing RT; the frequency of application appears to

be more important. Because hyposalivation is irreversible in most head and neck irradiation patients, especially those treated with standard therapy, the application of fluoride must be continued indefinitely; otherwise, caries will develop within months.[50,53-56]

In patients receiving parotid-sparing IMRT, where salivary output has been shown to increase over time,[12,14-15,17,20] and in patients receiving amifostine during RT, evidence suggests that caries risk may be reduced.[57] Amifostine is a radioprotective drug that has been shown to have a significant protective effect on the salivary glands[58] and oral health.[57] In the past, controversy has surrounded this drug because of two potential problems: tumor protection and toxic side effects. Nevertheless, amifostine is increasingly being added to many chemoradiation (CRT) protocols to protect the salivary glands.[59] If so, these new types of RT may allow modification of current caries prevention recommendations. Further research is needed to investigate modification to current guidelines for these new treatment modalities.

e. Periodontal disease: RT effects on periodontal health include direct effects on the periodontium, and indirect effects associated with changes in the oral microflora caused by radiation-induced xerostomia. Two potential problems result: accelerated periodontal attachment loss and increased risk for osteoradionecrosis (ORN) associated with periodontal disease. RT causes changes in both bone and soft tissue that can produce hypovascular, hypocellular and hypoxic bone.[60-61] This reduces the capacity of the affected bone to remodel and, depending on the dose, may increase the risk of infection, which can lead to osteoradionecrosis, discussed in the next section.

A recent study showed increased tooth loss and greater periodontal attachment loss in teeth that were within high-dose irradiated sites (Figure 5).[62] Because attachment loss in teeth was greater in the irradiated fields, the authors recommend that dentists consider the impact of increased attachment loss on remaining teeth, when planning dental treatment before RT.

It is well-established that periodontal involvement of teeth in high-dose irradiated sites can produce osteoradionecrosis.[63-64] Extractions in irradiated bone may increase risk for ORN but pre-irradiation extraction of teeth carries a lower risk of ORN than extractions following RT.[64-66] Periodontal treatment, including periodontal surgery, is possible within irradiated sites. In a study conducted in 1994,[67] various periodontal surgeries were performed in compliant patients with good oral hygiene and a mean follow-up of 38 months. Although all patients showed isolated sites of increased pocket depth, only four patients showed sites where the pocket depth increased by more than 2 mm. The authors concluded that if few stigmata of RT are seen, such as induration of soft tissue, mucosal and skin telangiectasia, loss of facial hair, mucosal cutaneous atrophy, and xerostomia, the risk of osteonecrosis (ORN) might be reduced. Meticulous surgical technique should be employed with nonsurgical periodontal management. The authors further concluded that periodontal surgery could be performed in selected patients following RT, if all these conditions are met.[67]

Prevention of periodontal disease and attachment loss. Optimal oral hygiene must be maintained because of the lowered biological potential for healing of the periodontium after radiation therapy. The risk for developing ORN is reduced in patients who receive topical fluoride applications and maintain good oral hygiene because they are less likely to develop caries, periodontal disease and their sequelae.[53,68-69] These measures help to reduce the likelihood of rampant periodontal destruction that occurs in the absence of good oral hygiene, especially within high-dose irradiated sites.[63]

f. Osteoradionecrosis (ORN): ORN is caused by the hypoxic, hypocellular, hypovascular deterioration of bone that has been irradiated. Marx[60] has proposed that this results from the radiation-induced deficient cellular turnover and collagen synthesis in a hypoxic, hypovascular and hypocellular environment in which tissue breakdown exceeds the repair capabilities of the wounded tissue. Clinically, ORN may initially present as bone lysis under intact gingiva and mucosa (type I). This process is self-limiting because the damaged bone sequestrates, then is shed with subsequent healing. If the soft tissue breaks down, the bone becomes exposed to saliva and secondary contamination occurs. Sepsis may also be introduced by dental extraction or surgery, producing a more aggressive form (type II) (Figure 6). This progressive form may produce severe pain or fracture, and require extensive resection. The reported incidence of ORN varies widely depending on the institution, type of RT, and follow-up time. The reported incidence of ORN ranges from 0.92 percent of all head and neck cancer patients receiving RT to 2.59 percent of patients receiving post-irradiation extractions.[69-70]

Sulaiman and colleagues[69] reviewed the records of 1,194 patients followed in the Memorial Sloan Kettering Cancer Center (MSKCC) Dental Service during 1998-

