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Article *in* Cancer · October 1992

DOI: 10.1002/1097-0142(19921015)70:8<2171::AID-CNCR2820700827>3.0.CO;2-S

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Protocol for the Prevention and Treatment of Oral Sequelae Resulting from Head and Neck Radiation Therapy

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In addition to the desired antitumor effects, head and neck radiation therapy induces damage in normal tissues that may result in oral sequelae such as mucositis, hyposalivation, radiation caries, taste loss, trismus, soft-tissue necrosis, and osteoradionecrosis. These sequelae may be dose-limiting and have a tremendous effect on the patient's quality of life. Current policies to prevent these sequelae primarily are based on clinical experience and show great diversity. A protocol for the prevention and treatment of oral sequelae resulting from head and neck radiation therapy, based on fundamental research and data derived from the literature, is presented. The protocol is particularly applicable in centers with a dental team. This team should be involved at the time of initial diagnosis so that a successful preventive regimen is an integral part of the overall cancer treatment regimen. *Cancer* **1992; 70:2171–2180.**

Key words: radiation therapy, side effect, prevention, treatment, hyposalivation, mucositis, xerostomia.

Radiation therapy plays an important role in the care of patients with head and neck cancer.[1] Because of the location of the primary tumor or the lymph node metastases, the salivary glands, oral cavity, and jaws often are included in the treatment portals.[2] As a result, changes induced by exposure to radiation occur in these tissues; these changes can lead to mucositis, hyposalivation, radiation caries, taste loss, trismus, soft-tissue necrosis and osteoradionecrosis (ORN).[3,4] These oral sequelae may cause substantial problems during and after radiation therapy and are major factors in determining the patient's quality of life. Acute exacerbation of focal infection, e.g., periapical and periodontal infection, and severe mucositis occasionally may necessitate an adjustment or an interruption of the radiation treatment schedule. For these reasons, oral complications should be prevented or reduced to a minimum.[5]

Most prevention procedures described in the literature are based on clinical experience. The result is a great diversity in treatment policies[6–9] and in the preventive approach in daily practice.[10] Many publications in this field deal only with one sequela. Overall protocols are rare or are extremely concise. In this report, a new overall protocol for the prevention and treatment of oral sequelae resulting from head and neck radiation therapy is proposed. The scientific basis of this protocol is formed by the hyposalivation studies of Vissink,[11] the mucositis studies of Spijkervet,[12] and the radiation caries studies of Jansma,[13] supplemented with data derived from the literature. The protocol is especially applicable in centers operating with a dental team (ideally consisting of an oral and maxillofacial surgeon, a hospital dentist, and an oral hygienist) that is devoted to the wide range of preventive and treatment measures.

Prevention and Treatment

The protocol can be divided into three phases of patient care, namely before radiation exposure (Table 1), during radiation exposure (Table 2), and after radiation exposure (Table 3). The primary issues of patient care before radiation exposure are screening, consequential treatment, explication, patient motivation, and initiation of preventive measures. Management during radia-

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The authors thank Dr. H. J. Guchelaar, Department of Pharmacy, University Hospital Groningen, for providing the composition of the sodium fluoride gel.

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Accepted for publication January 7, 1992.

Table 1. Care of Patient Before Radiation Therapy

Physical and radiographic examination
Dentition (caries, restorations, calculus, vitality)
Periodontium (bleeding index, pocket depth, furcation involvement)
Oral hygiene (plaque, bleeding index, denture hygiene)
Dental awareness and motivation
Oral mucosa and alveolar process (infection, irritation fibroma, hyperplasia, exostosis)
Dentures (fit of partial or full dentures)
Mouth opening (on indication)
Radiographic examination
Panoramic radiograph (intraoral radiographs when indicated)
Detection of foci (periapical infections, periodontal disease, unerupted or partially erupted teeth, residual root tips, cysts)
Treatment and prophylaxis
Extraction of nonsalvageable teeth and surgical removal of foci (alveolotomy, primary wound closure, 3 weeks of wound healing)
Dental prophylaxis (polishing, scaling, root planing, curettage)
Restorative dental procedures (restorations, endodontics)
Dentures (correction of ill-fitting dentures, no soft lining)
Initiation of preventive regimen
Plaque removal (tooth brushing, interdental plaque removal)
Topical fluoride (application of neutral 1% sodium fluoride gel every second day, custom-made fluoride carriers)
Oral rinses (salt–soda rinses at least 8–10 times daily)
Selective oral flora elimination (lozenges containing polymyxin E, tobramycin, and amphotericin B four times daily)
Denture wearing discouraged after the start of radiation therapy
Trismus prevention (exercises from the start of radiation therapy, when indicated)
Nutritional advises (instructions, counseling; ideally by a dietitian)

tion therapy is characterized by prevention and treatment of acute complications induced by radiation exposure and comprehensive counseling. After radiation therapy, the prevention and treatment of chronic and late complications in conjunction with close follow-up are the main issues of patient care. The protocol is schematically depicted in Figure 1.

