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Dietary Intake in Head and Neck Irradiated Patients with Permanent Dry Mouth Symptoms

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Radiotherapy of the head and neck region, which includes the major and minor salivary glands in the radiation field, usually leads to temporary or permanent xerostomia. This may affect eating and increase the risk of inadequate intake of energy and nutrients. The aim of the present study was to investigate the effects of radiotherapy-induced xerostomia on energy and nutrient intake in individuals treated for malignancies in the head and neck region. The dietary intake of 24 patients with a low chewing stimulated whole saliva flow rate (<0.5 ml/min) and in age and sex matched controls with normal flow rate (>1.0 ml/min) was recorded for 7 days. The average daily energy intake was nearly 300 kcal lower in the irradiated patients with dry mouth symptoms than in the control group. The mean intake in the former group was 1925 kcal per day whereas the control group had an intake of 2219 kcal per day. Irradiated patients with dry mouth symptoms had significantly lower mean intakes of vitamin A, β-carotene, vitamin E, vitamin B_6, folacine, iron and zinc than those in the control group. There was also a lower intake of vitamin C, but this was not statistically significant. The intake of vitamins A and C exceeded or reached the levels recommended in the Swedish Nutritional recommendations, but the average intakes of fibre, iron, β-carotene, vitamin E, zinc, selenium, and iron did not reach recommended levels, in neither the experimental nor the control group. There was a slight positive correlation between energy intake and saliva secretion rate in the control group, but the energy intake was totally independent of variations in secretion rate in the irradiated patients with low secretion rate.

Keywords: head and neck irradiation, saliva, xerostomia, diet, oral cancer

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INTRODUCTION

RADIOTHERAPY OF malignancies in the head and neck region usually includes the major and minor salivary glands in the radiation field. Conventional radiation schedules, i.e. 2 Gy per day, leads to a marked decrease in saliva flow rate and changes in saliva composition within the first week of radiation, and to continuously impaired flow rate during the treatment period [1–4].

Although large inter-individual variations are reported, permanent xerostomia normally occurs when the salivary glands are irradiated to the maximal dose acceptable to normal tissue [1, 5, 6]. The degree of impairment of the saliva flow varies, and the effects may be temporary or persist permanently [7, 8]. These variations depend mainly on radiation dose but also on individual factors.

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Saliva produced by the major salivary glands and mucus produced by the minor salivary glands protect the mucous membranes and teeth, lubricate the food bolus and facilitate eating and speaking. Saliva also has additional protective roles in acidity regulation and antimicrobial defence by immunoglobulin and non-immunoglobulin glycoproteins [9]. Decreased secretion from the salivary glands may lead to dry mouth symptoms, such as oral pain and burning sensations, and loss of taste and appetite [10–12], as well as increased incidence of oral disease. These oral discomforts affect eating and selection of foods and increase the risk of inadequate intake of energy and nutrients [13, 14]. Patients treated with radiotherapy for malignancies in the head and neck region experience eating disorders during the treatment period [15, 16], and extensive efforts are provided to maintain energy and nutrient intake during the treatment period.

The aim of the present study was to test the hypothesis that low saliva secretion rate generated by radiotherapy has long-term adverse effects on energy and nutrient intake in individuals treated for malignancies in the head and neck region.

SUBJECTS AND METHODS

Irradiated dry mouth (experimental) group

All patients, treated with radiotherapy for malignancies in the head and neck region at the Department of Oncology at the University Hospital in Umeå, Sweden, are provided with dental health care at the Department of Cariology, University Dental Clinic, Umeå. 35 consecutive patients who received irradiation to the head and neck with curative intent, with objective and subjective dry mouth symptoms persisting at least 4 months after completion of radiotherapy were selected for the study. Details concerning the patients are included and the radiotherapy schedules used are shown in Table 1a and b. The radiation doses varied with the diagnosis according to commonly accepted treatment strategies. Two main groups were outlined, one group was given 39–55 Gy and the other was treated with 55–68 Gy. The dose to at least 50% of the oral cavity was at least 90–95% of the prescribed target dose.

Whole saliva, stimulated by chewing on a 1 g piece of paraffin, was collected for 5 min, according to previously described, standardised procedures [17], on two separate occasions. If the volume secreted per minute was below or equal to 0.5 ml on both occasions the inclusion criteria were met and the patient was asked to participate in the study. Twenty men and 15 women were invited to participate, and from these, an informed consent was obtained from 14 men and 10 women. The mean age in the irradiated group was 56 years with a range of 21–71 years.