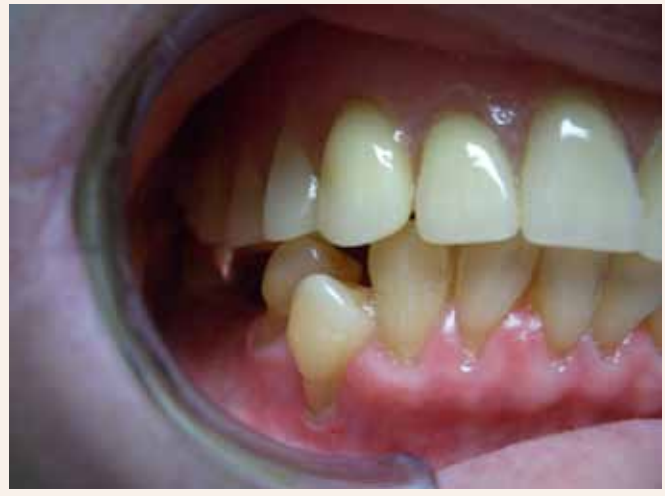

Figure 5 — Gingival recession on mandibular teeth in the field, more than two years post radiotherapy. Patient wears a complete upper denture.

2001. Mean time for follow-up was 22.09 months. Decisions to perform pre-irradiation dental extractions were based on several factors: radiation dose, modality of treatment, field of radiation, and tumor prognosis, as well as pre-existing periodontal condition of the tooth or teeth, severity of caries, pulpal involvement and status, presence of advanced or symptomatic periodontal disease, mobility with root furcation involvement, residual root tips not fully covered by alveolar bone or showing radiolucencies and symptomatic impacted or incompletely erupted teeth that were not fully covered by alveolar bone. Following formal empiric guidelines at MSKCC regarding dental extractions in patients receiving radiation therapy for head and neck cancer, almost 85 percent of patients did not require dental extractions to prevent ORN. Of the 77 patients who had extractions before radiation, the majority (41) had periodontal disease, usually in an acute or advanced state. Tooth mobility accounted for 37.66 percent of the patients who had extractions.[69]

Both the study of Sulaiman and colleagues[69] and a previous study by Beumer and colleagues[71] reported that selected tooth removal before radiation therapy reduced the risk of necrosis when the teeth had periodontal disease, particularly mandibular molars with furcation involvement. In the Beumer study, 2.14 percent (four patients) developed ORN. All four patients who developed ORN after extractions in irradiated bone originally had squamous cell carcinoma of the base of tongue (2), oral tongue (1) or floor of mouth (1). Two of these patients had a radiation dose greater than 70 Gy. All of the extractions were located in the posterior region of the mandible in the irradiated field.[71]

Figure 6 — Osteoradionecrosis in the right posterior mandible, five years post-radiotherapy and after hyperbaric oxygen therapy. This female patient received chemoradiotherapy for squamous cell carcinoma of the right tongue base, and within a few months developed permanent xerostomia and rampant dental caries. Reportedly, daily fluoride and preventive dental treatment had not been implemented. Pain and infection ensued and led to extraction of molars on this side. This asymptomatic lesion consisting of exposed bone was unchanged since her previous recall, six months prior.

In the Sulaiman study[69] extractions were done at least two weeks before RT whenever possible. Their protocol for dentate patients undergoing RT or with a history of RT included a neutral fluoride regimen — usually neutral NaF 1.1 percent in a 5,000-ppm dentifrice toothpaste. For patients with extensive dental restorations, fluoride trays were also fabricated. Because 84.34 percent of their patients did not require extractions after RT, the investigators concluded that the fluoride regimen was efficacious. In addition, follow-up in the immediate post-radiation period was mandatory, with average follow-up time of 22 months post-extraction, with a range of 0-149 months. Most of the patients who had extractions did not experience post-operative complications.[69]

A recent retrospective study showed a further reduced incidence of ORN following IMRT for head and neck cancer. This reduced incidence was attributed to parotid sparing and better dental treatment, which reduced the number of dental extractions and surgical procedures required post-radiotherapy.[36]

Prevention of ORN. ORN may be prevented by extracting these teeth at least two weeks before RT: periodontally involved teeth; unerupted teeth with communication with the oral cavity; third molars with evidence of pathology such as cysts or pericoronitis; and pulpally involved or nonrestorable teeth. Prevention of dental caries and periodontal disease and their sequelae can prevent ORN in most cases. If teeth must be extracted after RT, care should be given to use atraumatic technique, smooth sharp edges of bone, and avoid reflection of the periosteum, if possible. The risk of dental extraction-related ORN does not appear to decrease over time after RT.

g. Trismus. Trismus can be a significant side effect of RT, especially if the lateral pterygoid muscles are in the field. In patients in whom the pterygoid muscles were irradiated, and not the temporomandibular joint (TMJ), 31 percent experienced trismus. In addition, radiation to the TMJ also was associated with a decrease in maximum vertical opening.[72-73] Limited mouth opening can interfere with proper oral hygiene and dental treatment. Therefore, before RT starts, patients who are at risk for developing trismus should receive instruction in jaw exercises that will help them maintain maximum mouth opening and jaw mobility. Tongue blades can be used to gradually increase the mandibular opening. Dynamic bite opening appliances have also been used.[74-75]

The dentist should measure the patient's maximum mouth opening and lateral movements before RT, and re-evaluate mandibular opening and function at follow-up dental visits. For patients who experience reduced mouth opening, the intensity and frequency of the exercises should increase, and a physical therapy regimen prescribed.