Table 2. Care of Patient During Radiation Treatment

Standard oral hygiene and preventive care
Plaque removal (tooth brushing, interdental plaque removal)
Topical fluoride (1% sodium fluoride gel application every second day)
Oral rinses (salt–soda rinses at least 8–10 times daily)
Selective oral flora elimination (lozenges containing polymyxin E, tobramycin, and amphotericin B four times daily)
Discouraging denture wearing
Nutritional counseling (monitoring body weight, instructions, artificial feeding)
Visits with dental team at least once a week
Additional measures (on indication)
Professional daily spraying with saline (mucositis, insufficient oral rinsing)
0.1% chlorhexidine rinses (plaque removal)
Sucralfate suspensions or viscous lidocaine (pain relief)
Saliva substitutes (relief of oral dryness)
Trismus prevention (exercises, measuring mouth opening)

Table 3. Care of Patient After Radiation Therapy

Follow-up
Frequent dental checkups, preferably coordinated with oncology recall
Examination, prevention, and treatment
Oral mucosa
Treatment of mucositis or recall mucositis (salt–soda rinses, lozenges containing polymyxin E, tobramycin, and amphotericin B)
Waiting period of 3 months before (re)placement of dentures
Careful examination of oral mucosa and denture hygiene
Oral dryness
Clinical assessment of salivary secretion (inspection, stimulation)
Relief of oral dryness (gustatory and tactile sialogogues, oral rinses, saliva substitutes, mucin-containing lozenges)
Dentition and periodontium
Evaluation and reinforcement of oral hygiene regimen
1% sodium fluoride gel application every second day lifelong; reduction guided by salivary function and oral hygiene
Physical and radiographic examination (caries, calculus, vitality, pocket depth)
Restorative and prophylactic dental procedures as needed
Extractions and other surgical procedures after radiation therapy under high-dose antibiotic coverage; prophylactic hyperbaric oxygen treatment on indication
Trismus prevention
Exercise program until 3–6 months after radiation therapy
Physiotherapy (on indication)
Nutritional counseling
Noncariogenic, nonirritating diet
Adjustments for hyposalivation and taste disturbances

Care of Patients before Radiation Therapy

All dentulous and edentulous patients of whom parts of the jaws, the major salivary glands, or the oral cavity will be located in the field of radiation should receive a comprehensive dental evaluation before radiation therapy (Table 1). The objectives of the evaluation are:

identification of risk factors for the development of oral complications, in particular those that may interfere with the radiation treatment, such as exacerbation of periapical and periodontal infections;
performance of necessary treatment and prophylaxis to reduce the likelihood of oral complications during and after radiation therapy;
initiation of a comprehensive preventive care program.

To maximize the effect of this screening, adequate time for dental treatment, fabrication of fluoride car-

