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Quantitative estimation of doses to salivary glands from using brachytherapy in head and neck cancers

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ABSTRACT

PURPOSE: To quantify the percentage doses received by salivary glands (SGDs) in head and neck interstitial brachytherapy (BT).
METHODS AND MATERIALS: The study included 43 patients who underwent high−dose rate iridium-192 implant for oral cavity and oropharyngeal lesions treated with BT as a boost. BT dose varied with disease stage and external radiation dose, with the total mean dose of 66 ± 4 Gy. Patients were divided into two groups, midline and lateralized, based on anatomic implant location. Different dose parameters such as D_{max}, D_{mean}, $DV_{30\%}$ of individual glands were derived from dose volume histogram representing the percentage maximum dose, mean dose, and dose received by 30% volume of individual SGDs, respectively. For better perception of the impact of BT on individual SGDs, the doses received are extrapolated to radical BT dose of 60 Gy.
RESULTS: For lateralized implants, the highest dose received by ipsilateral parotid (PTD) was 12.3% seen in tonsillar implants. The contralateral PTD receives minimal doses. As expected, the ipsilateral submandibular gland (SMG) received high doses in the range of 80% of the total prescribed dose, whereas contralateral SMG received 10% of ipsilateral dose. For the midline implants, the mean dose range for PTD was 7−11% of the total prescribed dose and for SMG between 17% and 56%, depending on the location.
CONCLUSIONS: The study quantifies the percentage doses received by the individual SGDs in interstitial head and neck BT for use in future planning of the BT procedures and for salivary functional studies, prediction of damage, and quality-of-life parameters.

Keywords: Brachytherapy; Salivary glands; Xerostomia; Head and neck cancers

Introduction

Cancers of the oral cavity and oropharyngeal region, in the early stages, can be treated equally well by surgery or radiation therapy (1−5). Treatment-related toxicities and resulting morbidity dictate the choice of treatment in routine clinical practice. One of the commonest and most important complications of head and neck (H&N) radiotherapy (RT) is salivary gland (SGD) damage that is manifested in the form of acute and late xerostomia, which can significantly affect the quality of life of the patients (6−10). Both external radiation and brachytherapy (BT) are responsible for these side effects, but the spectrum of the scale of damage can vary from minimal with BT to severe with teletherapy. It must be emphasized that xerostomia is proportional to the degree and extent of SGD damage, which in turn depends on the sum total of effective dose received by individual and/or all glands (11).

The "quantitative relationship" between the dose−volume distribution of individual major SGDs, the extent and severity of damage of these glands with such doses, and their functional outcome is not well documented in the

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literature. Various techniques like three-dimensional conformal radiotherapy (12, 13), intensity-modulated radiotherapy (IMRT) (14–19), and BT (20, 21) can reduce dose to SGDs, and thereby reduce the extent of damage. However, all attempts of sparing the SGDs from effects of radiation cannot be embarked on until one develops a better understanding of the above-mentioned quantitative relationship.

With the advent of highly technical and computerized calculation systems, we can now calculate the exact doses received by the SGDs with various forms of external beam radiotherapy (EBRT) and BT. There are large data now that specify these doses for EBRT depending on various sites for H&N cancers, but the lacuna persists as far as BT is concerned. Because of paucity of data on the exact amount of doses received by the SGDs during BT for different sites in the H&N, it is difficult to undertake comparative studies with regard to this modality. Also functional studies of SGDs require the preliminary data regarding doses received by the major SGDs during BT for different sites for adequate correlation between deterioration of function and amount of radiation received by the SGDs. This study was undertaken to estimate and report the actual doses, measured in terms of percentage values, received by individual major SGDs in malignancies of the oral cavity and oropharynx treated with interstitial BT.

Methods and materials

Patient selection

The study group includes 43 patients, the demographic features of whom are discussed in Table 1.The age ranged from 40 to 78 years with a median age of 58 years. The various sites treated were oral tongue (OT) (12 patients), Base of tongue (BOT) including vallecula and epiglottis (16 patients), tonsil/soft palate (SP) including posterior pharyngeal wall (15 patients). The patients were of varying stages, 70% belonging to early stages (Stage I/II), whereas 30% were advanced stages (Stage III/IV). Depending on the stage and requirement for treating the neck, patients were treated with varying doses of EBRT to the primary (mean dose ~46 Gy), followed by interstitial BT to a radical total equivalent dose ranging between 62 and 70 Gy (mean dose 66 ± 4 Gy standard deviation). The dose and delivery details of EBRT are not elaborated as the focus of the study is the percentage estimation of SGD doses with BT.

Table 1

Patient characteristics	No. of patients
Sex	
Male	38
Female	5
Age	
<50	14
⩾50	29
Disease location	
OT	12
Tonsil/SP	15
BOT including epiglottis	16
Stage of disease	
Early (AJCC Stage I/II)	30
Advanced (AJCC Stage III/IV)	13
Implant volume (cc)	
OT	33 (±11)
Tonsil	19 (±6)
BOT	29 (±13)
SP and hard palate	34 (±12)

OT = oral tongue; SP = soft palate; BOT = base of tongue; AJCC = American Joint Committee on Cancer.

Interstitial BT for the specific site was performed under general anesthesia with volume implant, keeping the BT and oncological principles in consideration. Implant planes were subject to size and site of lesion as also on the need to deliver adequate dose to adjacent site vulnerable for potential spread. Patients were treated on the microselectron high–dose rate unit with iridium-192, with a radical BT dose depending on the amount of EBRT given. The dose per fraction was 4.5 Gy, twice a day with a minimum duration of 6–8 h between the two fractions.

Technique for the OT and BOT implants

There are various techniques for OT and BOT interstitial implants. We follow nonloop plastic bead technique for the same, and the technique was extended for vallecula and epiglottis. Implant generally requires double plane, but depending on the tumor size and stage of disease, a volume implant (three to four planes as needed) may be considered necessary. Each plane may have four to six tubes, as necessary. The technique involves insertion of 17G stainless steel needle from submental region taking enough care to avoid damage to critical structure. It is followed with the insertion of a double-lead tube, which forms the posterior most line of individual plane. Our technique differs slightly as we use plastic tubes with beads that have two slits (horizontal and vertical) for the anterior tubes. Vertical slit attaches with the tube itself, whereas the horizontal slit allows threading of tapered portion of posterior most double-lead tube through it. The required number of anterior tubes is inserted, with their beaded intraoral ends resting on the surface of the tongue. The tapered portion of posterior most tube passes through each of these beads in individual planes such that the tube now rests over the surface and forms crossings for respective planes to correct for underdose at the surface. The acceptable distance between the tubes and the planes is kept at around 1.0–1.2 cm. At the end of procedure, posterior double-lead tube is replaced by a single-lead tube with metal button at one end that rests anterior to the bead of the anterior most line of that plane and prevents slippage of posterior most tube. A full description of the implant technique is beyond the scope of this article, but interested readers are referred to other articles (22–24). Figure 1 shows a diagrammatic representation.