Pre-RT Dental Assessment and Treatment

Patients scheduled to undergo RT should receive a

comprehensive dental assessment before therapy begins. The assessment should be conducted soon after diagnosis to allow adequate time for wound healing if teeth need to be extracted. The dentist must understand the basis for RT, the radiation treatment planned (dose, schedule and fields), and the oral/dental/periodontal status of the patient in order to make appropriate treatment decisions. Therefore, a consultation with the radiation oncologist and the medical oncologist, if the patient is undergoing chemotherapy, is recommended.

Goals of Dental Management

The dentist caring for a head and neck cancer patient should have clearly defined goals of dental management during the three phases of treatment:

1. Pretreatment goals
   a. eliminate potential sources of infection;
   b. counsel patient about short- and long-term complications of cancer therapy;
   c. provide preventive care.

2. Goals during cancer therapy
   a. provide supportive care for oral mucositis;
   b. provide treatment of oral candidiasis;
   c. manage xerostomia;
   d. prevent trismus.

3. Long-term, post-treatment goals
   a. manage xerostomia;
   b. prevent and minimize trismus;
   c. prevent and treat dental caries;
   d. prevent postradiation osteonecrosis (ORN);
   e. detect tumor recurrence.

Pre-RT dental treatment planning is imperative to address:

1. the limited time to provide dental treatment to the patient, especially if the prognosis for survival is poor;

2. the risk of ORN in irradiated bone with dental extractions or untreated infection;

3. the increased risk of dental caries in the patient whose radiation field includes major salivary glands.

Ideally, treatment planning for all patients should include disease control and prevention phases of care. Prosthetic rehabilitation usually is provided several months after RT. Disease control includes caries removal and restorations, scaling and prophylaxis, establishing good oral hygiene, removing overhanging restorations, and replacing defective restorations, especially if irritating the soft tissues. If deep scaling is needed (pocket depths less than 6 mm) the dentist should allow 14 days healing time before therapy if possible. Ill-fitting dentures should be repaired or replaced. The placement of soft liners should be avoided because they can be a nidus for candidiasis[76] and the surfaces tend to be irregular and irritating.

If teeth are to be retained, the dentist should provide the patient with daily fluoride therapy, either as 1.1 percent NaF gel in custom dental trays or as 1.1 percent NaF toothpaste to be used once daily before, during and after RT, for the rest of the patient's life. Regular dental recalls are essential to maintain compliance with preventive strategies[53,77] and detect disease at an early stage.

The dentist should encourage the patient to adopt a non-cariogenic diet. Tooth extraction should be performed 14 days before radiation or chemotherapy starts. After RT, allow at least three months of healing time to elapse before providing prostheses in edentulous patients. There appears to be little evidence to support a longer delay to definitive prosthetic care.[78] During pre-RT extractions, the dentist should aggressively remove sharp pieces of bone to avoid alveoloplasty later. If the lateral pterygoid muscles are within the field of radiation and trismus poses a risk, the patient should receive instruction on mandibular range of motion exercises. After RT, the exercises should be reassessed and, if necessary, modified. Caries prevention plans may also include the prescription of pilocarpine or cevemeline to stimulate salivary flow,[22,79] chewing sugarless gum containing xylitol, and rinsing with artificial saliva containing calcium and phosphate to encourage remineralization.[80]

Decisions to extract teeth. Formalized dental treatment planning models have been proposed in which decisions are based on both dental and cancer therapy conditions.[81-82] The primary decision is when teeth should be extracted before therapy. In Schiodt's model,[82] dental conditions associated with high risk dental risk factors (DRF) include:

- teeth with primary and secondary deep caries;
- root caries > ½ the root circumference;
- pulpal disease and periapical disease (nonvital pulps and no previous RCT), periapical osteitis > 3 mm;
- internal/external root resorption;
- probing depth or gingival recession > 6 mm.

Other high risk factors include furcation involvement, mobility > 2 mm, partially impacted teeth and residual root tips, fully impacted teeth with "pericoronal pathoses," poor oral hygiene and low dental awareness or lack of cooperation.