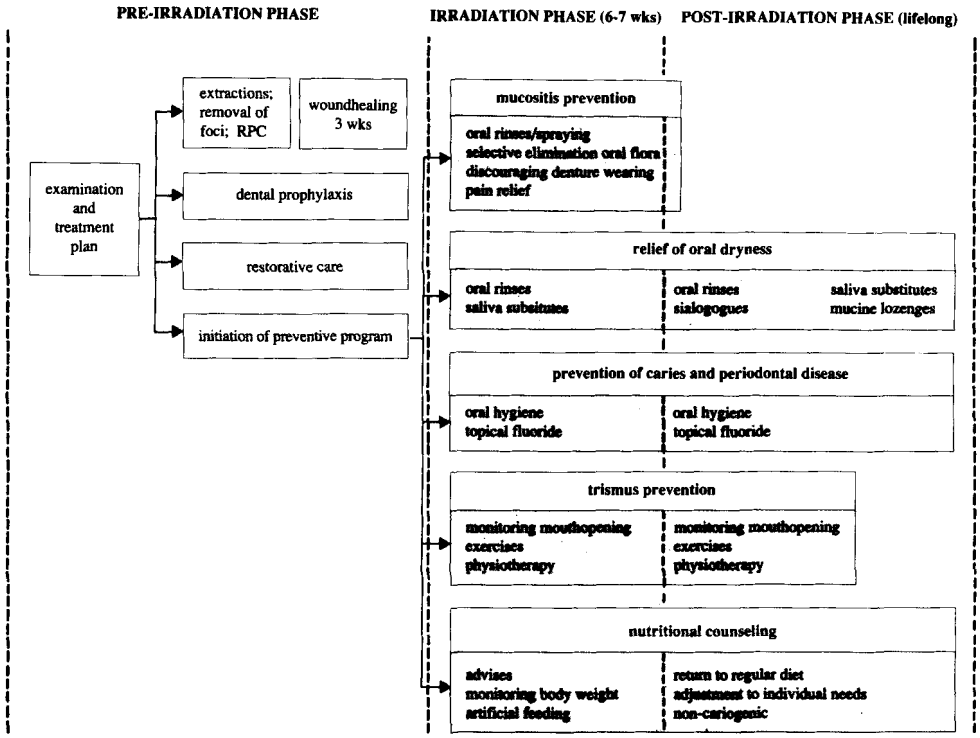

Figure 1. The primary concerns of patient care before, during, and after radiation therapy.

riers, and wound healing after extractions or other surgical procedures is needed. That is why the initial appointment for dental evaluation must be made shortly after initial cancer diagnosis and at least 3 weeks before the onset of radiation therapy.

Physical and Radiographic Examination

Dentition. The patient's dentition should be examined. Teeth must be checked for carious lesions, defective restorations, sources of potential irritation of the oral mucosa and periodontium, e.g., sharp or rough fillings and calculus, and vitality of the pulp.

Periodontium. The periodontal status is a major dental consideration and should be thoroughly screened by measuring pocket depths and assessment of furcation involvement.

Oral hygiene. The level of oral hygiene should be checked carefully. Plaque and bleeding indices are helpful parameters. The hygiene of partial or full dentures also should be checked.

Dental awareness and motivation. The patient's dental awareness is an important consideration in the dental evaluation. The protocol aims at preventing or reducing oral sequelae, some of which may have lifelong duration (hyposalivation) or risk (radiation caries or ORN). Thus, patients must possess the motivation and physical ability to maintain dentition properly and to comply completely with the prescribed oral hygiene and preventive regimen. Oral hygiene and dental status may be indicative of what can be expected in this respect.

Oral mucosa and alveolar process. The oral mucosa and alveolar process must be checked, especially for conditions that may interfere with future denture wearing, such as ulcerations, fibromas, irritation hyperplasia, bony spicules, and tori.

Dentures. The fit of dentures should be checked because ill-fitting dentures are a potential source of irritation and trauma of the mucosal surfaces exposed to radiation and the underlying bone.

Mouth opening. The maximum mouth opening (interarch distance) should be recorded before radiation therapy when development of trismus is anticipated, i.e., when masticatory muscles or other soft tissues surrounding the temporomandibular joint are included in the field of radiation, particularly in instances of tumor invasion and surgical resections before radiation exposure in these regions.[1,6]

Oral flora. Gram-negative bacilli and their endotoxins were found to play a significant role in the development of serious forms of mucositis.[14] Thus, all patients for whom a substantial part of the oral mucosa will be located in the field of radiation exposure should receive selective oral flora elimination. Because of the long-term administration of antibiotics and antimycotics, it is preferable to take baseline cultures, with the

oral washing method described by Spijkervet et al.[15] in these patients.

Radiographic examination. In addition to the physical examination, radiographic screening must be done for all patients. A panoramic radiograph, supplemented by intraoral radiographs when necessary, is most suitable for the detection of risk factors such as periodontal and periapical infections, cysts, third molar pathology, unerupted or partially erupted teeth, and residual root tips.

Treatment and Prophylaxis

After the oral examination is performed, a dental treatment plan is made. In principle, maintenance of as many teeth as possible, prevention of the necessity of extractions after radiation therapy, and prevention of acute complications that may interfere with the radiation treatment are the primary goals. All teeth with a questionable prognosis should be extracted before radiation therapy. For the decision of extraction before radiation therapy or maintenance of teeth, several factors are of importance. They include the patient's motivation and ability to comply with the preventive regimen. A lack of motivation on the part of the patient should lead to a decision to extract teeth before radiation therapy. Radiation exposure type, field, and dose also are important. The risk of development of ORN is maximal after cumulative doses to the bone that exceed 65 Gy; this is particularly true of the molar region of the mandible.[16,17]

Extractions before radiation therapy and surgical removal of other foci. Extraction or surgical removal of teeth usually is indicated in these circumstances:

advanced carious lesions with questionable pulpal status or pulpal involvement;
extensive periapical lesions;
moderate to advanced periodontal disease (pocket-depth in excess of 5 mm), especially with advanced bone loss, mobility, or furcation involvement;
residual root tips not fully covered by alveolar bone or showing radiolucency;
impacted or incompletely erupted teeth that are not fully covered by alveolar bone or that are in contact with the oral environment;
teeth in close proximity to tumor.

