The Journal of Laryngology & Otology (2009), ***123***, *108–113*.

doi:10.1017/S0022215108002466

Main Article

Evaluation of irradiated salivary gland function in patients with head and neck tumours treated with radiotherapy

A Baharudin, A Khairuddin, A Nizam*, A R Samsuddin†

Abstract

Introduction: Radiotherapy is an important treatment modality for head and neck tumours. One of its major drawbacks is post-treatment salivary gland hypofunction. This study was performed to objectively evaluate the salivary gland function in post-irradiated head and neck tumour patients.

Methods: We performed a cross-sectional study of 30 patients with head and neck tumours who had received radiotherapy. Unstimulated and stimulated whole salivary flow rates were assessed in these 30 patients, and compared with those of 30 normal subjects. Unstimulated whole saliva was measured by the draining method, while the spitting method was used to collect stimulated whole saliva.

Results: Both unstimulated and stimulated whole salivary flow rates were significantly reduced in the irradiated patients, compared with the normal subjects. This difference was statistically significant ($p = 0.0001$).

Conclusion: Salivary function in post-irradiated head and neck tumour patients (assessed as salivary flow rates) was significantly reduced compared with normal controls, suggesting marked salivary gland hypofunction.

Key words: Head and Neck Neoplasms; Radiation Therapy; Salivary Glands

Introduction

Changes in the salivary glands and in the composition of saliva can occur as a result of ionising irradiation of salivary gland cells. Salivary function is extremely responsive to radiation. At least 50 per cent of function is lost after only 1000 cGy in one week of radiotherapy. In conventional radiotherapy for head and neck cancer, patients usually receive about 6000 to 7000 cGy over six to seven weeks. One study found that such radiation doses cause 80 per cent salivary dysfunction, which may last for years after radiotherapy.[1]

Radiation causes damage to both the acinar and ductal systems of the salivary glands; however, the principal damage is to the acinar parenchyma. Serous acini are more responsive to radiation therapy than mucinous acini. At the beginning of irradiation, there is a prompt, marked elevation of serum amylase levels and a decrease in serum immunoglobulin A, both of which progress with increasing dose.[2,3] The effects of radiotherapy on salivary glands are probably due to effects on the fine vasculature of the glands, with secondary changes in the parenchymal epithelium and interstitial and interlobular fibrosis, leading to degeneration of the functional acini. Later, the damaged secretory acinar cells within the glands are replaced by ductal elements and inflammatory cells. This damage causes an apparent increase in salivary sodium and chloride and a decrease in salivary bicarbonate.[4] These changes account for the thick, tenacious and acidic character of post-irradiation saliva.

When the major salivary glands are exposed within the radiation field, salivary gland dysfunction commonly develops.[5] Basal whole salivary flow may reach a measurable minimum two to three weeks after delivery of 2300 cGy of fractionated radiotherapy.[6]

Dreizen *et al.*[7] showed that salivary flow progressively decreases with radiotherapy, and that after three years the percentage of decrease exceeds 90 per cent and is presumably permanent. The extent of salivary dysfunction is primarily determined by the radiation field and the total dose of radiation.[5]

The aim of this study was to objectively assess the salivary gland function in post-irradiated head and neck tumour patients, the majority of whom had received radiotherapy at the radiotherapy and oncology unit of the Hospital of the Science University of Malaysia. The radiotherapy service provided by this hospital began in 1996 and mainly serves the population of the east coast of the Malaysian peninsula.

From the Departments of Otorhinolaryngology – Head And Neck Surgery and *Community Medicine, School of Medical Sciences, and the †School Of Dental Sciences, Universiti Sains Malaysia, Kelantan, Malaysia
Accepted for publication: 25 February 2008. First published online 1 May 2008.

However, in some instances patients were also referred from other parts of the country.

Patients and methods

We conducted a cross-sectional study of head and neck tumour patients who had received radiotherapy treatment between July 2002 and September 2003 at the otorhinolaryngology clinic of the department of otorhinolaryngology and the department of radiotherapy and oncology, School of Medical Sciences, University Sains Malaysia. Patients were seen in the combined oncology–otorhinolaryngology and head and neck clinic during their follow up. Informed consent was obtained prior to inclusion in the study. There were two groups; a study group of patients who had undergone radiotherapy for various head and neck tumours, and a control group comprising patients seen in the University Sains Malaysia otorhinolaryngology clinic for other problems.

