Case study

The Radiographer 2008; 55 (1): 7–11

Tin foil modified electron radiation of the skin of the nose

Wendy D Arancini, Sharon A Brackenridge

Perth Radiation Oncology, Wembley, WA 6014, Australia.
Correspondence sharon.brackenridge@radonc.com.au

Abstract Radiation therapy to the skin of the nose for non-melanoma skin cancer is common in Australia yet presents numerous dosimetric and practical challenges. A tin foil modified electron (TME) radiation technique has been used routinely at Perth Radiation Oncology since 2001. The development of this technique over an extended period involving almost 100 cases is reported and key processes at simulation, planning and treatment delivery are described. A summary of major clinical outcomes is presented for 53 patients treated with TME between 2001 and 2005.

Keywords: bolus, electrons, nose, radiation therapy, skin cancer, tin foil, TME

Introduction

Exposure to UVB radiation from the sun is well accepted as the most common environmental cause of skin cancer.[1,2] Most parts of Australia experience a high proportion of sunny days and days with many hours of sunshine, so it is not surprising that Australia has a high incidence of non-melanoma skin cancer. Different parts of the body receive different levels of exposure to the sun, with the skin of the nose considered an area of the face receiving most exposure along with the ears and cheeks.[1] In the case of basal cell carcinomas, lesions of these most exposed areas of the face occur twenty times as commonly as lesions in other parts of the body.[1]

Surgery and radiation therapy offer equivalent control rates for non-melanoma skin cancers.[2] Patient age and general health condition, size and location of the tumour, treatment complication rates and cosmesis[2, 3] play a part in determining a treatment management plan. Where disease is extensive or recurrent, surgical treatment options may necessitate use of a prosthesis. Prosthetic rehabilitation following extensive surgery has been shown to produce results considered cosmetically acceptable to clinicians,[4,5] however, patient satisfaction with the cosmetic outcome is largely unreported.

Radiation therapy provides an effective alternative for selected patients, particularly those who are older, those with co-morbidities, those with inoperable disease[6] or those for whom surgical management will result in severe disfigurement. The key advantages of radiation therapy as a treatment modality for non-melanoma skin cancers of the nasal skin are the opportunity to preserve anatomy and the avoidance of surgery.[3] Documented side effects of radiation therapy treatment to this area of the face include hypopigmentation, atrophy and telangiectasia.[3,7,8]

The skin of the nose is commonly irradiated using electron beams. The planning and delivery of electrons to the nose presents some challenges. The irregular contours of the nose complicate radiation therapy dosimetry. The contour variation of the facial topography, the air cavities within the nose, and the oblique incidence of the radiation beam to the skin surface cause distortion of the absorbed dose distribution.[3,9,10]

While a single electron portal can often adequately cover the target volume geometrically, the dose distribution is frequently unsatisfactory.[9] Equally, the use of matched adjacent electron portals can lead to areas of underdose or overdose in the junction area.[7] While the area of overdose may be small enough, generally, to be considered clinically insignificant, the area of underdose may lead to adverse clinical outcomes if located in the gross tumour volume (GTV).[9] Multiple static electron portals, each encompassing the entire planning target volume (PTV), present a distinct advantage by providing a means of minimising obliquity without the need for junctions. In reviewing their experiences in the use of multiple static electron portals to deliver conformal radiation therapy to the nose, Zackrisson and Karlsson (1996) indicate that adding two fields at a 20 degree angle from vertical in the transverse plane considerably improved the homogeneity of the dose distribution.[9]

Typically for electron beams, the surface dose is lower than the therapeutic level so tissue equivalent bolus is placed at the surface[11] to ensure adequate irradiation of superficial tissues. Such use of tissue equivalent bolus causes a decrease in the therapeutic range equivalent to the thickness of the bolus.[11] Paraffin wax bolus is commonly employed, however custom fabrication of wax bolus is a time-consuming, difficult process.[10] Gelatine-based or 'flab' materials may prove more resource-effective, but there remain practical difficulties in using any of these conventional bolus types as there is frequently dosimetric distortion due to air gaps between the bolus and the skin surface, caused by the manner in which the bolus has been constructed,[7] the placement of the bolus during treatment, or changes in the lesion during the treatment course.