Deeply impacted teeth that are covered completely by bone and mucosa usually can be left without risk of late problems.[1,8]

Extractions and surgical removal of residual root tips, impacted teeth, and other foci such as cysts should be performed atraumatically with regard to tissue handling. Alveolotomy (lowering and smoothing the bony alveolar margins) and primary wound closure are necessary to speed healing and to eliminate sharp ridges and bony spicules, which may project into the overlying soft tissues.[17] This is particularly important for prosthetic considerations because negligible bone remodeling can be expected after radiation therapy.

Nonvital teeth located in the field of radiation without periapical radiolucency and not causing complaints can be treated endodontically. With mandibular molars, apicoectomies with orthograde filling are preferred because of the high ORN risk in this region and the frequent problems with endodontic treatment on multirooted teeth. Teeth with small or moderate periapical granulomas without periodontal involvement that are important for oral functioning or rehabilitation should be treated with apicoectomies. Extraction is indicated for extensive periapical radiolucency, simultaneous periodontal involvement, and lack of function.

Irritation hyperplasia, fibromas, bony spicules, and tori should be removed when they interfere with denture wearing or construction of new dentures.

Adequate time for wound healing before radiation therapy is essential because it is related to the development of ORN.[18] Healing times of 3 weeks generally are considered safe and should be the rule.[19] Routinely antibiotic coverage is not recommended because there is no evidence that antibiotics influence healing in the absence of infection.[1] Careful examination of the extraction sites must be performed before radiation treatment. With the examination, the clinician can determine the healing period required for the patient.

Dental prophylaxis and restorative care. It is crucial to bring the periodontium into optimal condition before radiation therapy because of the lowered potential for healing afterward.[20] Thorough oral hygiene procedures, including scaling and polishing or subgingival root planing and curettage, should be performed as needed. Overhanging restorations should be recontoured or renewed to remove plaque and food retention factors. Extensive scaling and subgingival curettage should be completed at least 3 weeks before radiation therapy to allow for sufficient wound healing. With advanced periodontal disease (pocket-depth of more than 5 mm), extraction is inevitable because of the risk of ORN and the lack of time for sufficient periodontal treatment, such as flap operations.

Restorative care, including restoration of carious lesions and replacement of defective restorations, should be performed as needed.

Ill-fitting partial or full dentures should be corrected. Temporary soft liners exhibit increased friction because of the hyposalivation induced by radiation exposure. In addition, they may easily become colon-

ized with yeasts because of their porosity. Thus, soft liners are contraindicated in patients with head and neck radiation exposure. Construction of new dentures should be postponed until 3 months after radiation therapy.

Initiation of a New Preventive Regimen

A protocol aimed at prevention and relief of mucositis, prevention of hyposalivation-related dental caries and periodontal disease (and thus ORN), relief of oral dryness, and prevention of weight loss and trismus must be instituted in all patients at risk. Because most preventive measures must be continued throughout the patient's life, patient and family education, counseling, and motivation are critical to the success of the preventive regimen.

Oral hygiene. Patients must be instructed about an effective daily plaque removal. Instructions regarding the use of a soft toothbrush with a fluoride-containing toothpaste and the Bass-technique of sulcular brushing are needed. The use of dental floss or soft wooden toothpicks is imperative for removal of interdental plaque. Interproximal brushes, irrigating devices, and plaque-disclosing tablets can be helpful. Proper oral hygiene cannot be overemphasized, and patients efforts should be evaluated before radiation therapy. Instructions regarding denture hygiene should be provided.

