HOW I DO IT

Interstitial Brachytherapy for Early Oral Tongue Cancer Using Iridium Hairpin or Wire

RKC Ngan, RKY Wong, F Tang

Department of Clinical Oncology, Queen Elizabeth Hospital, Hong Kong

ABSTRACT

Although both radiotherapy and surgery can cure the majority of patients with early oral tongue cancer, radiotherapy consisting mainly of interstitial brachytherapy has the advantage of preserving the tongue function. Interstitial brachytherapy alone employing iridium-192 hairpins or wires has been the standard radiotherapy during the past few years for localised early oral tongue cancer at the Queen Elizabeth Hospital, Hong Kong. Close adherence to appropriate techniques for preimplant preparation, implantation, dosimetric calculation, and postimplant nursing should yield rewarding results with a good therapeutic index.

Key Words: Tongue cancer, Interstitial brachytherapy, Iridium

INTRODUCTION

Early oral tongue cancers are generally regarded as those cancers arising from the anterior two-thirds of the tongue, measuring less than 4 cm in the maximum dimension (T1 and T2, American Joint Committee on Cancer [AJCC] staging 1997), and without significant palpable neck lymph nodes (N0, AJCC staging 1997).[1] Traditionally, early oral tongue cancers have been managed by either transoral partial- or hemiglossectomy with or without neck lymph node dissection, or radiotherapy consisting of either interstitial brachytherapy alone or a combination of external and interstitial brachytherapy. Surgical resection confers a local control rate of 76% to 91% for those achieving >1 cm or 'clear' margins, but the local control rate drops to 67% to 85% when the margin of resection is less than 1 cm or when a second resection is necessitated to achieve clear margins.[2-4] Perineural invasion has also been reported to adversely affect the outcome after surgical resection when the local control is reduced to 38%.[4] On the other hand, vast experience with long-term follow-up in patients treated with radiotherapy has also been reported, particularly from French and Japanese institutions using interstitial brachytherapy with radium-226/caesium-137 needles or iridium-192 wires or hairpins as mainstay radiotherapy. A local control rate of 79% to 98% for T1 and 61% to 91% for T2 disease is seen after radiotherapy.[5-14] Two large French studies have shown a trend for better local control for T2 cancer when the radiotherapy is delivered wholly by interstitial brachytherapy (88% and 89%) rather than a combination of external and interstitial brachytherapy (36% and 50%), even when tumour size adjustment has been made.[15,16] These results are echoed by a smaller report from the USA that suggests shorter overall treatment and smaller contribution from external radiotherapy give better results in local control.[17]

EXPERIENCE AT THE QUEEN ELIZABETH HOSPITAL

In a retrospective review of 135 patients with early oral tongue cancer treated from 1966 to 2001 by interstitial brachytherapy with or without external radiotherapy, the 5-year local control rate was 82%. (R Ngan, unpublished data.) There was no difference in results according to whether the interstitial brachytherapy is delivered by radium-226/caesium-137 or iridium-192. Radium-226 preloaded needles were used from 1966 until 1989 when they were replaced by caesium-137 preloaded needles. Iridium-192 (afterloaded hairpins or wires) first became available in the early 1990s and we fully switched to using iridium-192 hairpins (supplemented by wires when required) via the guide-gutter

Correspondence: Dr RKC Ngan, Department of Clinical Oncology, Queen Elizabeth Hospital, 30 Gascoigne Road, Kowloon, Hong Kong.
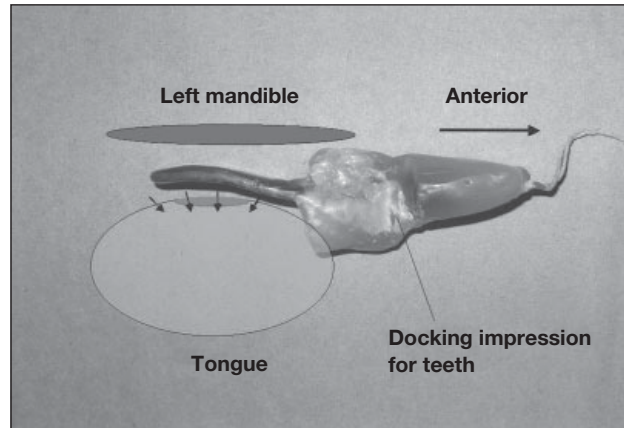*Tel: (852) 2958 6258; Fax: (852) 2359 4782;*
E-mail: ngankc@ha.org.hk

technique in 1998. Indeed, 25 of the 135 interstitial implants were performed with iridium-192. Thirteen more patients were treated by the guide-gutter technique employing iridium-192 hairpins during 2002 to 2003. We report our experience of this technique in more than 40 patients during the past 10 years.