This model also considers malignancy risk factors (MRF). High malignancy risk factors include radiation dose > 55 Gy, a radiation field that includes molars, teeth that are near the tumor, and if radiotherapy begins in fewer than 14 days. This decision-making model suggests that teeth considered as high MRF and high DRF should be removed.[82] However, extraction decisions also should consider the strategic importance of the teeth, the overall impression of the patient, and the risk associated with extraction (clinical judgment).[81]

Zlotolow[76] also proposed that the dentist consider the following factors when determining whether or not to extract teeth:

- an optimal recovery time after teeth extraction is 14 to 21 days;
- bone remodeling may occur after RT;
- the risk of ORN is greater in the mandible;

- primary wound closure and alveolectomy may be needed to decrease healing time;
- nonvital asymptomatic teeth in the field can be endodontically treated.

In summary, the decision to extract teeth before RT should consider:

- teeth that are in a high-dose radiation field. Such teeth are non-restorable or may require significant restorative, periodontal, endodontic, or orthodontic intervention.
- patients with moderate to severe periodontal disease (pocket depths > 5-6 mm) or with advanced recession.

The dentist may develop a more aggressive dental treatment plan for the patient with low dental awareness, lack of motivation or cooperation, a poor history of regular dental care treatment, poor oral hygiene, and evidence of past dental/periodontal disease. The dentist also should consider factors such as position of teeth, relative importance of such teeth for function, oral hygiene, potential impact of trismus and limited mouth opening on oral hygiene and dental treatment, taurodontism, and root anatomy.

See Table 2 for the Pre-Radiation Therapy Protocol from the University of Michigan Department of Oral and Maxillofacial Surgery and Hospital Dentistry. This and other information can also be accessed at http://sitemaker.umich.edu/dent.onc. At our institution all patients planned to receive head and neck RT are referred for dental evaluation and treatment, and cleared from a dental standpoint before RT begins. Although the majority of patients are seen in the Hospital Dentistry Department prior to RT, in order to expedite treatment, most patients return to their private dentist in the community for long-term dental maintenance. In cancer treatment centers and hospitals without a dentistry department, which is most common, this pre-RT dental care is provided by private practice dentists in the community.

Although not widely published in the literature, and thus not cited in the aforementioned guidelines, at the University of Michigan and other medical centers in the U.S. standard supportive care for dentate patients undergoing head and neck RT with metal restorations included the fabrication of mucosal guards. These guards are made of putty silicone impression material with the patient in occlusion, and cover the teeth to prevent radiation backscatter off metallic restorations to oral mucosa which would normally be in direct contact with these fillings and crowns (Figure 2). The patient wears these guards during simulation and subsequent radiation treatments. In our experience this strategy appears to reduce the severity of mucositis in regions of mucosa which are normally in contact with these restorations. More formal investigation of the efficacy of these mucosal guards to reduce mucositis associated with RT is clearly indicated.[35-36]

Conclusions

Dental treatment decisions require an understanding of the staging of the patient's cancer and prognosis for survival, the types of therapy planned, timing of therapy, patient's motivation and ability to cooperate, and anticipated oral complications of treatment.

In general, the dental care provider can help prepare the patient prior to therapy by treating any active or potential dental infection, providing patient education, and supportive care during treatment. The dental treatment and oral management of patients with head and neck cancer should include an oral evaluation including periodontal examination before the patient begins cancer treatment. This evaluation will help to prevent or mitigate oral complications associated with radiation and chemotherapy, and systemic sequelae of oral infection.

Many of the oral complications of cancer therapy, such as mucositis, oral candidiasis, and osteoradionecrosis, are managed by the oncology team. Radiation-induced xerostomia and dental disease is the responsibility of the dental team. The general dentist or specialist in private practice who is asked to provide dental care for the head and neck cancer patient must be familiar with the most current recommendations for care and understand the scientific rationale. Dentists should be prepared to consult with the oncology team in order to provide the most appropriate care for the cancer patient before treatment, and for the rest of the patient's life. ✧

References

1. Jemal A, Siegel R, Xu J, Ward E. Cancer statistics, 2010. CA Cancer J Clin 2010;60:277-300.

2. Jemal A, Siegel R, Ward E, Murray T, Xu J, Thun MJ. Cancer statistics, 2007. CA Cancer J Clin 2007;57:43-66.

3. Brandwein-Gensler M, Smith RV. Prognostic indicators in head and neck oncology including the new 7th edition of the AJCC staging system. Head Neck Pathol 2010;4:53-61.

4. Dreizen S. Oral complications of cancer therapies. Description and incidence of oral complications. NCI Monogr 1990:11-5.

5. Cooper JS, Fu K, Marks J, Silverman S. Late effects of radiation therapy in the head and neck region. Int J Radiat Oncol Biol Phys 1995;31:1141-64.

6. Barker GJ, Epstein JB, Williams KB, Gorsky M, Raber-Durlacher JE. Current practice and knowledge of oral care for cancer patients: a survey of supportive health care providers. Support Care Cancer 2005;13:32-41.