Caries prevention and topical fluorides. Although oral hygiene measures are imperative in the prevention of radiation caries, it has been shown that oral hygiene alone is inadequate as a safeguard against radiation caries.[21–23] Topical fluoride applications are needed to prevent radiation caries. A neutral 1% sodium fluoride gel, self-applied every second day using custom-made carriers, in conjunction with strict oral hygiene measures is an effective preventive regimen.[23] Acidulated gels are not indicated in patients receiving radiation exposure because such gels may lead to significant decalcification without sufficient remineralization potential in the presence of hyposalivation. They also may cause mucosal irritation with burning pain, erythema, and ulceration.[4,9] In addition, sodium fluoride preparations are preferred to stannous fluoride because the latter has unpleasant side effects, such as bad taste, sensitivity of teeth and gingivae, and staining of arrested lesions.[24]

At the initial dental appointment, impressions should be taken to fabricate flexible fluoride carriers that extend approximately 3 mm beyond the free margin of gingivae and fit the teeth closely to allow for adequate fluoride coverage. They must be made before radiation therapy. After the patient has thoroughly brushed and flossed, the 1% sodium fluoride (NaF) gel should be applied for 5–10 minutes every second day, preferably immediately before bedtime. The carriers must not be overfilled; a few drops of gel are sufficient. After removing the carriers, the patient spits out excess gel without rinsing and must refrain from drinking, brushing, or eating for 30 minutes. Patients with an extreme gag reflex can apply the fluoride gel using a toothbrush instead of a carrier.

In patients with large metal restorations or crowns located in the field of radiation, carriers of double thickness can be fabricated; these carriers must be worn during radiation exposure to prevent tissue injury by scattering, thereby preventing localized mucositis, especially of the buccal mucosa.

Oral rinse instructions. For relief of oral discomfort during radiation therapy, cleansing agents are recommended to reduce mucosal irritation, to remove thickened secretions and debris from mucosa and dentition, and to moisture and lubricate the mucosa.[25] When radiation therapy begins, the patient should rinse the mouth at least eight to ten times a day for 1 minute with a salt-soda solution (one liter lukewarm water with one teaspoon each of NaCl and Na_2CO_3). This solution is preferred because of its ability to dissolve mucus and loosen debris.

Daily professional spraying of the oral cavity with saline using a spraying device (Heberle spray set, Lameris, Ultrecht, The Netherlands) is a good supplement to thorough mechanical cleansing. Professional spraying should be performed, especially for patients who have serious complaints because of mucositis or who are unable to rinse sufficiently.

Saliva substitutes. Symptomatic relief of oral dryness also can be accomplished with saliva substitutes. Although mucin-containing substitutes seem to be more effective,[26,27] carboxymethylcellulose (CMC)-containing substitutes may be beneficial. The success of using saliva substitutes is strictly dependent on the instructions delivered with their prescription. The patient should moisten the oral cavity abundantly with an atomizer, spread the substitute over the entire oral cavity and swallow or expectorate the surplus. As soon as the sensation of dryness returns, the treatment should be repeated. The substitute can be used ad libitum. Saliva substitutes can be diluted with water for patients who find the agents' viscosity objectionable. Difficulty in speech and swallowing and nocturnal oral discomfort are the most useful indices for their use.

Selective oral flora elimination. Selective elimination of gram-negative bacilli from the oral flora during radiation therapy has resulted in prevention of the more severe stages of mucositis (pseudomembranes and ulcers).[14] Four times daily administration of 1-g loz-

enges containing 2 mg polymyxin E, 1.8 mg tobramycin, and 10 mg amphotericin B (PTA) is prescribed to all patients for whom a substantial part of the oral mucosa will be located in the field of radiation. The PTA lozenges should be used from the onset of radiation therapy, during its full course, and until mucositis signs have disappeared. Although unrelated to the pathogenesis of mucositis, the preventive administration of the topical antifungal amphotericin B is indicated in this population to prevent yeast stomatitis.[28]

Denture wearing. Dentures, especially ill-fitting ones, may cause mucosal irritation during radiation therapy; this irritation may aggravate mucosal pain and mucositis. The policy must be to discourage the wearing of partial and full dentures from the start of radiation therapy in all patients in whom a substantial area of the oral mucosa is located in the field of radiation and who will receive a curative radiation dose. An exception must be made for patients wearing resection prostheses and obturators, which are needed for closure of the surgical defect and for prevention of tissue retraction into this defect.

Trismus prevention. Prevention of trismus, rather than its treatment, is a desirable objective. As soon as radiation therapy begins, patients at risk of trismus need daily exercises, such as properly instructed stretching, to maintain maximum opening and jaw mobility. The additional use of tongue blades or rubber stops of increasing size is helpful and stimulating because they act as measuring devices. Dynamic bite openers[2] that contain springs and bands and are designed to restretch muscles also can be used for prevention in pediatric patients.

Nutritional instructions. The oral intake of food during radiation therapy may be impeded because of taste loss, changes in amount and viscosity of saliva, and pain, caused by mucositis, on eating and swallowing.[3,29] Resulting weight loss leads to weakness, inactivity, discouragement, and susceptibility to infection.