Control group

The inclusion criteria for participants in the control group was no disease present, taking no medication, and a chewing stimulated whole saliva secretion rate exceeding 1.0 ml/min. 24 patients who had recently completed dental treatment at the Department of Cariology, University Dental Clinic, Umeå were matched according to sex and age with the experiment group. The controls were randomly selected from patient files at the Department of Cariology. The mean age in the control group was 58 years with a range of 21–71 years.

Table 1a. Patients treated with irradiation to doses of 39–55 Gy, n = 15

Site	No. of patients	TNM	Stage	Dose (Gy)
Non-Hodgkin lymphoma	4		1A	39.86–40.06
	1		2A	40.4
	2		1E	40.0–40.4
Hodgkin's disease	4		1A	39.2–40.8
	3		2A	39.82–40.3
Carcinoma of the larynx	1	T3N1M0		50.5

Table 1b. Patients treated with irradiation to doses of 55–68 Gy, n = 9

Site	No. of patients	TNM	Dose (Gy)
Carcinoma of the tonsil	1	T1N0M0	68.0
Carcinoma of the tongue	1	T3N0M0	67.76
	1	T1N1M0	72.4
Carcinoma of the epipharynx	1	T4NXM0	67.41
	1	T2N1M0	64.8
	1	T2N2M0	66.2
Carcinoma of the floor of the mouth	1	T3N2M0	65.1
Carcinoma of the larynx	1	T2N0M0	66.4
Carcinoma of the hypopharynx	1	T2N2M0	66.2

Dietary registration

Dietary intake was recorded for 7 consecutive days using a partly precoded food record [18]. The 7-day food record contained a series of precoded food alternatives for breakfast, lunch and dinner, and blank spaces for additional alternatives and for between meals and snacks. Four photographs on various portion sizes were printed in the 7-day food record to support the estimation of amounts of food consumed.

The 7-day food records were mailed to the participants. Within 4 days of the food record being received, information was carefully given by one of two trained instructors (IB and IA). The completed dietary recordings were returned by mail and occasionally the participants were additionally interviewed on the telephone. The energy and nutrient intake was calculated with a computer-based program (MATs, Rudans Lättdata, Eskilstuna, Sweden) using the database from the National Food Administration (Uppsala, Sweden) [19].

Statistical analyses

Statistical analyses were done using the software Fystat™ (DatAid AB, Umeå, Sweden). Mean values and 95% confidence intervals of the means were calculated for the crude energy and nutrient data and for the individual's energy and nutrient intake as a percentage of the appropriate values in the Swedish Nutritional Recommendations [20] and the American National Institute for Cancer for β-carotene [21]. Differences between the means for the daily average intakes in the dry mouth and the control group were tested using a one-sided, non-parametric test, Mann–Whitney *U*-test [22]. Spearman correlation coefficients were calculated to search for univariate association between saliva secretion rate and daily energy intake. *P*-values below 0.05 were considered statistically significant.

RESULTS

Of the 35 patients with subjective and objective dry mouth symptoms, 24 volunteered to participate in the study. The reason for non-participation was lack of interest in keeping a dietary record. Of the 26 individuals asked to participate as members of the control group, 24 became participants; 2 were excluded due to acute illness.

Table 2. Comparison of irradiated patients with dry mouth symptoms and a control group. Data are presented as means and 95% confidence intervals (C.I.)

	Dry mouth group		Control group	
	Mean	95% C.I.	Mean	95% C.I.
Women/men (*n*)	10/14		10/14	
Months after irradiation	11.5	7.1–15.9	—	—
Age (years)	56	50–62	58	50–65
BMI (kg/m^2)	23.9	22.3–25.6	25.2	23.9–26.5
Saliva flow rate (ml/min)	0.19	0.12–0.27	2.16	1.80–2.53

Table 3. Daily intake (mean and 95% C.I.) of energy, energy providing nutrients, sucrose and fibre in irradiated patients with dry mouth symptoms and a control group

	Dry mouth group		Control group		Mann–Whitney
	Mean	95% C.I.	Mean	95% C.I.	*U*-test
Energy (kcal)	1925	1658–2192	2219	1968–2469	$P=0.065$
Protein (g)	74	64–84	81	72–91	NS
Fat (g)	82	69–95	89	76–102	NS
Carbohydrate (g)	215	182–248	265	234–295	$P<0.05$
Sucrose (g)	32	23–41	47	36–58	$P<0.05$
Fibre (g)	14	12–17	20	18–22	$P<0.01$
Protein (E%)	16	15–17	15	14–16	NS
Fat (E%)	38	35–40	35	33–37	NS
Carbohydrate (E%)	45	43–47	49	46–51	$P<0.05$

NS, not significant.