Lambert, *et al.* (1999) found that the use of high density metal foil as a bolus material for electron beams allows a therapeutic dose level at the skin surface while minimally affecting the therapeutic range.[11] Tin foil is a high density metal foil that is generally easily available, relatively inexpensive, easy to use[11] and simple to clean. Tin foil modified electron beams have been demonstrated as possessing superior depth dose characteristics compared with wax-bolused beams, resulting in improved coverage of superficial lesions.[12] Use of tin foil as bolus effects an increase in therapeutic interval that is not possible with tissue equivalent bolus.[11, 13] Unlike the situation for conventional tissue equivalent bolus, air gaps of up to 5 mm between a phantom surface and the tin foil have negligible effect on the relative surface dose or therapeutic range.[13] Tin foil modified electron

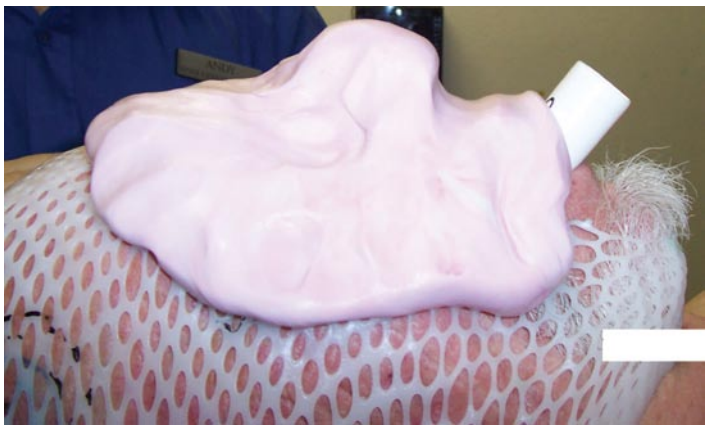

Fig. 1. Impression putty in place at simulation.

beams have been demonstrated as possessing superior depth dose characteristics compared to wax-bolused beams, resulting in improved coverage of superficial lesions.[12]

Tin foil as bolus for the treatment of superficial non-melanoma skin cancers of the nose commenced at Perth Radiation Oncology in October 2001. This tin foil modified electron (TME) radiation technique has been employed for almost 100 patients, often for disease recurrent after surgery, for inoperable tumours or where multifocal disease is present. The use of TME for treatment of superficial non-melanoma skin cancers of the nose is now routine at Perth Radiation Oncology.

Methods and materials

Simulation

Patients are positioned supine using a MedTec (Upwey, Vic, Australia) immobilisation system including a thermoplastic head cast. In the initial development of this technique, the neck was hypoextended so that the anterior surface of the nose was parallel to the couch top. This position proved uncomfortable for patients to maintain and time-consuming to achieve at daily set-up, so patients are now positioned in a more comfortable, neutral position. A narrow tube to enable breathing is placed in the patient's mouth and a thermoplastic cast is prepared. After cooling, the head cast is removed from the patient and the area around the eyes and nose cut away to facilitate access to the treatment volume.

The extent of the volume to be treated to the 90% therapeutic isodose is marked on the patient's skin using a dark-coloured wax pencil in the same manner as a routine superficial radiation therapy clinical mark-up, ensuring that the markings are contiguous and well defined. Impression putty is smoothed over the patient's eyes, nose and anterior cheeks in a layer approximately 1 cm thick (Fig. 1). Plaster bandage strips are placed across the putty to protect the integrity of the mould. Once the plaster has hardened, the entire impression is removed from the patient's face. Field limits are recorded relative to vertical baseline, columella and midline and close-up digital photographs captured from the direct anterior view and both lateral views. The patient is CT scanned, acquiring a dataset with 1 mm slices. Overall, the total time required for simulation and CT is not significantly different to that required for techniques using wax bolus.