7. Epstein JB, Parker IR, Epstein MS, Gupta A, Kutis S, Witkowski DM. A survey of National Cancer Institute-designated comprehensive cancer centers' oral health supportive care practices and resources in the USA. Support Care Cancer 2007;15:357-62.

8. Epstein JB, Parker IR, Epstein MS, Stevenson-Moore P. Cancer-related oral health care services and resources: a survey of oral and dental care in Canadian cancer centres. J Can Dent Assoc 2004;70:302-4.

9. Wijers OB, Levendag PC, Braaksma MM, Boonzaaijer M, Visch LL, Schmitz PI. Patients with head and neck cancer cured by radiation therapy: a survey of the dry mouth syndrome in long-term survivors. Head Neck 2002;24:737-47.

10. Moller P, Perrier M, Ozsahin M, Monnier P. A prospective study of salivary gland function in patients undergoing radiotherapy for squamous cell carcinoma of the oropharynx. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:173-89.

11. Grundmann O, Mitchell GC, Limesand KH. Sensitivity of salivary glands to radiation: from animal models to therapies. J Dent Res 2009;88:894-903.

12. Eisbruch A, Ten Haken RK, Kim HM, Marsh LH, Ship JA. Dose, volume, and function relationships in parotid salivary glands following conformal and intensity-modulated irradiation of head and neck cancer. Int J Radiat Oncol Biol Phys

1999;45:577-87.

13. Malouf JG, Aragon C, Henson BS, Eisbruch A, Ship JA. Influence of parotid-sparing radiotherapy on xerostomia in head and neck cancer patients. Cancer Detect Prev 2003;27:305-10.

14. Henson BS, Eisbruch A, D'Hondt E, Ship JA. Two-year longitudinal study of parotid salivary flow rates in head and neck cancer patients receiving unilateral neck parotid-sparing radiotherapy treatment. Oral Oncol 1999;35:234-41.

15. Henson BS, Inglehart MR, Eisbruch A, Ship JA. Preserved salivary output and xerostomia-related quality of life in head and neck cancer patients receiving parotid-sparing radiotherapy. Oral Oncol 2001;37:84-93.

16. Mell LK, Mehrotra AK, Mundt AJ. Intensity-modulated radiation therapy use in the U.S., 2004. Cancer 2005;104:1296-303.

17. Murdoch-Kinch CA, Kim HM, Vineberg KA, Ship JA, Eisbruch A. Dose-effect relationships for the submandibular salivary glands and implications for their sparing

Table 2 — Pre-Radiation Therapy Oral Evaluation Protocol, University of Michigan Hospital Dentistry

1. Patient education, both oral and written
   a. Effect on salivary glands
      i. Dry mouth strategies
         1. Increased hydration
         2. Salivary substitutes
         3. Salivary stimulation – sugarless chewing gum, pilocarpine, cevimeline
      ii. Caries prevention
         1. Diet counseling
         2. Daily fluoride use
         3. Regular frequent dental check-ups
   b. Effect on bone in irradiated field
      i. Need for pre-RT dental evaluation
         1. Consult usually requested by radiation oncology
      ii. Need for UMHS contact prior to future extraction or surgery in the irradiated field.
   c. Potential for trismus
      i. Maintain range of motion
         1. Tongue blades
         2. Therabite™
         3. Dynabite™

2. Patient evaluation and treatment plan
   a. Consult should provide adequate information about planned field. If not, contact radiation oncologist.
      i. All head and neck cancer patients at University of Michigan now undergo parotid-sparing IMRT
   b. Determine the need for extraction based on periodontal and dental condition, oral hygiene, history of regular dental visits, etc.
   c. If time permits and patient wishes, perform extractions at the time; or schedule for future day.
   d. Inform radiation oncologist of time required for healing before starting RT.
   e. Oral hygiene instructions, other treatment to be scheduled.

3. If indicated in consult, fabricate silicone tooth guards to minimize radiation backscatter. Consult should indicate if guards should be fabricated in a position with teeth open or closed. If time is available to trim and smooth the guards, deliver at this time. If not enough time is available, reschedule the patient.

4. If xerostomia is anticipated, consider fluoride use using toothbrush application or carriers. If there are multiple missing teeth, the toothbrush technique is preferred. Alginate impressions are made if carriers are to be made. Schedule patient to return for delivery of these. At this time prescription can be provided for fluoride.
   a. Sodium fluoride dentifrice or gel, OR
   b. Stannous fluoride gel

5. Schedule the patient to return in approximately seven weeks, during the last week of radiation therapy. If the date is not known, advise the patient to schedule this appointment. During this appointment, reinforce the information provided earlier about caries prevention. Determine where the patient will be getting his routine dental care, either with the local dentist or in our clinic.

6. If care is to be provided in private practice, we continue to be a resource regarding dental treatment and information for the patient and his dentist.

by intensity modulated radiotherapy. Int J Radiat Oncol Biol Phys 2008;72:373-82.