The inclusion criteria comprised head and neck tumour patients who had completed radiation therapy over one year previously and were aged between 20 and 70 years. A one-year post-radiotherapy period was necessary because acute radiation effects such as mucositis usually resolve by about three months, and late sequelae (in this case, salivary gland hypofunction) usually present eight months or more after completion of treatment.[8]

The following exclusion criteria were applied: any medication which might influence salivary production, secretion or flow (in particular, drugs with anticholinergic properties, including antidepressants, antihistamines and diuretics); systemic medical illness (e.g. diabetes mellitus, renal diseases and thyroid diseases); autoimmune or connective tissue diseases; previous disease or surgical removal of any major salivary gland; pre-existing xerostomia or any related oral morbidity, due to any cause; and a post-radiation interval of less than one year.

Saliva sampling

The appearance of each patient's oral cavity saliva was categorised into one of the following groups; normal, frothy, minimal, or dry (i.e. no saliva).

Salivary flow rate measurement

Salivary gland function was assessed objectively based on two parameters, the unstimulated whole salivary flow rate and the stimulated whole salivary flow rate. The latter required use of 2 per cent citric acid solution. These measurements were performed on both study and control subjects. The mean value for each measurement, for both groups, was compared.

Unstimulated whole salivary flow rate

The unstimulated whole salivary flow rate was measured by the draining method, as follows.[9] Patients refrained from eating or smoking for 90 minutes before the test session. The saliva was collected during a five-minute session under supervision. Subjects were asked to lean forward, keep their eyes open, minimise movement of the tongue and lips, and to allow saliva to drip off the lower lip into a container. At the end of five minutes, the patients were asked to expectorate into the container. The total amount of saliva collected and the flow rate (in ml/min) were measured. An average unstimulated whole salivary flow rate of 0.3–0.4 ml/min has been designated as normal; a rate of less than 0.1 ml/min is considered abnormal.[10]

Stimulated whole salivary flow rate

The stimulated whole salivary flow rate was measured by the spitting method under supervision, as follows. Patients refrained from eating or smoking for 90 minutes before the test session. Two per cent citric acid solution was used to stimulate saliva production.[11] One ml of this solution was placed on the dorsum of the subject's tongue. The subject was then instructed to void the mouth of saliva at one-minute intervals for three minutes. The amount of total saliva collected and the flow rate (as ml/min) were determined. An average stimulated whole salivary flow rate of 1–2 ml/min has been designated as normal; a rate of less than 0.5 ml/min is considered abnormal.[10]

Radiotherapy

The majority of the patients had received radiotherapy at the radiotherapy and oncology department of the Hospital of the Science University of Malaysia. All data regarding their radiotherapy were traced and recorded for further analysis. For patients who had received radiotherapy at other centres, data were obtained from the respective centres and recorded. Data included tumour type, tumour–node–metastasis (TNM) staging, total radiation dose, duration of radiation, volume of field irradiated, and type of radiation.

Statistical analysis

Study results were recorded and analysed using the Statistical Package for the Social Sciences version 11 software. A p value of less than 0.05 was considered to be significant. Non-parametric correlations were used to analyse the relationship between xerostomia and the variables of interest.

Results

Demographic data

A total of 60 patients were recruited for the study. The study group comprised 30 patients who had undergone radiotherapy for various head and neck tumours and who fulfilled the selection criteria (described above). The control group comprised 30 patients selected randomly on attendance at the otorhinolaryngology clinic of the Hospital of the Science University of Malaysia for other problems. The study group consisted of 21 men (70 per cent) and nine women (30 per cent), aged between 18 and 69 years, with a mean age of 48.3 ± 15.46