PRE-BRACHYTHERAPY ASSESSMENT

Eligible patients with localised squamous cell carcinoma measuring 4 cm or less in the anterior two-thirds of the tongue can be treated by interstitial brachytherapy alone. The alternative option of surgery is also brought up for discussion among clinical oncologists, surgeons, and diagnostic radiologists in the combined head and neck cancer meeting, and the plan for radiotherapy is always endorsed after thorough discussion with the patient. Once the decision for interstitial brachytherapy is made, orders for iridium-192 hairpins or wires are placed approximately 10 to 14 days in advance of the implant date.

Preparation work for brachytherapy will proceed while waiting for the arrival of the iridium-192 hairpins. Usually, ultrasonography or magnetic resonance imaging scan of the tongue tumour is performed to delineate the depth of invasion or thickness of the tumour, which is far more indistinct than the anteroposterior and the superoinferior extent for a tumour situated at the lateral edge of the tongue, the most common site of oral tongue cancer. Dental surgeons are routinely consulted about the need to extract decaying teeth considered not amenable to conservative treatment in the years ahead. This is to avoid dental extraction following too closely to the brachytherapy, which may possibly lead to osteoradionecrosis. Very occasionally, teeth adjacent to the tongue cancer are removed to provide free space for the guide-gutter insertion, especially for more posterior tumours in patients with unusually narrow dental gaps. A customised mandibular spacer is fabricated before brachytherapy using a thin layer of lead shield (2 mm) embedded in wax. The wax extends anteriorly to provide a dental docking bite and then extends further anteriorly to form a handle protruding outside the mouth for manipulation. The lead shield is so fabricated to fit snugly in the glosso-gingival sulcus between the tongue and the inner aspect of the mandible to shield the mandible from the iridium-192 hairpins during the subsequent brachytherapy (Figure 1).

Management of the neck in tongue cancer is a subject of its own and is not relevant to the current discussion. Briefly, however, any occult neck metastasis is screened
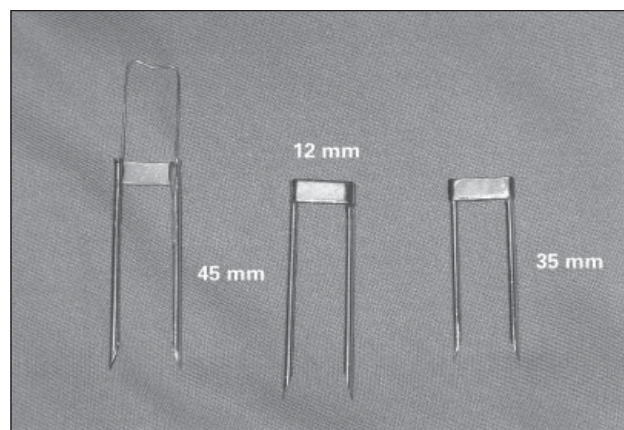

Figure 1. Superior view of a schematic illustration to show optimal positioning of the mandibular shield during brachytherapy.

by neck ultrasonography and, when necessary, by ultrasonography-guided fine-needle aspiration cytology. Selective neck dissection for ipsilateral levels I, II, and III lymphatics is usually performed approximately 6 to 8 weeks after brachytherapy for high-risk patients with unconfirmed neck metastasis. Small palpable or ultrasonography-detected lymph node metastasis will be treated by ipsilateral radical neck dissection 4 to 6 weeks later. Patients with larger primary tongue cancer or larger palpable neck metastasis will initially be managed by surgery.

INTRAOPERATIVE PROCEDURES USING THE GUIDE-GUTTER TECHNIQUE
Instruments

Guide-gutters are hollow metallic needles consisting of 2 vertical limbs joined by a horizontal flange (Figure 2). The vertical limbs of guide-gutters are originally 6 cm in length when manufactured. At the Queen Elizabeth Hospital, they are cut to 4.5 cm long from the inlet

Figure 2. Guide-gutters with vertical limbs of different lengths to be afterloaded with hairpins of similar dimensions.

to the tip and are 12 mm apart measuring between the centres of the lumens. There is a 0.8-mm slit along the medial side of the limbs of the guide-gutter and the bore of the lumen of each limb is 1.4 mm, allowing easy access for the iridium-192 hairpin, which is 0.6 mm in diameter. The hairpins also come with a 6-cm length in the vertical limb and can also be cut to an appropriate length to suit corresponding guide-gutters. When required, the length of the limbs can be further cut to 3.5 cm to suit special circumstances. Implantation of the guide-gutters is performed by limb- or flange-holding forceps while the afterloading of the hairpins is done using hairpin-holding forceps.