Due to the nature of the impression putty, the wax pencil marks transfer precisely to the internal surface of the impression. A plaster cast of the impression is made providing an exact replica of the treatment site and surrounding facial contours. The plaster cast provides a firm base to produce customised bolus from tin foil: the stock tin foil used is 0.3 mm in thickness and is extremely

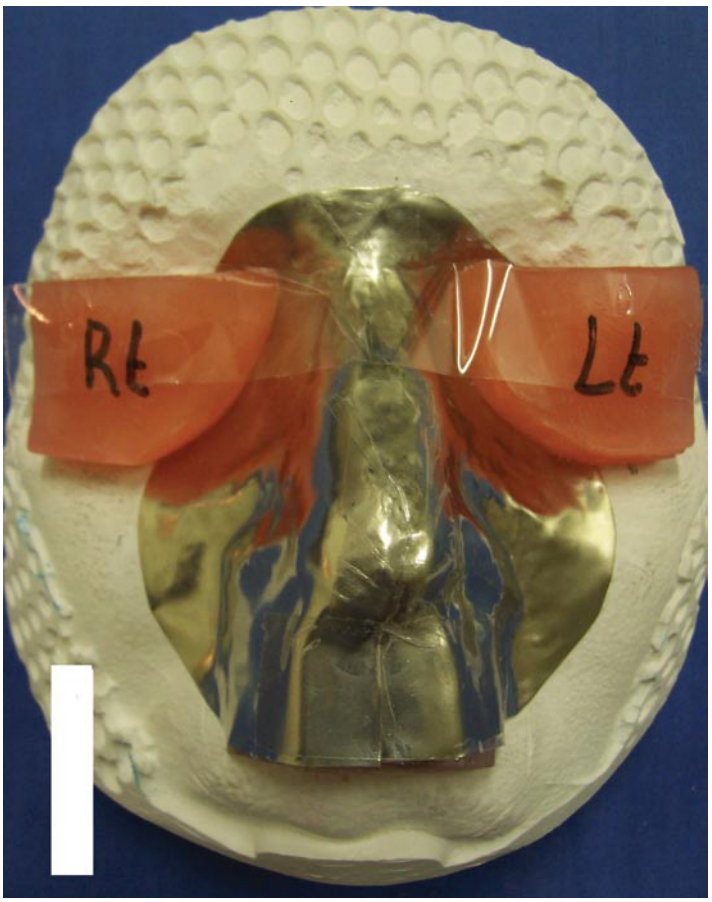

Fig. 2. Example of tin foil bolus and eye shields.

malleable and simple to work. The wax pencil marks from the internal surface of the impression are absorbed by the porous plaster, resulting in precise delineation of the treatment volume on the plaster cast and providing a guide to the size and shape of customised bolus required. The tin is moulded in two sections. Each section follows the contours and profile of one side of the nose, and the two sections are joined approximately along midline using tape. The customised bolus extends approximately 1 cm beyond the volume delineated at simulation as the final treatment portals will, necessarily, extend past these limits to achieve 90% dose coverage. Customised wax eye shields are prepared and, in the event that these abut with the tin foil, can be manufactured to ensure a snug fit. Where it is likely that the electron portals will splay onto the patient's upper lip, a small wax block is manufactured to abut the nose inferiorly and is designed for a neat fit with the tin foils (Fig. 2). While manufacturing these treatment accessories is somewhat labour-intensive, we have found that the process to create customised tin foil and eye shields is significantly faster and simpler than the production of customised wax bolus.

Planning

Using the photographs and measurements recorded at simulation, a PTV is rendered to visually match the clinical marks defined at simulation. The PTV extends posteriorly into the patient's tissue to the treatment depth specified by the radiation oncologist, usually 0.5 cm. Generally, three monoisocentric electron portals are employed, each encompassing the entire PTV and thus eliminating the need for junctions (Fig. 3). Electron energies used range from 4–10 MeV and are selected to optimise coverage of the PTV. One portal is positioned in skin apposition in the superior-inferior direction following the profile of the nose, while the other two portals approximate skin apposition for each lateral