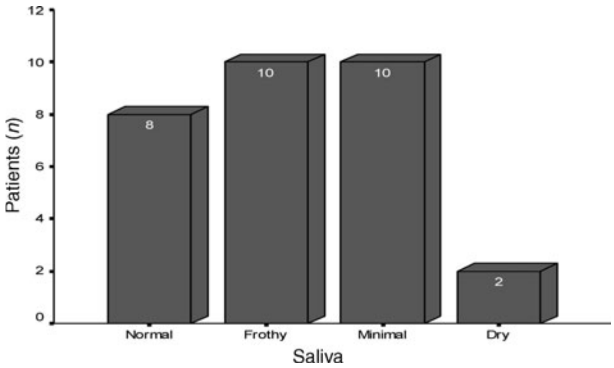

FIG. 1
Patients' oral cavity saliva. Numbers in bars indicate totals.

years. In the control group, the gender distribution was more equal (16 men (53.3 per cent) and 14 women (46.7 per cent)), aged between 25 and 61 years, with the mean age of 41.7 ± 11.27 years.

Saliva sampling

Figure 1 shows the distribution of patients' saliva into the four categories (normal, frothy, minimal or dry). Only eight patients (26.7 per cent) were found to have normal saliva.

Whole salivary flow measurements

Salivary gland hyposecretion secondary to radiotherapy was assessed objectively. Unstimulated and stimulated whole salivary flow rates were calculated for both groups. Table I shows the range, median and interquartile range for the unstimulated and stimulated whole salivary flow rate measurements of both groups.

Statistical analysis of whole salivary flow rate measurements was performed using the non-parametric test and the Wilcoxon signed ranks test. There was a significant difference in flow rates between the study and control groups ($p = 0.0001$). Figure 2 shows the unstimulated and stimulated whole salivary flow rates for both groups. The control group showed a statistically significantly greater increase in whole salivary flow rate after stimulation of the salivary glands with 2 per cent citric acid solution, compared with the study group.

In the study group, 24 patients (80.0 per cent) had abnormal unstimulated whole salivary flow rates

TABLE I
WHOLE SALIVARY FLOW RATE IN PATIENTS AND CONTROLS

Salivary flow rate (ml/min)	Patients		Controls	
	Unstim	Stim	Unstim	Stim
Min	0.00	0.06	0.04	2.17
Max	0.30	2.73	0.60	4.93
Median	0.00	0.38	0.30	3.40
IQR	0.05	0.515	0.295	1.23

Unstim = unstimulated; stim = stimulated; min = minimum; max = maximum; IQR = interquartile range

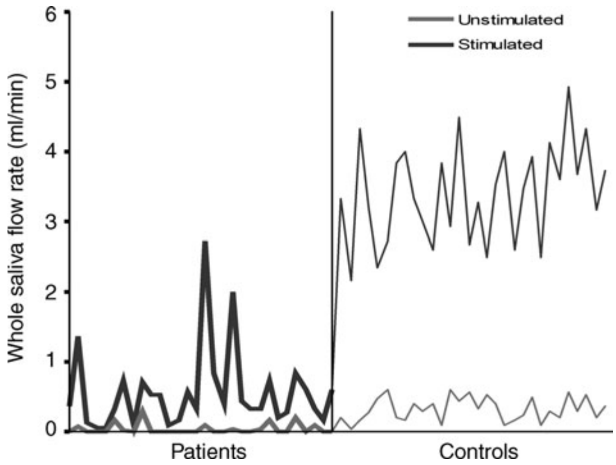

FIG. 2
Unstimulated and stimulated whole salivary flow rates for patients and controls.

(i.e. less than 0.1 ml/min), while 20 (66.7 per cent) had no unstimulated salivary flow at all (Figure 3). The median unstimulated whole salivary flow rate for the study group was 0.00 ml/min, with a range of 0–0.30 ml/min.

Seventeen study group patients (56.7 per cent) had abnormal stimulated whole salivary flow rates (i.e. less than 0.5 ml/min) (Figure 4). In the study group, the median stimulated whole salivary flow rate was 0.38 ml/min, with a range of 0.06–2.73 ml/min.

This difference between unstimulated and stimulated whole salivary flow rates was statistically significant (Spearman's rank correlation; $r = 0.515$; $p < 0.004$). In all patients, the stimulated whole salivary flow rate was greater than the unstimulated whole salivary flow rate.