Preimplant

General anaethesia is essential to ensure optimal geometry of the guide-gutter and therefore the hairpin implant. With the patient lying supine on the operation table, the neck should be hyperextended by padding up the shoulders. We prefer to insert a nasogastric feeding tube to avoid vigorous tongue movement during oral feeding while delivering brachytherapy. The patient is then draped after standard sterilisation procedures to the oral cavity and skin around the mouth and neck. Povidone iodine antiseptic (10% water volume) and 75% alcohol are necessary for the skin sterilisation, especially in the submental area when the plastic loop technique is used to supplement the guide-gutter technique for large volume implants or for more posteriorly-situated tumours. Two stay stitches (3/0 Mersilk suture) are placed in the anterior one-third of the tongue for retracting the tongue out for better inspection and palpation of the tumour and implant geometry configuration. Exposure is further facilitated by placing a Doyen mouth gag (Downs Surgical, Aesculap Ltd, Sheffield, UK) into the mouth on the contralateral side. Packing gauze is then inserted using MaGill intratracheal catheter forceps (Downs Surgical, Aesculap Ltd, Sheffield, UK) into the oropharynx at the back of the tongue to collect any hairpins accidentally falling off during the afterloading procedure.

Implant Procedures — Guide-gutter Method

Gross tumour is identified and measured. A margin of 1 cm is usually given in the anteroposterior and superoinferior dimensions to define the implanted tumour volume, while a 5 mm margin usually suffices for the medial direction. The implanted tumour volume is then inked on the tongue mucosa. We find it useful to use a wooden stick 4.5 cm long (the vertical length of the guide-gutter) to simulate the positioning of the
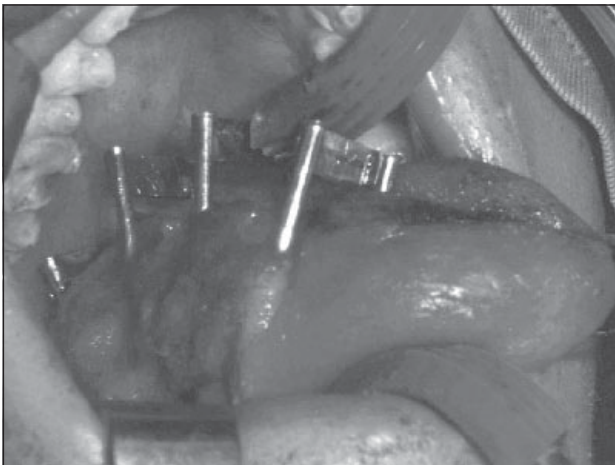
guide-gutters during the configuration of the implant geometry on the tongue mucosa. As stipulated in the Paris system, which requires the radioactive sources to be parallel and equidistant from one another, the hairpins are inserted 12 mm from one another across the implanted tumour volume. To take an example of a T2 tumour at the right lateral edge of tongue measuring 3 cm in the anteroposterior direction, 2 cm in the superoinferior direction and 5 mm thick, the anteroposterior and superoinferior dimensions of the implanted tumour volume are 5 cm and 4 cm, respectively, while the thickness will be 1 cm. The implanted tumour volume will therefore be adequately covered by 5 pairs of hairpins placed 12 mm from one another along the right lateral edge. Commonly, 4 to 5 pairs of hairpins are required for a typical T1 or T2 tumour less than 7 to 8 mm thick. The mucosal entry points for insertion of both limbs of all the guide-gutters, as well as the mapping of the virtual alignment of the guide-gutters on the lateral tongue edge, are inked for guidance of parallelism and equal spacing. These markings may require amendment following insertion of the first few guide-gutters due to tissue oedema and the necessary corrections to follow the alignment of the first few guide-gutters inserted.