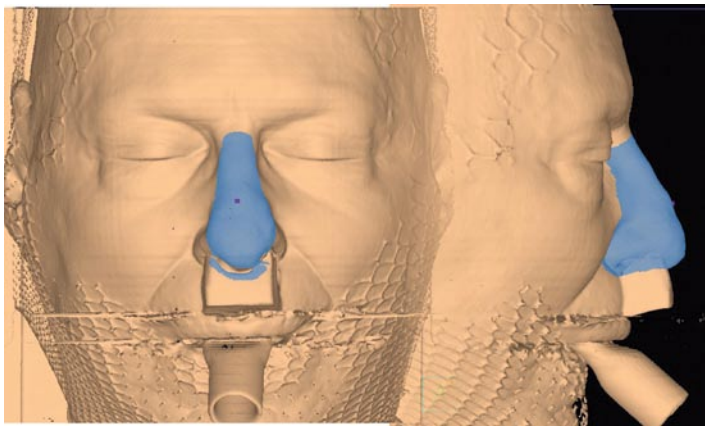

Fig. 3. Skin render demonstrating extent of the treatment portals on the patient's skin. Note that inferior splay is absorbed by the wax block.

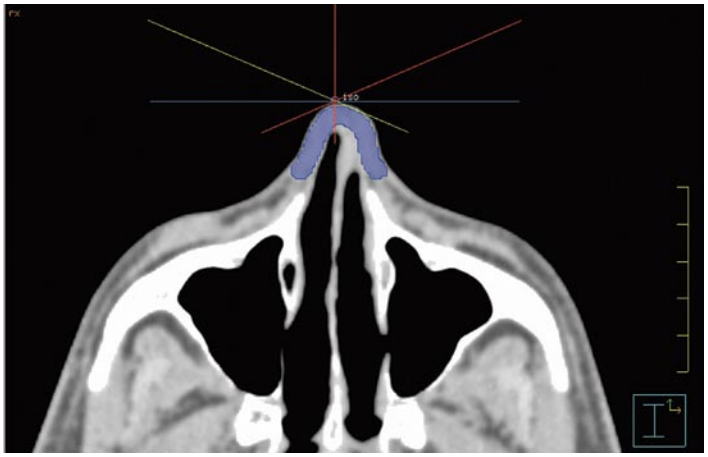

Fig. 4. Typical beam arrangement – transverse view.

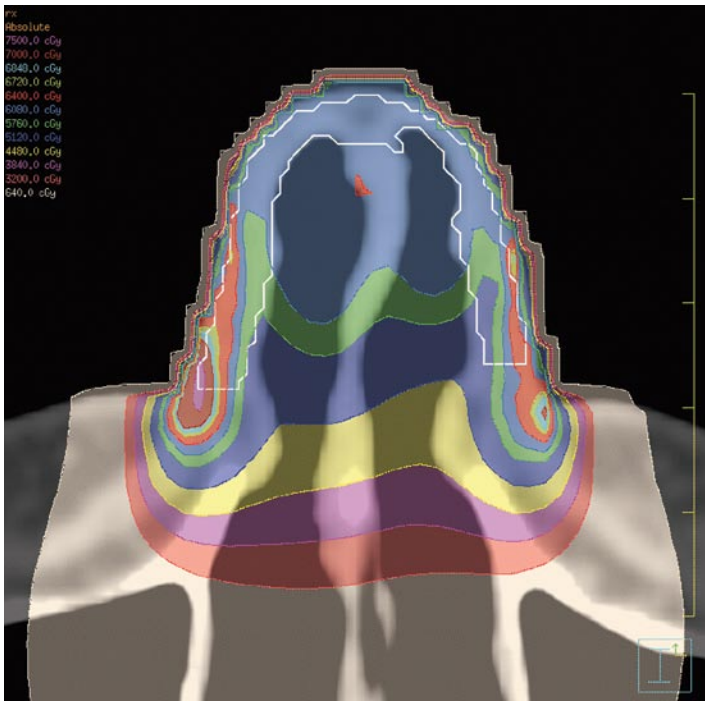

Fig. 5. Typical isodose distribution – transverse view (PTV is delineated in white).