Radiotherapy data collection

All the necessary data regarding patients' radiotherapy treatment was traced through their medical records and analysed for correlation with the study parameters. The diagnoses of the study group patients are shown in Table II. Nasopharyngeal

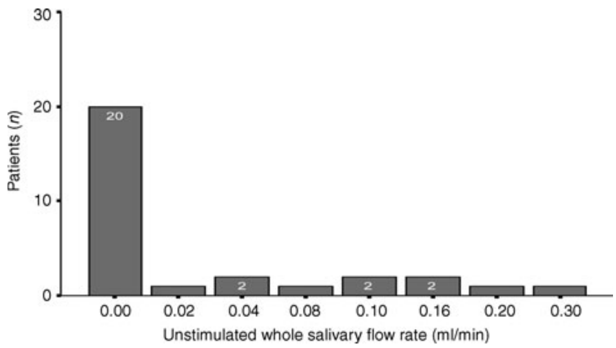

FIG. 3
Unstimulated whole salivary flow rates in study patients. Numbers in bars indicate totals. The x-axis shows uneven increments as not all numbers have been shown.

https://doi.org/10.1017/S0022215108002466 Published online by Cambridge University Press

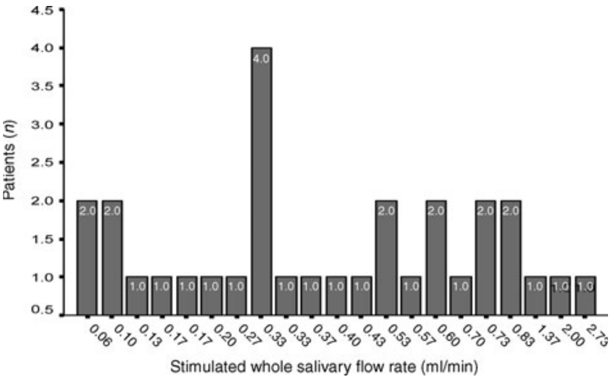

FIG. 4

Stimulated whole salivary flow rates in study patients. Numbers in bars indicate totals. The x-axis shows uneven increments as not all numbers have been shown.

carcinoma constituted 73.3 per cent (22 patients) of the diagnoses. Other types of cancers were laryngeal cancer (three patients, 10 per cent), hard palate cancer (two, 6.7 per cent), oral cancer (one, 3.3 per cent), thyroid cancer (one, 3.3 per cent) and nasopharyngeal angiofibroma (one, 3.3 per cent).

For the 29 patients with head and neck cancer, TNM classification was used to stage the tumours prior to commencement of radiotherapy. Three patients (10.3 per cent) were at stage I, eleven (38.0 per cent) at stage II, five (17.2 per cent) at stage III and ten (34.5 per cent) at stage IV. The patient with nasopharyngeal angiofibroma was at stage IV (Fisch's classification)[12] post-surgery but still had residual intracranial extension.

All of the study patients had received conventional radiotherapy (2 Gy/fraction daily, five times a week). All had received irradiation doses of more than 40 Gy with parallel opposed fields or anterior or posterior fields. All of the study patients had been irradiated in the head and neck region (the parotid, submandibular and sublingual glands were included in the field), except for three patients with laryngeal cancer and one patient with thyroid cancer, who had been irradiated only in the neck region. The median total radiation dose was 70 Gy and the median duration of radiation was 59.5 days.

Discussion

This study was conducted to objectively assess salivary gland function among patients who had undergone radiotherapy for head and neck tumours. The confounding effects in this study were age, gender and tumour type. Roesink and Terhaard[13] evaluated stimulated salivary function of the parotid glands in 108 patients with head and neck malignancies prior to radiotherapy. They found that the stimulated parotid salivary output was not correlated with patients' physiological or clinical variables, including sex, age, cigarette and alcohol use, parotid volume, tumour location, T and N stage, and pre-radiotherapy surgery. Although the present study measured whole salivary flow rather than parotid salivary flow, both parameters are comparable since most of the salivary output comes from the parotid glands, and the parotid glands are the most affected by radiotherapy. Therefore, it is reasonable to assume that both parameters would produce a similar outcome.