For exceptionally thick or infiltrative tumours, we can convert the configuration of the double-plane implant to a volume implant by using plastic loops to substitute additional guide-gutters in the medial part of the implanted tumour volume. Similarly, anticipated difficulty in inserting the guide-gutters and then hairpin afterloading can be avoided in a posterior tumour extending to near the posterior one-third of tongue, when the most posterior guide-gutter(s) is/are replaced by plastic loops inserted by a different method using a submental approach (see below).
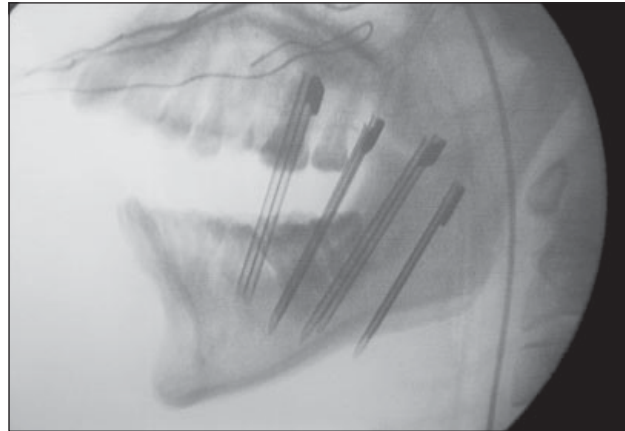
For a typical implant consisting of 4 to 5 hairpins, we find it useful to insert the second-most posterior or the middle guide-gutter first to serve as the yardstick for aligning the remaining guide-gutters. The most posterior guide-gutter is then inserted, followed by the others as we work forwards. Sometimes it is useful to insert the most anterior guide-gutter before the others for very anterior tumours, as the mandibular arch may lie in the way of the limbs of the most anterior guide-gutter, thus requiring the limbs of the guide-gutter to slant more posteriorly than desirable. More posterior guide-gutters will therefore be required to adopt such an inclining alignment to ensure parallelism and

uniformity in dosimetry. The other alternative is to use a shorter guide-gutter/hairpin (3.5 cm) for the most anterior position to avoiding hitting the mandibular arch if such shortening does not adversely affect the dose coverage of the implanted tumour volume.

During the insertion of the guide-gutters, it is best to only minimally retract the tongue anteriorly as there may be a significant difference in the distance between different guide-gutters or hairpins in the neutral un-retracted position when the patient recovers from general anaesthesia and regains muscle tone during the following week of brachytherapy. With the tumour bulging laterally from the lateral edge of tongue, it is often advisable to apply fingers to manually flatten the tongue edge bearing the tumour so that the guide-gutters can be inserted starting approximately 10 mm superior to the gross tumour and penetrating 1 to 2 mm to the lateral free edge of the tumour/tongue for adequate dose coverage (Figure 3). Sometimes, when anatomically desirable, the shoulder and upper portion of the lateral limb of the guide-gutter is allowed to rest on the lateral tumour edge while the lower portion is submerged superficially within the tumour tissue. Upon completing insertion of all the guide-gutters, the tongue is replaced in its neutral position and the position screened by a portable image-intensifier (BV29, Philips Medical System, Best, The Netherlands) in broadly orthogonal views of lateral and anteroposterior directions (Figure 4). Corrections can be made if suboptimal geometry is confirmed until satisfactory geometry is obtained. This should not be overemphasised, however, as perfect geometry and parallelism among guide-gutters visualised on an image-intensifier does not necessarily imply perfect topographic matching of

Figure 4. Guide-gutter positions seen with an image-intensifier — lateral view.

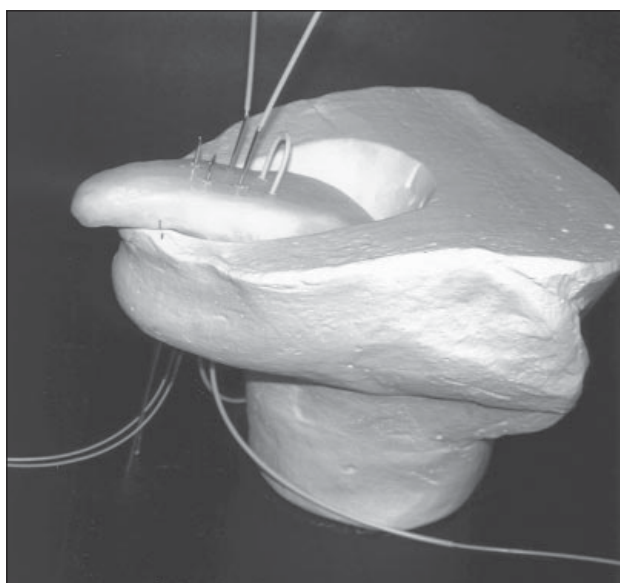the implant configuration to the tumour volume in the tongue.