18. Jabbari S, Kim HM, Feng M, et al. Matched case-control study of quality of life and xerostomia after intensity-modulated radiotherapy or standard radiotherapy for head-and-neck cancer: initial report. Int J Radiat Oncol Biol Phys 2005;63:725-31.

19. Chao KS, Majhail N, Huang CJ, et al. Intensity-modulated radiation therapy reduces late salivary toxicity without compromising tumor control in patients with oropharyngeal carcinoma: a comparison with conventional techniques. Radiother Oncol 2001;61:275-80.

20. Chao KS. Protection of salivary function by intensity-modulated radiation therapy in patients with head and neck cancer. Semin Radiat Oncol 2002;12:20-5.

21. Johnson JT, Ferretti GA, Nethery WJ, et al. Oral pilocarpine for post-irradiation xerostomia in patients with head and neck cancer. N Engl J Med 1993;329:390-5.

22. Gorsky M, Epstein JB, Parry J, Epstein MS, Le ND, Silverman S, Jr. The efficacy of pilocarpine and bethanechol upon saliva production in cancer patients with hyposalivation following radiation therapy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;97:190-5.

23. Axelsson P, Larsson UB. ⟨Saliva stimulating effect of SST. A clinical long-term study⟩. Tandlakartidningen 1991;83:698-9.

24. Epstein JB, Schubert MM. Synergistic effect of sialagogues in management of xerostomia after radiation therapy. Oral Surg Oral Med Oral Pathol 1987;64:179-82.

25. Epstein JB, Emerton S, Le ND, Stevenson-Moore P. A double-blind crossover trial of Oral Balance gel and Biotene toothpaste versus placebo in patients with xerostomia following radiation therapy. Oral Oncol 1999;35:132-7.

26. Momm F, Volegova-Neher NJ, Schulte-Monting J, Guttenberger R. Different saliva substitutes for treatment of xerostomia following radiotherapy. A prospective crossover study. Strahlenther Onkol 2005;181:231-6.

27. Rhodus NL, Bereuter J. Clinical evaluation of a commercially available oral moisturizer in relieving signs and symptoms of xerostomia in postirradiation head and neck cancer patients and patients with Sjogren's syndrome. J Otolaryngol 2000;29:28-34.

About the Authors

Carol Anne Murdoch-Kinch, D.D.S., Ph.D., is an associate professor of dentistry and associate dean for academic affairs at the University of Michigan School of Dentistry. She received her D.D.S. degree in 1985 from Dalhousie University, completed a residency in oral medicine and radiology, and completed a Ph.D. from Indiana University in 1996. She practices oral medicine and conducts multi-disciplinary clinical research in oral oncology and salivary dysfunction in the Department of Hospital Dentistry. She currently serves as a director of the American Board of Oral Medicine.

Murdoch-Kinch

Samuel Zwetchkenbaum, D.D.S., M.P.H., received his D.D.S. degree from the University of North Carolina and completed a general practice residency at Hennepin County Medical Center in Minneapolis. He completed training programs in prosthodontics and then maxillofacial prosthodontics at M.D. Anderson Cancer Center in Houston, Texas. He received an M.P.H. in health management and policy from the University of Michigan School of Public Health in 2006. Sam is the program director of University of Michigan's general practice residency and section chief of hospital dentistry.

Zwetchkenbaum

28. Rubenstein EB, Peterson DE, Schubert M, et al. Clinical practice guidelines for the prevention and treatment of cancer therapy-induced oral and gastrointestinal mucositis. Cancer 2004;100:2026-46.

29. Sonis ST. Mucositis: The impact, biology and therapeutic opportunities of oral mucositis. Oral Oncol 2009;45:1015-20.

30. Elting LS, Cooksley CD, Chambers MS, Garden AS. Risk, outcomes, and costs of radiation-induced oral mucositis among patients with head-and-neck malignancies. Int J Radiat Oncol Biol Phys 2007;68:1110-20.

31. Elting LS, Keefe DM, Sonis ST, et al. Patient-reported measurements of oral mucositis in head and neck cancer patients treated with radiotherapy with or without chemotherapy: demonstration of increased frequency, severity, resistance to palliation, and impact on quality of life. Cancer 2008;113:2704-13.

32. Scully C, Sonis S, Diz PD. Oral mucositis. Oral Dis 2006;12:229-41.

33. Sonis ST. Oral mucositis in cancer therapy. J Support Oncol 2004;2:3-8.

34. Kaanders JH, Fleming TJ, Ang KK, Maor MH, Peters LJ. Devices valuable in head and neck radiotherapy. Int J Radiat Oncol Biol Phys 1992;23:639-45.

35. Reitemeier B, Reitemeier G, Schmidt A, et al. Evaluation of a device for attenuation of electron release from dental restorations in a therapeutic radiation field. J Prosthet Dent 2002;87:323-7.