In general, radiotherapy which includes the salivary glands in the radiation field causes disruption of salivary gland function. Reduction in salivary flow has been documented previously during a course of radiotherapy which included major proportions of salivary tissue within the treatment volume. In humans especially, the parotid glands are markedly sensitive to radiation, with a reduction in salivary flow being detected after just one fraction of a course of treatment.[14] Table III lists several studies that have demonstrated early salivary flow changes after radiotherapy.

All of the patients in the present study had been irradiated in the head and neck region (the parotid, submandibular and sublingual glands were included in the field), except for three patients with laryngeal cancer and one with thyroid cancer, who had been irradiated only in the neck region, thus sparing most of the salivary glands. The four latter patients were found to have no evidence of abnormally reduced whole salivary flow rates. Since in these cases the salivary glands were not included in the radiation field, this would explain why these patients had no evidence of salivary gland hypofunction.

It is evident from the above observations that inclusion of salivary glands in the radiotherapy treatment field is one important predictor of salivary gland hyposecretion, which may later result in xerostomia. Valdez[5] stated that the radiation field is one of several important factors which determine the extent of radiation-induced salivary dysfunction. When all the major salivary glands are included within the radiation field, the mean salivary output can be reduced by as much as 93 per cent.[7] Patients requiring bilateral irradiation, with the major salivary glands entirely within the radiation field, usually suffer severe xerostomia and salivary dysfunction. On the contrary, where tumours allow part of the salivary glands to be spared from irradiation (such as laryngeal or thyroid cancers), patients usually suffer less salivary dysfunction and xerostomia.[5]

Our study used both unstimulated and stimulated whole saliva collection to measure salivary gland hyposecretion. This method – in particular, unstimulated saliva collection – has been proven to be effective for confirming the degree of xerostomia, compared with measurement of salivary output

TABLE II

TUMOUR TYPES TREATED BY RADIOTHERAPY

Diagnosis	*n*	%
Nasopharyngeal carcinoma	22	73.3
Laryngeal cancer	3	10.0
Hard palate cancer	2	6.7
Oral cavity cancer	1	3.3
Thyroid cancer	1	3.3
Nasopharyngeal angiofibroma	1	3.3
Total	30	100

https://doi.org/10.1017/S0022215108002466 Published online by Cambridge University Press

TABLE III

STUDIES REPORTING ALTERED SALIVARY FLOW POST-RADIOTHERAPY

Study	Pts (*n*)	Saliva collection technique	RT	Post-RT salivary flow (%* (post-RT time period))
Shannon *et al.*[16]	10	Unstimulated whole saliva (dribbling)	9 Gy/wk 4 fractions/wk Total 22.5–54 Gy	40 (1 wk) 29 (2 wks) 24 (3 wks) 19 (4 wks) 9 (5 wks) 5 (6 wks)
Wescott *et al.*[6]	13	Unstimulated whole saliva (dribbling)	9 Gy/wk 4 fractions/wk Total 45–63 Gy	36 (3 days)
Dreizen *et al.*[17]	42	Stimulated whole saliva (spitting)	10 Gy/wk 5 fractions/wk Total >50 Gy	43 (1 wk) 24 (6 wks)
Shannon *et al.*[14]	7	Unstimulated parotid saliva (Lashley cups)	9 Gy/wk 4 fractions/wk Total >50 Gy	50 (1 day) 0 (3 days)
Eneroth *et al.*[18]	4	Stimulated parotid saliva (Lashley cups)	10 Gy/wk 5 fractions/wk Total >40 Gy	18 (1 wk) <2 (4 wks)
Mossman *et al.*[4]	25	Stimulated parotid saliva (Lashley cups)	10 Gy/wk 5 fractions/wk Total 61 Gy (mean)	50 (1 wk) 0 (6 wks)

*As percentage of pre-RT flow. Reprinted with permission.[15] Pts = patients; RT = radiotherapy; wk = week

from individual salivary glands (in particular, the parotid glands).[19]