Afterloading of Iridium-192

After confirmation of the guide-gutter positions and before hairpin afterloading, 3/0 Mersilk sutures are stitched across the horizontal flange of the guide-gutters from beneath the tongue mucosa. With 3 cm-thick lead shields positioned in place for personnel protection, iridium-192 hairpins already cut to 4 cm (or as required) are lifted from a portable lead safe with hairpin-lifting needles (Nycomed, Amersham Plc, Amersham, England) and inserted into the hollow guide-gutters. Care is exercised to align the guide-gutter parallel to the hairpin limbs to allow smooth and quick placement of the hairpin into position. The guide-gutter is then removed from the tongue parallel to the hairpin, while the hairpin is secured in position temporarily by forceps holding onto its horizontal limb. Subsequently, knots will be tied across the horizontal limb using the silk previously stitched in place to hold the hairpin in position during the whole period of brachytherapy treatment. The afterloading procedure starts anteriorly and we work one by one posteriorly until all the hairpins are inserted and the guide-gutters removed. Sometimes, bleeding from arterioles or the tumour bed may be encountered upon removal of a guide-gutter, which may be alarming in the first instance but is usually controlled by simple pressure for a few minutes. There is no concern of prolonged radiation exposure to the body if one works behind the lead shield which will shield off more than 90% of the relatively low-energy photons emitted from iridium-192. The average whole-body dose received by a brachytherapist performing the brachytherapy is less than 100 micro-Sieverts during a typical tongue implant. Radiation dose to the

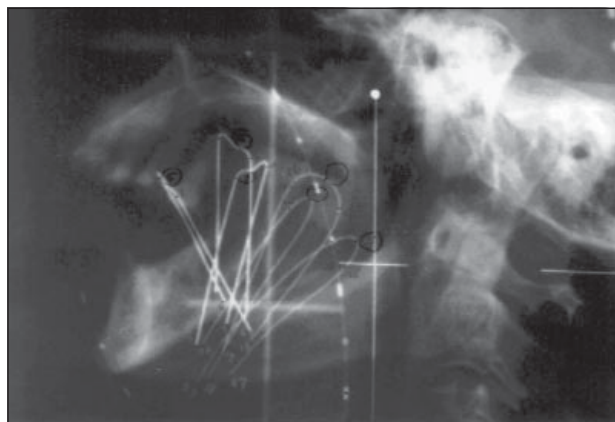**Figure 3.** Guide-gutters inserted 1 to 2 mm deep to the tumour edge.

fingers and hands can be significantly reduced by using long forceps or needle holders during the haemostatic manipulation or hairpin afterloading. Only rarely do we need to apply haemostatic stitches to control bleeding. The whole operation, including hairpin afterloading, rarely takes more than 90 minutes.

PLASTIC LOOP METHOD

Implanted tumour volume as defined above is again marked on the tongue surface. As the metallic needles or plastic catheters (Nucletron, Veenendaal, The Netherlands) are inserted through the submental skin and then directed superiorly, the corresponding submental skin entry points and the tongue dorsum exit points for the needles/plastic catheters are similarly marked. To be consistent with the adjacent guide-gutters within the implant, the separation between the plastic catheters is again about 12 mm on the tongue dorsum and along the distance of the loop where an active iridium-192 wire will be afterloaded. The separation at the submental skin is often less due to a smaller workable area in the submental region. When the 2 adjacent needles have been successfully inserted through the full vertical thickness of the tongue to emerge at the tongue dorsum, each end of the plastic catheter is inserted transorally into the tip of each needle and pulled through the original tracks of the 2 needles until a loop is formed on the tongue dorsum as the needles are withdrawn simultaneously from below (Figure 5). The 2 free ends of the catheter are then secured in position by tight-fitting buttons on the submental skin surface. A radio-

Figure 6. A combination of hairpins and wires in the same patient.