Nutritional counseling and dietary instructions are important for minimizing weight loss and preventing the necessity of nasogastric feeding. All patients should receive dietary instructions before radiation therapy, ideally by a dietitian. Foods high in sucrose enhance the cariogenic activity and should be avoided, as should spicy and acidic foods that are intolerable to the sensitive oral mucosa. To ease mastication in association with hyposalivation and mucositis, patients are encouraged to increase fluid intake and to eat moistened foods served at room temperature. Small frequent feedings are recommended when appetite is poor and when swallowing is difficult. Tobacco and alcohol use, which contributes to mucosal irritation, is strongly discouraged. Adequacy of oral intake should be monitored by regularly measuring the body weight.

Patient Care during Radiation Treatment

Maintenance of optimal oral hygiene, preventive measures, and relief of oral discomfort are the primary concerns during the radiation treatment period (Table 2). During this time, patients must have checkups by the radiation therapist and must be screened by a member of the dental team at least once a week. During these screening visits, the oral situation, the oral hygiene, and preventive measures should be checked, evaluated, and if necessary reinforced. Additional measures can be initiated, depending on the oral status and complaints.

Oral Hygiene

If tooth brushing has become painful because of mucositis, one or more of the following additional measures should be initiated: professional cleansing of the dentition by an oral hygienist during the weekly visits; 0.1% aqueous chlorhexidine rinses three to four times daily for additional plaque control; and rinses with a topical anesthetic, such as viscous lidocaine, shortly before tooth brushing to relief pain from brushing. Patients also may be advised to soften their toothbrush with hot tap water before use.

Topical fluorides. The neutral 1% NaF gel must be applied every second day by the patient using the custom-made carriers.

Mucositis prevention and therapy. Patients should rinse their mouths at least eight to ten times daily with the salt-soda solution and use the PTA lozenges four times daily during the full course of radiation therapy. When patients have difficulties in dissolving the PTA lozenges because of hyposalivation, they should be instructed to moisten their mouths and remove the remnants of the lozenge after 30 minutes of sucking. To monitor oral flora, surveillance cultures should be taken weekly in all patients using PTA lozenges.[14]

Denture wearing is discouraged after radiation therapy begins. With large metal restorations or crowns located in the field of radiation, patients should wear their double-thickness carriers during radiation exposure. In patients with severe complaints caused by mucositis or who are unable to rinse sufficiently, additional daily spraying with saline should be performed by the oral hygienist or nursing staff. Once mucositis has developed, a sucralfate suspension (1 g/15 ml) can be prescribed for pain relief as a rinsing agent.[30]

Relief of oral dryness. Oral rinses with salt and soda are important for mechanical cleansing during radiation therapy but also sufficiently relieve oral dryness in most patients. If they do not, their frequency can be increased, and patients can be encouraged to increase fluid intake, provided the beverages are noncariogenic and nonirritating to the oral mucosa. Saliva substitutes also can be prescribed.

Trismus prevention. All patients at risk of having trismus should perform the instructed exercises. When the interarch distance decreases, the exercise program should be intensified, occasionally in combination with physiotherapy, to regain the lost interarch distance.

Nutritional counseling. When weight loss exceeds 1 kg per week, enriched dietary supplements are recommended. Nasogastric feeding is indicated when a loss of 10% of the body weight before radiation exposure is observed in the third or fourth week of radiation therapy.[31]

Care of the Patient after Radiation Therapy

In addition to relief of oral dryness and discomfort, the primary purpose of the protocol after radiation therapy is prevention of radiation caries, periodontal disease, extractions, and thus ORN (Table 3). Oral hygiene must be maintained at a high level indefinitely in all patients, whereas topical fluoride applications must be continued lifelong in most dentulous patients. The risk of noncompliance increases with time after radiation therapy. Patients must be placed on a regular dental recall schedule and be judiciously followed up for the rest of their lives. This is necessary to check, evaluate, and reinforce the oral hygiene regimen, to encourage patients to adhere to the protocol, and to counsel a possible reduction in fluoride usage. As a general rule, follow-up visits should be weekly during the first month, every three months during the next year, and less frequently thereafter; however, schedules may differ, depending on the level of oral hygiene, degree of hyposalivation, and whether the patient is dentulous or edentulous. For reasons of efficacy, the follow-up visits should be combined with the oncology recall. The patient's dentist, when instructed properly, can play an important role in the period after radiation therapy by caring for the patient during these visits or working with the dental team.