In this study, mixed whole saliva was collected by the drainage and spitting methods. These methods involved only minimal effort from the patients, required no difficult technique and used very minimal equipment (only a saliva collecting container). Thus, these methods proved to be simple and cost-effective. Other techniques of collecting whole saliva reported in the literature include the use of suction, a cotton roll and other absorbent devices. These methods are more difficult to employ, as they are more technical and require special and expensive equipment. The suction method requires special instruments to collect the saliva. The method using the cotton roll and absorbent devices can also be used for quantitation purposes. In this process, the cotton roll is weighed before and after it has been soaked with saliva. However, saliva is filtered through the cotton fibre in the process, preventing whole saliva from being collected.[20]

Salivary flow studies can confirm the functional status of all the salivary glands. The results of the current study demonstrate that salivary gland hyposecretion is common in post-irradiated head and neck tumour patients. Eighty per cent ($n = 24$) of the study group patients had abnormally low unstimulated whole salivary flow rates (i.e. less than 0.1 ml/min), whilst 42 per cent ($n = 17$) had abnormally low stimulated whole salivary flow rates (i.e. less than 0.5 ml/min). Although more than half of the study group patients did not have abnormal stimulated whole salivary flow rates, their stimulated salivary output was probably still inadequate. Both the unstimulated and stimulated whole salivary outputs of the study group patients were significantly lower than those of the control subjects. In addition, the unstimulated whole salivary output is a more important predictor of salivary gland dysfunction, as described above. The results of previous studies also suggest that salivary gland hyposecretion or hypofunction is common in post-irradiated head and neck tumour patients. Valdez *et al.*[11] reported a significant reduction of salivary flow in 50 patients with radiation-induced xerostomia, compared with controls. Out of 24 patients with abnormal unstimulated salivary flow rates, 83.3 per cent (20 patients) had no unstimulated whole saliva flow, implying no resting salivary function. These patients can be considered to have salivary gland dysfunction rather than hypofunction.

- **Ionising irradiation of salivary gland cells can result in changes in the glands and in saliva composition**
- **This study was performed to objectively evaluate salivary gland function in post-irradiated head and neck tumour patients**
- **Both the unstimulated and stimulated whole salivary flow rates of the patients were significantly reduced, compared with normal subjects, suggesting marked salivary gland hypofunction**

Two radiotherapy factors were evaluated in the present study and analysed for correlation with the study parameters: the total radiotherapy dose and the radiotherapy duration. We found no significant correlation between these radiotherapy parameters and the salivary flow rates, both unstimulated and stimulated. However, the study showed a weak relationship between unstimulated whole salivary flow rates and total radiotherapy dose ($p = 0.114$). As the total radiotherapy dose increased, there was a tendency for the unstimulated salivary flow to decrease more than the stimulated salivary flow rates. This finding is consistent with many reported studies which have shown that higher radiation doses are associated with reduced salivary flow rates, particularly the unstimulated rate.[11]

This can be further supported by an observation in the present study. In all patients in whom the salivary glands were included within the radiation field, the salivary flow rates were obviously reduced, indicating salivary gland hyposecretion, hypofunction or even dysfunction. However, this was not observed in one patient with hard palate cancer and one with nasopharyngeal angiofibroma. The patient with hard palate cancer had an unstimulated whole salivary flow rate at the cut-off point of 0.1 ml/min. The patient with nasopharyngeal angiofibroma had a normal unstimulated whole salivary flow rate (0.16 ml/min). Interestingly, this latter patient received a total radiotherapy dose of 45 Gy; at this radiation level, the patient may still have had some residual salivary function. Many studies have reported that the extent of salivary dysfunction is determined not only by the radiation field but also by the radiation dose.[5,11,21]

Valdez *et al.*[11] stated that complete loss of salivary function was observed following irradiation doses over 60 Gy. Doses below 50 Gy were found to have less influence on salivary gland function, with gradual recovery observed a few years after radiotherapy.[22]

Conclusion

The results of this study indicate that salivary gland hyposecretion is a common problem in patients who have undergone radiotherapy for head and neck tumours. The salivary function of these patients (measured by salivary flow rates) is significantly reduced compared with normal control subjects, suggesting marked salivary gland hyposecretion, which in many cases may have progressed to salivary gland dysfunction.