36. Ben-David MA, Diamante M, Radawski JD, et al. Lack of osteoradionecrosis of the mandible after intensity-modulated radiotherapy for head and neck cancer: likely contributions of both dental care and improved dose distributions. Int J Radiat Oncol Biol Phys 2007;68:396-402.

37. Redding SW, Zellars RC, Kirkpatrick WR, et al. Epidemiology of oropharyngeal candida colonization and infection in patients receiving radiation for head and neck cancer. J Clin Microbiol 1999;37:3896-900.

38. Vazquez JA, Sobel JD. Mucosal candidiasis. Infect Dis Clin North Am 2002;16:793-820.

39. Groll AH, Piscitelli SC, Walsh TJ. Clinical pharmacology of systemic antifungal agents: a comprehensive review of agents in clinical use, current investigational compounds, and putative targets for antifungal drug development. Adv Pharmacol 1998;44:343-500.

40. Clarkson JE, Worthington HV, Eden OB. Interventions for treating oral candidiasis for patients with cancer receiving treatment. Cochrane Database Syst Rev 2004:CD001972.

41. Worthington HV, Clarkson JE, Eden OB. Interventions for treating oral candidiasis for patients with cancer receiving treatment. Cochrane Database Syst Rev 2007:CD001972.

42. Brown LR, Dreizen S, Daly TE, et al. Interrelations of oral microorganisms, immunoglobulins, and dental caries following radiotherapy. J Dent Res 1978;57:882-93.

43. Keene HJ, Fleming TJ. Prevalence of caries-associated microflora after radiotherapy in patients with cancer of the head and neck. Oral Surg Oral Med Oral Pathol 1987;64:421-6.

44. Llory H, Dammron A, Gioanni M, Frank RM. Some population changes in oral anaerobic microorganisms, Streptococcus mutans and yeasts following irradiation of the salivry glands. Caries Res 1972;6:298-311.

45. Regezi JA, Courtney RM, Kerr DA. Dental management of patients irradiated for oral cancer. Cancer 1976;38:994-1000.

46. Daly TE, Drane JB. Proceedings: The management of teeth related to the treatment of oral cancer. Proc Natl Cancer Conf 1972;7:147-54.

47. Epstein JB, McBride BC, Stevenson-Moore P, Merilees H, Spinelli J. The efficacy of chlorhexidine gel in reduction of streptococcus mutans and lactobacillus species in patients treated with radiation therapy. Oral Surg Oral Med Oral Pathol 1991;71:172-8.

48. Joyston-Bechal S, Hayes K, Davenport ES, Hardie JM. Caries incidence, mutans streptococci and lactobacilli in irradiated patients during a 12-month preventive programme using chlorhexidine and fluoride. Caries Res 1992;26:384-90.

49. Vissink A, Burlage FR, Spijkervet FK, Jansma J, Coppes RP. Prevention and treatment of the consequences of head and neck radiotherapy. Crit Rev Oral Biol Med 2003;14:213-25.

50. Jansma J, Vissink A, Gravenmade EJ, Visch LL, Fidler V, Retief DH. In vivo study on the prevention of postradiation caries. Caries Res 1989;23:172-8.

51. Fleming TJ. Use of topical fluoride by patients receiving cancer therapy. Curr Probl Cancer 1983;7:37-41.

52. Al-Joburi W, Clark C, Fisher R. A comparison of the effectiveness of two systems for the prevention of radiation caries. Clin Prev Dent 1991;13:15-9.

53. Epstein JB, van der Meij EH, Lunn R, Stevenson-Moore P. Effects of compliance with fluoride gel application on caries and caries risk in patients after radiation

therapy for head and neck cancer. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1996;82:268-75.

54. Dreizen S, Brown LR, Daly TE, Drane JB. Prevention of xerostomia-related dental caries in irradiated cancer patients. J Dent Res 1977;56:99-104.

55. Horiot JC, Bone MC, Ibrahim E, Castro JR. Systematic dental management in head and neck irradiation. Int J Radiat Oncol Biol Phys 1981;7:1025-9.

56. Horiot JC, Schraub S, Bone MC, et al. Dental preservation in patients irradiated for head and neck tumours: A 10-year experience with topical fluoride and a randomized trial between two fluoridation methods. Radiother Oncol 1983;1:77-82.

57. Rudat V, Meyer J, Momm F, et al. Protective effect of amifostine on dental health after radiotherapy of the head and neck. Int J Radiat Oncol Biol Phys 2000;48:1339-43.

58. Brizel DM, Wasserman TH, Henke M, et al. Phase III randomized trial of amifostine as a radioprotector in head and neck cancer. J Clin Oncol 2000;18:3339-45.