Oral Mucosa

Mucositis. Frequent rinsing with salt-soda solutions, the use of PTA lozenges, and other preventive or therapeutic measures should be continued until mucositis signs have disappeared. With recall mucositis, the basic regimen of mucositis prevention should be reinstituted.

Dentures. The oral mucosa that has been exposed to radiation is vulnerable and easily damaged, a condition that is aggravated by hyposalivation.[32] Trauma to the edentulous alveolar ridge may result in soft-tissue necrosis and lead to ORN. Dentures are considered to be a potential source of such trauma.[33] Timing of their (re)placement is controversial. Factors such as compliance, amount and consistency of saliva, presence of recent extraction sites, and experience in wearing dentures before radiation therapy are important decisive parameters. Our guideline is to wait 3 months before (re)placing dentures so that initial mucosal changes have subsided. This waiting period is extended to 6 months for patients who had extractions before radiation therapy in the field of the radiation-exposed area. An exception is made for resection prostheses.

After dentures are replaced or constructed and placed, preferably by an experienced hospital dentist, the patient should remove the dentures at night. Denture hygiene should be stressed to the patient. Because of increased friction, porosity, and accumulation of debris, soft liners are not indicated in this group of patients.

If irritation develops, dentures must be removed immediately and the mouth must be examined by the dental team. Stringent continuous care after radiation therapy is essential in denture-wearing patients. The fit of the dentures should be checked every year by the family dentist or by the dental team.

Oral Dryness

The degree of hyposalivation and return of salivary gland function primarily depend on the total radiation dose and the volume of salivary gland tissue located in the field of radiation, whereas the initial salivary flow also is of importance.[34,35] Studies have indicated that there is almost no recovery of salivary flow when the major salivary glands are situated in the treatment portals and receive a cumulative radiation dose in excess of 40 Gy.[21,35] In many patients with head and neck cancer, cumulative radiation dosages of 60–70 Gy are administered to one or more of the salivary glands, so hyposalivation is irreversible in most instances. This has a tremendous effect on caries challenge and quality of life for the patient.

Relief of oral dryness. The management of hyposalivation involves a combination of two strategies: stimulation of residual capacity of salivary glands and relief of oral dryness. Most patients experience improve-

ment in symptoms from frequent moistening of the mouth by drinking or rinsing with water, tea, salt-soda solutions, extracts of camomile, and home remedies, such as old brown ale and blueberry juice. Additional treatment of oral dryness should be instituted, depending on the subjective complaints of the patient. During each follow-up visit, questions regarding such complaints should be asked and verified by clinical assessment. For this assessment of the degree of hyposalivation, a few parameters are of interest, including appearance of the oral mucosa (dry, atrophic, fissured), aspect of the oral fluid (more viscous), and level of salivary secretion in rest and after stimulation.

When stimulation of salivary glands shows residual capacity, sialogogues can be used to relieve oral dryness. Good results can be obtained with gustatory and tactile sialogogues, such as sugar-free chewing gum and acidulated sweets. However, the latter can be used only in limited amounts because they often are intolerable to the mucosa exposed to radiation. Although their usefulness seems limited because of their potential side effects, pharmacologic sialogogues such as pilocarpine have been reported to be successful in stimulating additional secretion.[36,37]

Saliva substitutes that contain mucin or CMC also can be prescribed; the mucin-containing substitutes seem to be the most effective.[26,27] Construction of a saliva substitute reservoir in a denture has been helpful in a number of selected patients,[38,39] but application of the substitute with an atomizer, provided it is used correctly, is sufficient in most patients. Recently, promising results were obtained with the use of mucin-containing lozenges in the treatment of oral symptoms of xerostomia.[40] These lozenges are particularly useful when combined with mucin-containing saliva substitutes.

Dentition

Oral hygiene. Patients must maintain a high level of oral hygiene throughout their lives. Oral hygiene should be checked carefully during follow-up visits. If necessary, patients should be motivated and oral hygiene measures reinforced.