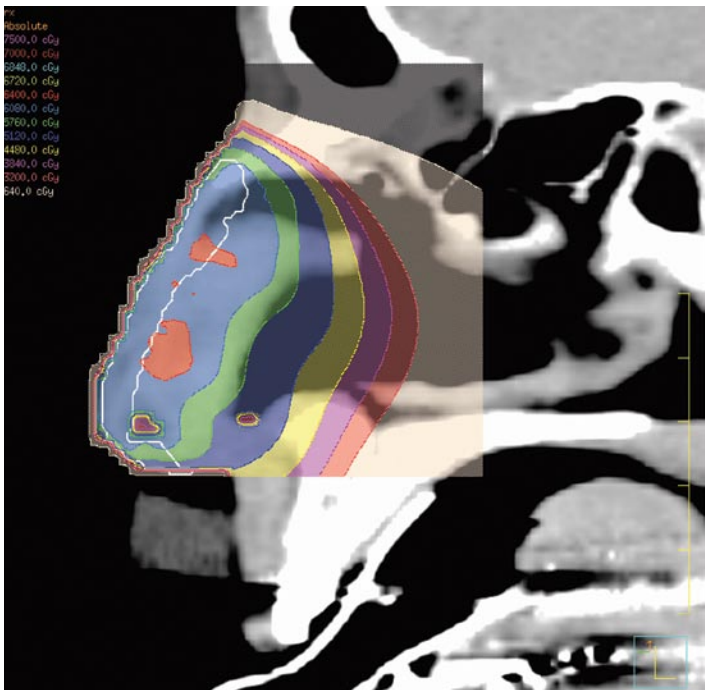

Fig. 6. Typical isodose distribution – sagittal view (PTV is delineated in white).

aspect of the nose (Fig. 4). The prescribed dose is generally 60 Gy at 2.0 Gy per daily fraction normalised to 100% at a dose point placed in the central region of the PTV.

Beam data has been modelled and calibrated for the Pinnacle3 TPS such that a single layer of 0.3 mm tin foil is automatically incorporated into the calculation. In this way, it is unnecessary for the planning radiation therapist to add the bolus as a beam modifier. It is sometimes challenging to identify the most appropriate location for placement of the prescription or dose point due to the small, irregular fields and a lack of sufficient unit density tissue in the PTV. In these situations, the prescription or dose point is located as centrally as possible within the PTV such that the point is within at least 0.5 cubic centimetres of unit density tissue. A dose grid of 1 mm resolution incorporates all beams and the PTV to maximise the calculation accuracy.

Beam weightings are adjusted to optimise PTV coverage, with a minimum therapeutic isodose level of 90% (Figs. 5, 6). Absolute maximum doses are, occasionally, relatively high at up to 130% of the prescribed dose: it should be noted, however, that the tissue volume involved is generally in the vicinity of 0.01 cm^3. When one considers the tiny volume affected by this absolute maximum, the dose variation across the volume is deemed clinically acceptable. At the 1 cm^3 volumetric level, dose is generally in the vicinity of 110% of the prescribed dose. An additional, secondary calculation occurs with the dose grid resolution adjusted to 4 mm and incorporating all beams, the PTV, the orbits and lenses to identify maximum dose received by the eyes. This calculation is not considered sufficiently accurate for treatment monitor units but serves as a satisfactory estimate of dose to the eyes. A typical DVH demonstrating coverage of the PTV and dose to critical structures is depicted in Fig. 7.

Treatment delivery

Patients are positioned as for simulation with the thermoplastic head cast and breathing tube in place. Treatment radiation therapists use a combination of the set-up measurements determined in planning and rendered 3D skin images derived from the planning CT data set to accurately position the isocentre and, subsequently, confirm each field prior to treatment. Using a monoisocentric