opaque marker wire (Nucletron, Veenendaal, The Netherlands) is then inserted through the lumen for radiological verification of parallelism and geometry using the image-intensifier in a similar fashion. This is followed by afterloading of an iridium-192 wire impregnated in a thin nylon catheter and cut to a desirable length dependent upon the requirements of the implanted tumour volume. An example of combined guide-gutter and plastic loop techniques in the same patient is shown in Figure 6. The plastic loop technique using the submental approach can be easily adapted for high-dose rate interstitial brachytherapy using remote afterloading devices such as MicroSelectron (Nucletron, Veenendaal, The Netherlands). Plastic catheters can be inserted through the submental area in a parallel planar fashion with the help of a template and then secured appropriately on the tongue dorsum simulating either a single or double plane 'needle' implant without looping.[18] The catheters can then be connected to the afterloading device and the small high-activity iridium-192 source will then travel linearly in small steps through individual catheters in turn to simulate line sources within the implanted tumour volume. While the whole brachytherapy treatment still lasts for a few days when the brachytherapy is delivered in approximately 10 twice daily fractions, the patient can stay in the general ward and radiation exposure to the medical and nursing staff can be eliminated.[18]

BRACHYTHERAPY DOSIMETRY

Orthogonal films (anteroposterior and lateral views) are usually taken the day following the implant as imaging too soon may miss the postimplant tissue swelling and consequent geometry distortion (Figure 7). At the Queen Elizabeth Hospital, the 3-dimensional positions of the hairpins or wires are digitised into a computer and reconstructed. With a known activity of iridium-192 in

Figure 5. Model demonstrating the plastic loop technique using metallic needles and plastic catheters — iridium wires will be afterloaded into the plastic catheters from below.

Figure 7. Lateral radiograph showing hairpins in the tongue.

the hairpin or wire (usually around 1 mCi/cm), the dosimetric plot consisting of isodose lines representing different dose rates expressed in cGy/hour is computed by the Target planning system (IGE Medical Systems, Waukeska, England) and printed out for different transverse or sagittal sections of the implant. The Paris system is strictly followed during the computation algorithm of dosimetry and the duration of the implant is calculated when the total dose and the prescribed dose rate (the reference dose rate in the Paris system, which is 85% of the basal dose rate) are specified. The total dose prescribed for T1 and T2 cancer is 65 Gy and 70 Gy, respectively, if brachytherapy is the only treatment, while 30 to 35 Gy is prescribed as brachytherapy boost after 45 to 50 Gy external radiotherapy. The dose rate for a typical implant is approximately 40 to 60 cGy/hour, necessitating a total duration of 5 to 6 days for full brachytherapy dose delivery.

POSTOPERATIVE CARE DURING BRACHYTHERAPY

The patient is nursed in a suite with self-contained washroom facilities, shielded from the adjacent area by thick concrete and a lead-shielded door. The room is also equipped with close-circuit TV and intercom speaker-phones to facilitate nursing. Portable lead shields are also placed at the bedside to allow optimal shielding of medical personnel attending to the patient. Family visits, unless absolutely necessary, are discouraged as far as possible during brachytherapy but a direct telephone line is available for communication to ease anxiety. Oral hygiene should be maintained by regular antiseptic mouth rinses and antibiotics if required. Oral feeding could be substituted by tube feeding.

It is advisable to give a short course of steroids, at least during the initial few days, as excessive tissue or tumour oedema (especially after difficult implants demanding multiple correcting attempts to optimise geometry) can increase the inter-hairpin distances in a random fashion. Moreover, lateral tumour swelling away from the hairpins at the free lateral edge of the tumour may effectively lead to undesirable underdosing at the corresponding region.

As soon as the patient has fully recovered from general anaesthesia, the patient should be advised to put the mandibular spacer in place at least during most of the waking hours. For safety purposes, the spacer should be removed before sleep. The 2 additional bonuses of an in situ mandibular spacer just adjacent to the implanted tumour are flattening out and pushing of the lateral free edge medially towards the hairpins, and providing a 'bolus' on the free edge for back-scatter of radiation to the tumour surface (Figure 1).

POST-BRACHYTHERAPY FOLLOW-UP

After brachytherapy treatment, patients should be very closely monitored during the first 2 years, when approximately 50% of local relapses are detected. However, local relapse continues to appear up to 10 years after brachytherapy in the cohort of 135 patients retrospectively reviewed and long-term follow up is mandatory for successful surgical salvage. (R Ngan, unpublished data.) Osteoradionecrosis is infrequent and should be initially managed conservatively by medications and hyperbaric oxygen.

CONCLUSIONS

Brachytherapy can be an effective modality of treatment for early oral tongue cancer with a high success rate and low morbidity, if the details of technique and principles of dosimetry are stringently followed. In expert hands, it remains a powerful tool in the armamentarium of organ-preservation therapies.

ACKNOWLEDGEMENTS

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