Topical fluoride. Topical fluoride application must be continued as long as hyposalivation exists, which is lifelong in most patients.[21,41] Although some authors mention the possibility of reducing the frequency of fluoride application, depending on such factors as level of oral hygiene and salivary flow rate,[4,7] and despite that reduction of the application frequency is common in Dutch radiation therapy institutes,[10] no studies regarding fluoride reduction have been reported to justify this measure. Because of the irreversibility of hyposalivation in many patients and the aggressiveness and high cariogenity of the xerostomic oral environment as observed in in situ studies,[22,23,42] the application of a 1% neutral NaF gel every second day must be continued throughout the patient's life. Reduction of the application frequency is justified only in patients with objective indications of recovery of salivary flow in combination with a high level of oral hygiene. In this respect, one must remember that in approximately one third of the xerostomic patients, there is no correlation between objective and subjective mouth dryness.[43] In addition, reduction must be guided by close follow-up for evaluation and possibility of individual adjustment and quick intervention. Should initial carious lesions appear, duration and frequency of fluoride applications can be increased temporarily for remineralization and caries arrest. Topical fluoride should be applied at least twice a year. Applications can be performed by a dentist or an oral hygienist during follow-up visits.

Physical and radiographic examination. The patient's dentition should be checked carefully for carious lesions and calculus. Periapical films and bitewings should be made to examine teeth previously treated by endodontics or apicoectomies and for caries detection. The periodontium should be thoroughly screened by measuring pocket depths.

Restorative and prophylactic care. If carious lesions develop, they should be treated immediately because of the rapid progression in xerostomic patients. Teeth with nonvital pulps located in jaw segments exposed to radiation should be treated endodontically, rather than by apicoectomy, because of the amount of wounding. Removal of calculus by scaling and root planing and curettage also should be performed to optimize periodontal health. Chronic periodontal disease may induce ORN and should be prevented.

Extractions after radiation therapy. Extraction of teeth from jaw segments exposed to radiation is a significant factor predisposing to ORN.[17] Screening before radiation, treatment, and the institution of a regimen are aimed at preventing the necessity of these extractions. The necessity for extraction after radiation therapy usually is caused by insufficient screening before radiation therapy and patient noncompliance with the regimen. Several investigators have shown that the time elapsed between radiation therapy and tooth removal has little direct bearing on the occurrence of ORN,[44] whereas others have reported the risk to increase with time.[19] However, it seems that limited extractions can be done successfully when necessary, provided adequate preventive measures are taken.

Extractions are performed with careful soft-tissue

handling, alveolotomies, and primary wound closure. This is important to speed healing and for future prosthetic considerations. Prophylactic high-dose, broad spectrum antibiotic coverage, eg, cephalosporins, is started a few days before extraction and continued for 2 weeks to prevent wound infection. Preventive hyperbaric oxygen treatment has been proven to be more beneficial than antibiotic prophylaxis in preventing ORN[45] but is not widely available in most countries. Prophylactic hyperbaric oxygen treatment must be used in patients who require extractions or who experienced excessive wounding in segments previously exposed to radiation and who are considered to be at the highest risk of having ORN, ie, patients with cumulative radiation doses in excess of 65 Gy to mandibular segments and who have risk factors such as impeded blood supply caused by tumor operation, abuse of alcohol and tobacco, and compromised general health. Wound healing of extractions performed after radiation therapy should be checked regularly.

Trismus Prevention

Trismus (with muscular cause) may develop as late as 3–6 months after completion of radiation therapy.[8,33] Thus, patients at risk of having trismus are advised to continue exercises during this period and should be assisted by physiotherapy when indicated. The interarch distance should be measured during follow-up visits and compared with the distance as determined before radiation exposure.

Nutritional Counseling

After mucositis signs have subsided, patients generally may return to a regular diet. Because of the hyposalivation induced by radiation therapy and its related taste disturbances, foods may have to be moistened and served with liquids for an indefinite period of time, and smell and taste may have to be adapted to individual needs.

Epilogue

A protocol for the prevention and reduction of most oral sequelae resulting from head and neck radiation therapy has been proposed; the scientific basis is formed by the hyposalivation studies of Vissink,[10] the mucositis studies of Spijkervet,[12] and the radiation caries studies of Jansma,[13] in combination with data derived from the literature. The protocol is especially applicable in centers operating with a dental team, which ideally consists of an oral and maxillofacial surgeon, a hospital dentist, and an oral hygienist, that is devoted to covering the wide range of preventive and treatment measures. This team should be involved at the time of initial cancer diagnosis so that a preventive regimen is an integral part of the overall cancer treatment regimen. The role of a family dentist before and during radiation therapy probably is limited because of the complexity of oral screening and oral care, the possible complications during radiation therapy, and the fact that most family dentists rarely are confronted with this type of patient. In our opinion, the family dentist's role is limited to the care of patients with uncomplicated disease after they have received radiation therapy.

With the implementation of new radiation exposure schedules in head and neck radiation therapy (more early side effects in association with hyperfractionation and accelerated treatment) and the increasing number of aged dentulous patients, adequate prevention is a matter of increasing importance.

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