Table 4. Daily intake of micronutrients (mean and 95% C.I.) in irradiated patients with dry mouth symptoms and a control group

	Dry mouth group		Control group		Mann-Whitney
	Mean	95% C.I.	Mean	95% C.I.	*U*-test
Vitamin A (mg)	1.5	1.0–1.9	2.1	1.6–2.5	$P<0.05$
β-Carotene (mg)	1.9	1.2–2.6	2.6	1.9–3.3	$P<0.05$
Vitamin E (mg)	5.8	4.9–6.6	6.7	5.9–7.5	$P<0.05$
Vitamin C (mg)	62	42–83	76	60–93	$P=0.06$
Vitamin B_6 (mg)	1.9	1.6–2.1	2.2	2.0–2.4	$P<0.05$
Folacine (μg)	191	158–224	232	209–257	$P<0.01$
Selenium (μg)	30.4	26.1–34.8	35.3	30.2–40.3	NS
Iron (mg)	12.9	10.8–15.0	15.3	13.6–17.0	$P<0.05$
Zinc (mg)	9.7	8.4–11.0	11.5	10.3–12.6	$P<0.05$

NS, not significant.

The proportions of men and women, age and relative body weight of the irradiated dry mouth group and the control group are presented in Table 2. There was no significant difference between the two groups for these variables. The average chewing stimulated saliva flow rate was 0.19 ml/min in the irradiated dry mouth group and 2.16 ml/min in the control group (Table 2). Thus, the secretion rate in the dry mouth group was 9% of that in the control group.

The average daily energy intake was nearly 300 kcal lower in the irradiated patients with dry mouth symptoms than in the control group. The mean intake (95% C.I.) in the former group was 1925 (1672–2178) kcal per day whereas the control group had an intake of 2219 (1986–2456) kcal per day (Table 3). A very low average energy intake for the 7-day period was reported by one man in the irradiated dry mouth group. He had an average daily energy intake of 463 kcal per day. The difference in energy intake in the two groups however, was not significant ($P=0.065$). The lower energy intake in the dry mouth group was related to significantly lower daily intakes of carbohydrates ($P<0.05$), sucrose ($P<0.05$) and fibre ($P<0.01$). The lower intake of carbohydrate lead to a lower percentage of the energy from carbohydrates ($P<0.05$) in the irradiated group (Table 3).

The difference in daily intake of micronutrients between the irradiated and control groups is compared in Table 4. Irradiated patients with dry mouth symptoms had significantly lower mean intakes of several micronutrients. Thus, the intakes of vitamin A ($P<0.05$), β-carotene ($P<0.05$), vitamin E ($P<0.05$), vitamin B_6 ($P<0.05$), folacine ($P<0.05$), iron ($P<0.05$) and zinc ($P<0.05$) were all significantly lower in the irradiated dry mouth group than in the control group. Lower intake, which did not reach statistical significance, was seen for vitamin C ($P=0.06$).

When the energy and nutrient intake for each individual was calculated as a percentage of the sex and age-specific recommendations given by The National Food Administration in Sweden [20] and the National Cancer Institute in U.S.A. [21] the differences between the groups were similar to those found for the crude data (Fig. 1). It could also be seen that the intake of vitamins A and C exceeded or reached the recommendations, but the average fibre, β-carotene, vitamin E, zinc, selenium, and iron intakes did not reach these levels, neither in the experimental nor the control groups.

A plot of the energy intake in relation to saliva secretion rate is shown in Fig. 2. The energy intake showed a weak positive correlation with saliva secretion flow rate in the control group

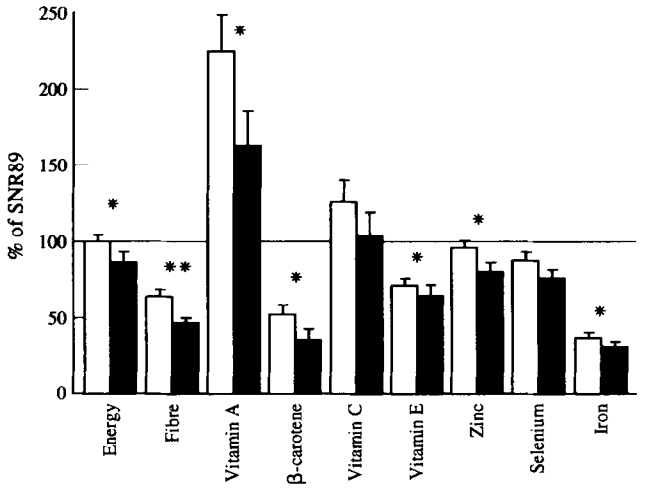

Fig. 1. Energy and nutrient intake in irradiated patients with dry mouth symptoms (■) and controls (□). Data are expressed as mean intake as a percentage of the Swedish Nutritional Recommendations [16] or, for β-carotene, the recommendations given by the American National Institute for Cancer.