59. Brizel DM, Overgaard J. Does amifostine have a role in chemoradiation treatment? Lancet Oncol 2003;4:378-81.

60. Marx RE. Osteoradionecrosis: a new concept of its pathophysiology. J Oral Maxillofac Surg 1983;41:283-8.

61. Marx RE, Johnson RP. Studies in the radiobiology of osteoradionecrosis and their clinical significance. Oral Surg Oral Med Oral Pathol 1987;64:379-90.

62. Epstein JB, Lunn R, Le N, Stevenson-Moore P. Periodontal attachment loss in patients after head and neck radiation therapy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998;86:673-7.

63. Galler C, Epstein JB, Guze KA, Buckles D, Stevenson-Moore P. The development of osteoradionecrosis from sites of periodontal disease activity: report of 3 cases. J Periodontol 1992;63:310-6.

64. Epstein JB, Rea G, Wong FL, Spinelli J, Stevenson-Moore P. Osteonecrosis: study of the relationship of dental extractions in patients receiving radiotherapy. Head Neck Surg 1987;10:48-54.

65. Chang DT, Sandow PR, Morris CG, et al. Do pre-irradiation dental extractions reduce the risk of osteoradionecrosis of the mandible? Head Neck 2007;29:528-36.

66. Lee IJ, Koom WS, Lee CG, et al. Risk factors and dose-effect relationship for mandibular osteoradionecrosis in oral and oropharyngeal cancer patients. Int J Radiat Oncol Biol Phys 2009;75:1084-91.

67. Epstein JB, Corbett T, Galler C, Stevenson-Moore P. Surgical periodontal treatment in the radiotherapy-treated head and neck cancer patient. Spec Care Dentist 1994;14:182-7.

68. Epstein JB, Stevenson-Moore P. Periodontal disease and periodontal management in patients with cancer. Oral Oncol 2001;37:613-9.

69. Sulaiman F, Huryn JM, Zlotolow IM. Dental extractions in the irradiated head and neck patient: a retrospective analysis of Memorial Sloan-Kettering Cancer Center protocols, criteria, and end results. J Oral Maxillofac Surg 2003;61:1123-31.

70. Morrish RB, Jr., Chan E, Silverman S, Jr., Meyer J, Fu KK, Greenspan D. Osteonecrosis in patients irradiated for head and neck carcinoma. Cancer 1981;47:1980-3.

71. Beumer J, 3rd, Harrison R, Sanders B, Kurrasch M. Postradiation dental extractions: a review of the literature and a report of 72 episodes. Head Neck Surg 1983;6:581-6.

72. Teguh DN, Levendag PC, Voet P, et al. Trismus in patients with oropharyngeal cancer: relationship with dose in structures of mastication apparatus. Head Neck 2008;30:622-30.

73. Bensadoun RJ, Riesenbeck D, Lockhart PB, Elting LS, Spijkervet FK, Brennan MT. A systematic review of trismus induced by cancer therapies in head and neck cancer patients. Support Care Cancer 2010;18:1033-8.

74. Brunello DL, Mandikos MN. The use of a dynamic opening device in the treatment of radiation induced trismus. Aust Prosthodont J 1995;9:45-8.

75. Shulman DH, Shipman B, Willis FB. Treating trismus with dynamic splinting: a case report. J Oral Sci 2009;51:141-4.

76. Zlotolow IM. Dental Oncology and Maxillofacial Prosthetics. Philadelphia: Lippincott Raven; 1999.

77. Epstein JB, van der Meij EH, Emerton SM, Le ND, Stevenson-Moore P. Compliance with fluoride gel use in irradiated patients. Spec Care Dentist 1995;15:218-22.

78. Gerngross PJ, Martin CD, Ball JD, et al. Period between completion of radiation therapy and prosthetic rehabilitation in edentulous patients: a retrospective study. J Prosthodont 2005;14:110-21.

79. Gornitsky M, Shenouda G, Sultanem K, et al. Double-blind randomized, placebo-controlled study of pilocarpine to salvage salivary gland function during radiotherapy of patients with head and neck cancer. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98:45-52.

80. Singh ML, Papas AS. Long-term clinical observation of dental caries in salivary hypofunction patients using a supersaturated calcium-phosphate remineralizing rinse. J Clin Dent 2009;20:87-92.

81. Bruins HH, Jolly DE, Koole R. Preradiation dental extraction decisions in patients with head and neck cancer. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;88:406-12.

82. Schiodt M, Hermund NU. Management of oral disease prior to radiation therapy. Support Care Cancer 2002;10:40-3.

83. Berean K, Epstein JB. Correspondence re: Brandwein M, Nuovo G, Ramer M, Orlowski W, Miller L: Epstein-Barr virus reactivation in hairy leukoplakia. Mod Pathol 9:298, 1996. Mod Pathol 1996;9:869-70.

Click here to take the online quiz!