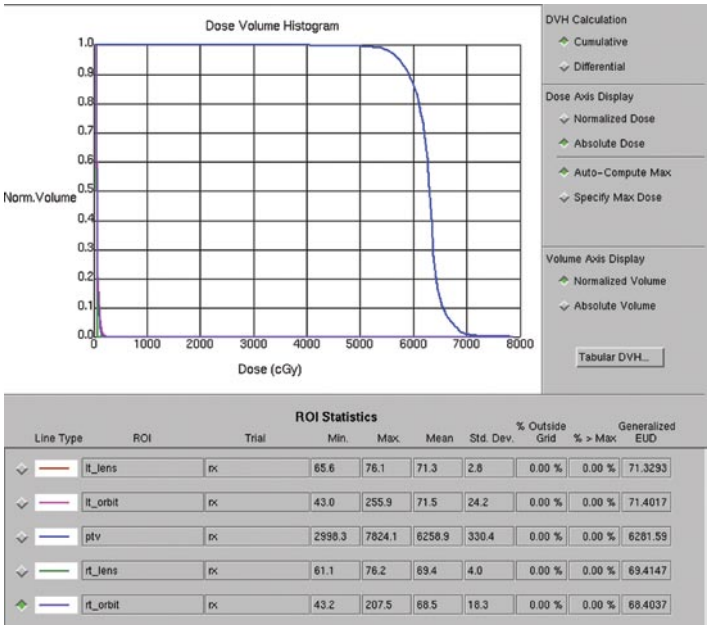

Fig. 7. Typical DVH demonstrating dose to PTV and lenses.

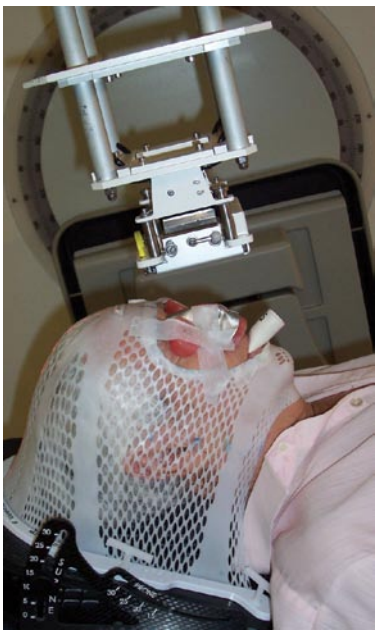

Fig. 8. Patient positioned for treatment with superior-anterior oblique portal.

technique minimises the intervention required between delivery of each of the three fields: generally, only a change in gantry angle, couch angle and customised electron insert is required. As the electron inserts are manufactured by hand, it is sometimes necessary to make tiny adjustments in couch longitude and latitude to compensate for slight inaccuracies in the centering of the inserts. Where corrections are required, treatment radiation therapists use rendered 3D skin images prepared at treatment planning to visually match the treated fields to the planned fields. Tin foils and wax accessories are lightly taped to prevent slippage (Fig. 8). Generally, patient positioning and treatment delivery take 10–15 minutes.

Results and discussion

Since 2001, almost 100 patients have received treatment for non-melanoma skin cancers of the nose using TME. Many of these patients have been high-risk candidates for recurrence. Clinical results for the cohort of patients treated between October 2001 and October 2005 have been examined to determine the clinical effectiveness of TME.[14] The cohort represents 53 patients with histologically proven non-melanoma skin cancer of the nose (72% BCC, 23% SCC and 5% both BCC and SCC). Median follow-up was 18 months. All except one patient remained free of in-field recurrence. TME was tolerated well by the cohort: using the RTOG/EORTC late radiation morbidity scoring scheme, scores of less than or equivalent to Grade 1 were reported by 88% of patients in the cohort for skin effects and 94% for mucous membrane effects. In general, we have observed that skin reactions are initially more severe compared with tissue-equivalent bolus techniques, however cosmesis post-radiation therapy treatment is considered excellent by the attending clinicians. Patients have indicated their satisfaction with the cosmetic outcome. Similarly, the use of TME has been observed as resulting in fewer late effects inside the nose, such as crusting and bleeding, compared with techniques using tissue-equivalent bolus.