References

1 Mossman KL. Quantitative radiation dose-response relationship for normal tissues in man. Responses of the salivary glands during radiotherapy. *Radiat Res* 1983;**95**: 392–9
2 Marks JE, Davis CC, Gottsman VL, Purdy JE, Lee F. The effects of radiation on parotid salivary function. *Int J Radiat Oncol Biol Phys* 1981;**7**:1013–19
3 Cheng VS, Downs J, Herbert D, Aramany M. Function of the parotid gland following radiation therapy for head and neck cancer. *Int J Radiat Oncol Biol Phys* 1981;**7**:253–8
4 Mossman KL, Shatzman AR, Chencharick JD. Effects of radiotherapy on human parotid saliva. *Radiat Res* 1981; **88**:403–412
5 Valdez IH. Radiation-induced salivary dysfunction: Clinical course and significance. *Spec Care Dentist* 1991;**11**: 252–5
6 Wescott WB, Mira JG, Starcke EN, Shannon IL, Thornby JI. Alterations in whole saliva flow rate induced by fractionated radiotherapy. *AJR Am J Roentgenol* 1978;**130**:145–9
7 Dreizen S, Brown LR, Handlers S, Levy BM. Radiation-induced xerostomia in cancer patients: effects on salivary and serum electrolytes. *Cancer* 1976;**38**:273–8
8 Kendall KA, McKenzie SW, Leonard RJ, Jones CU. Timing of swallowing events after single-modality treatment of head and neck carcinomas with radiotherapy. *Ann Otol Rhinol Laryngol* 2000;**109**:767–75
9 Navazesh M, Christensen CM. A comparison of whole mouth resting and stimulated salivary measurement procedures. *J Dent Res* 1982;**61**:1158–62
10 Anonymous. Saliva: its role in health and disease. FDI Working Group 10 of the Commission on Oral Health, Research and Epidemiology (CORE). *Int Dent J* 1992;**42**: 287–304
11 Valdez IH, Atkinson JC, Ship JA, Fox PC. Major salivary gland function in patients with radiation-induced xerostomia: flow rates and sialochemistry. *Int J Radiat Oncol Biol Phys* 1992;**25**:41–7
12 Fisch U. The infratemporal fossa approach for nasopharyngeal tumors. *Laryngoscope* 1983;**93**:36–44
13 Roesink JM, Terhaard CH. The influence of clinical factors on human stimulated parotid flow rate in cancer and other patients. *Oral Oncol* 2002;**38**:291–5
14 Shannon IL, Tridahl JN, Starcke EN. Radiosensitivity of the human parotid gland. *Proc Soc Exp Biol Med* 1978; **157**:50–3
15 Leslie MD, Dische S. The early changes in salivary gland function during and after radiotherapy given for head and neck cancer. *Radiother Oncol* 1994;**30**:26–32
16 Shannon IL, Feller RP, Beach PD. Parotid saliva acid phosphatase in health and disease. *Aust Dent J* 1976;**21**:138–42
17 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
18 Eneroth CM, Henrikson CO, Jakobsson PA. Effect of fractionated radiotherapy on salivary gland function. *Cancer* 1972;**30**:1147–53
19 Vitali C, Moutosopoulos HM, Bombaidieri S and The European Community Study Group. Diagnostic criteria for Sjogren's syndrome. *Ann Rheum Dis* 1994;**53**:637–47
20 Cawson R, Gleeson M. Anatomy and physiology of the salivary glands. In: Gleeson M, ed. *Scott-Brown's Otolaryngology*, 6th edn. Oxford: Butterworth-Heinemann, 1997:**1**
21 Fox PC. Acquired salivary dysfunction. Drug and radiation. *Ann N Y Acad Sci* 1998;**842**:132–7
22 Markitziu A, Zafiropaulos G, Tsalikis L, Cohen L. Gingival health and salivary function in head and neck irradiated patients, a five-year follow-up. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1992;**73**:427–33

Address for correspondence:
Dr Baharudin Abdullah,
Dept ORL-HNS,
School of Medical Sciences,
Universiti Sains Malaysia,
16150 Kubang Kerian,
Kelantan, Malaysia.

Fax: +609 7653370
E-mail: baharudin@kb.usm.my

Dr A Baharudin takes responsibility for the integrity of the content of the paper.
Competing interests: None declared