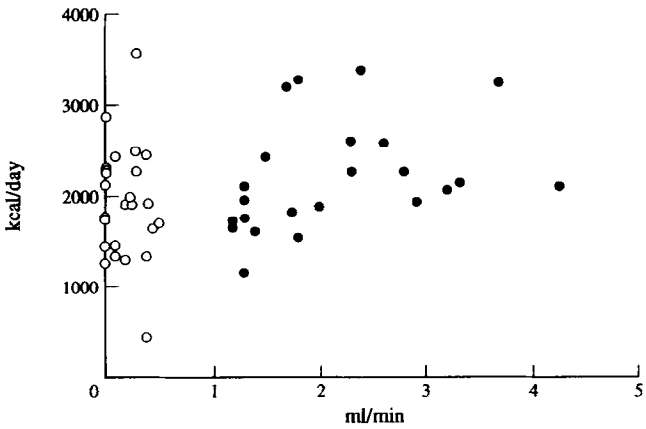

Fig. 2. Daily energy intake at various levels of stimulated whole saliva secretion rate in irradiated patients with dry mouth symptoms (○) and controls (●).

($r=0.36$ and $P<0.05$) but the energy intake was totally independent of variations in secretion rate in the irradiated patients with a low secretion rate.

DISCUSSION

Patients treated with radiotherapy for malignancies in the head and neck region frequently have eating problems as a result of oral pain and impaired saliva secretion during the treatment period. In some patients the treatment causes a reduction in the flow rate and in others a permanent xerostomia. In the present study we have shown that, in comparison with age and sex-matched controls, patients with a radiation-induced low saliva secretion rate had a slightly lower daily intake of energy and a significantly lower intake of several nutrients which have been associated with an increased risk of oral cancer [23–27].

11 of 35 patients chose not to participate in the study. The reason was an unwillingness to keep a 7-day food record. There is no reason to believe that the non-participants differed from the participants, since both groups expressed a similar degree of subjective dry mouth symptoms and oral discomfort. During the time saliva secretion was measured it was confirmed that the subjective feeling of a dry mouth corresponded to objective low secretion rates in the irradiated participants and that they had had no such symptoms before the radiotherapy.

The dietary intake was investigated using a partly precoded food diary which was mailed to the participants. The food diary has never been introduced to respondents by mail in earlier studies. However, the acceptance of the food diary was high among the participants and the fact that it was precoded simplified the subsequent data processing. The average energy and nutrient intakes found in the control group are in accordance with other studies in healthy adults [18, 28–30] and the average intakes reported by the dry mouth group are similar to intakes reported in two other studies in xerostomic patients [13, 14].

In the majority of cases, radiotherapy to the head and neck was related to squamous cell carcinoma in the oral cavity [31]. Several studies have shown tobacco use [32, 33] and low intake of vitamin C [23], vitamin A [24] and β-carotene [25] to be associated with increased risk of oral cancer while supplemental retinoic acid [25] or β-carotene [26] had led to normalisation of premalignant leukoplakia. In the present study we have shown that patients who have an irradiation-induced low saliva secretion rate ate less than control patients and, in addition to a slightly lower energy intake, there is a significantly lower intake of micronutrients, which is claimed to be associated with the risk of developing oral squamous cell carcinoma [27]. We could not find an age and sex-matched control group treated for malignancies in the head and neck region but with maintained normal saliva flow rate. It can, therefore, not be excluded that the patients treated with head and neck irradiation had lower intakes of these micronutrients before diagnosis and radiation treatment, neither can it be totally excluded that other long-term adverse effects from radiotherapy contribute to the differences found between the two groups. However, all irradiated participants ate food of normal consistency, except one man having full dentures in the upper and lower jaw, who ate mashed food. This man was matched with a man of the same age and with a similar dental status. None of the irradiated participants felt pain when they ate but some experienced taste disturbances and several had to sip a liquid in order to swallow the food bolus. These anamnestic statements support the hypothesis that the dry mouth situation affected eating. Further, two other studies support the hypothesis that xerostomia has an adverse effect on energy and nutrient intake [13, 14]. The conclusion from the present study, therefore, is that the adverse effect on diet intake due to radiotherapy to the head and neck may extend beyond the acute phase with mucositis and maximal xerostomia. Head and neck irradiated patients with long-term reduction of saliva secretion rate may, therefore, need dietary support for a longer period of time than is currently being provided.

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