The intended outcome of using bolus material for treatment to the skin of the nose is to ensure a clinically effective dose is delivered superficially. It is expected that the application of bolus will result in acute skin reactions, both externally and internally. Where tin foils are used as bolus material, we have observed that acute reactions of the external skin tend to be more severe than those for patients treated using tissue-equivalent bolus. Patients treated with TME experience erythema and dry desquamation, sometimes progressing to moist desquamation in the latter stages of treatment. In most cases the acute reaction of the external skin has virtually resolved at 4–6 weeks following completion of treatment. The skin of the internal surfaces of the nose demonstrates similar acute reactions. In the early stages of developing this technique, treatment radiation therapists packed the patient's nostrils with wet gauze in an effort to minimise skin reactions due to air cavities within the nose. It was determined however, that it was impossible to ensure that the nostrils were packed consistently at each treatment and all patients are now treated without packing. We have observed that internal skin reactions using TME have been no more severe than those where wax is employed and may, in fact, be somewhat less severe.

Conclusion

Radiation therapy treatment of the nose is complicated by the complex anatomical shape, the inhomogenous nature of the treatment volume and the physical properties of electron beams. The use of tin foil as a bolus material has enabled delivery of clinically effective treatment to the skin of the nose in a relatively simple and efficient manner that is tolerated well by patients. TME is now used routinely for the treatment of superficial cancers of the nose at Perth Radiation Oncology.

The authors gratefully acknowledge the contributions made by Dr Janelle Heywood and Dr Sean Geoghegan to the development of the TME technique.

References

1 Raasch B, Maclennan R, Wronski I, Robertson I. Body site specific incidence of basal and squamous cell carcinoma in an exposed population, Townsville, Australia. *Mutat Res* 1998; 422: 101–6.

2 Chao KSC, Perez CA, Brady LW. Radiation Oncology: Management Decisions 2 ed. Philadelphia: Lippinott Williams & Wilkins; 2002.

3 Tsao MN, Tsang RW, Liu F, Panzarella T, Rotstein L. Radiotherapy management for squamous cell carcinoma of the nasal skin: The Princess Margaret Hospital experience. *Int J Radiat Oncol Biol Phys* 2002; 52: 973–9.

4 Rodrigues S, Shenoy VK, Shenoy K. Prosthetic rehabilitation of a patient after partial rhinectomy: A clinical report. *J Prosthet Dent* 2005; 93: 125–8.

5 Sleilati F, Chaussard H, Kolb F, Mamelle G, Luboinski B. Management of

advanced and recurrent squamous cell carcinoma of the inner nasal lining. *Br J Oral Maxillofac Surg* 2005; 43: 126–33.

6 Mulkens PJM, Kreysel HW. Indications for radiotherapie in dermatologic oncology.S122.

7 Bedford JL, Childs PJ, Nordmark Hansen V, Warrington AP, Mendes RL, Glees JP. Treatment of extensive scalp lesions with segmental intensity-modulated photon therapy. *Int J Radiat Oncol Biol Phys* 2005; 62: 1549–58.

8 Turner SL, Lochrin CA, Dische S, Saunders MI, Maher EJ. Continuous Hyperfractionated Accelerated Radiotherapy in the treatment of carcinoma of the columella and vestibule of the nose. *Oral Oncol Eur J Canc* 1995; 31B: 368–72.

9 Zackrisson B, Karlsson M. Matching of electron beams for conformal therapy of target volumes at moderate depths. *Radiotherap Oncol* 1996; 39: 261–70.

10 Humphries SM, Boyd K, Cornish P, Newman FD. Comparison of super stiff and paraffin wax bolus in radiation therapy of irregular surfaces. *Medic Dosimet* 1996; 21: 155–7.

11 Lambert GD, Richmond ND, Kermode RH, Porter DJT. The use of high density metal foils to increase surface dose in low-energy clinical electron beams. *Radiotherap Oncol* 1999; 53: 161–6.

12 Geoghegan S, Heywood J, Arancini W. Electron Field Treatments for Superficial Nose Cancers Using Tin Foil Bolus. World Congress on Medical Physics & Biomedical Engineering. Sydney; 2003.

13 Healy BJ, Padmanabhan P, Nitschke K. Tin foil as bolus material for therapeutic electron beams from the Varian Clinac 2100C/D. *Aust Phys Engineer Sci Med* 2005; 28: 8–13.

14 Tang CL, Heywood J, Geoghegan S, Arancini W. The use of tin foil modified electron therapy on skin cancer of the nose: the Perth Radiation Oncology experience. Perth Radiation Oncology; 2007.