1 Introduction

Basal cell and squamous cell carcinomas of the skin usually occur on sun-exposed sites, the face being one of the sites of predilection, accounting for 95% of cases. Surgery in these sites (nose, ears, eyelids, lips) may be mutilating or require complex plastic reconstruction techniques under general anaesthesia.

Radiotherapy, and especially carefully tailored brachytherapy is a good alternative, if not the treatment of choice for those lesions that can not be safely removed by surgery with primary wound closure under local anaesthesia.

2 Anatomical Topography

As most skin cancers arise in the face, they are usually diagnosed at an early stage. However, deep extension to the orbit, ear or bone should always be ruled out. Deep extension along an embryonic pathway should always been suspected, especially in case of tumours involving the naso-labial fold, and adequate deep safety margins for resection as well as for brachytherapy must be taken (18).

3 Pathology

Most skin cancers are basal cell (65%) or squamous cell (30%) carcinomas (18). Brachytherapy is not indicated for skin melanomas.

4 Work Up

All suspected lesions should have a biopsy to confirm the diagnosis.

Local tumour extension should be carefully documented. Exact measurements (in mm) are required. Photographs may help to document local tumour extension. Suspected deep infiltration into the orbit, ear or other structures should be ruled out by CT or other investigations. In the case of multiple lesions, certainly at non sun-exposed areas or in young patients, a history of exposure to arsenic or tars should be sought. Where there are multiple basal cell carcinomas, X-Rays of the mandible and carpal region may be requested to rule out the Basal Cell Nevus Syndrome.
5 **Indications, Contra-indications**

5.1 **Indications**

- Basal cell as well as squamous cell carcinoma is radiosensitive, and most of these lesions are detected in an early stage, when the chance for cure by radiation is high. Both external radiotherapy (low energy X ray or electron beam) and brachytherapy can be used, but brachytherapy is preferred to X-rays when these are difficult to apply to curved areas, or to electron beams, which need extended fractionation. Therefore the main indications for brachytherapy are epidermal skin cancers T1 - T2 N0 on the face for which curative surgery with adequate margins cannot be offered without mutilation or without the need for extensive reconstructive surgery under general anaesthesia.

- Brachytherapy can also be used as a boost in larger T2 - T3 or in Tx N1 cases after external beam radiotherapy to the primary tumour and lymph nodes.

5.2 **Contraindications**

- Malignant melanoma of the skin which is not radiosensitive.
- Skin cancers invading bony structures.
- Upper eyelid lesions
- Pinna tumour involving both the concha and the external auditory canal, ear conduct or any other site where the anatomical situation makes the source positioning needed to provide adequate covering of the target volume impossible.

6 **Target Volume**

The clinical target volume for well-delineated squamous cell or basal cell carcinomas is the palpable or visible tumour with a safety margin of 3 mm for skin cancers and 5 mm for lip cancers (see chapter 8). For ill-defined lesions, such as morphea-like basal cell carcinomas, a wider safety margin is taken (5 to 7 mm).

7 **Technique**

Several techniques are available, and all of them can be carried out under local anaesthesia (hypodermic needles, silk wires, and inner nylon tubes) or without anaesthesia (mats and moulds). For some large volume implants, a classic nylon tubes treatment may be warranted, which usually needs a general anaesthesia.

Implantation is carried out according to the Paris system. The positioning of the lines is drawn on the skin, taking into account the Paris system rules to cover the target volume.

Most skin cancers can be treated by a single plane implant, using parallel lines, spaced 10 to 15 mm (E) from each other. The treated thickness of such implants varies from 5 to 7.5 mm for two lines (0.5 times E), and from 6 to 9 mm (0.6 E) for three or more lines. Consequently the source carriers must be implanted 2.5 to 4.5 mm beneath the skin surface. Implants which are too superficial may result in late visible teleangiectases along the source positions.

For curved planes, frequently occurring in skin cancers of the face, the reference isodose projects further at the concave than at the convex side. The arrangement of implanted or applied sources in those cases must take account of this shift in the isodose lines. Lesions thicker than the thickness of
the reference isodose of a single plane configuration, have to be treated by double plane implants (the second plane may be constructed "in air" above the tumour). However, sometimes it is easier to shave the exophytic part of the tumour with electrocoagulation.

7.1 Patient preparation

If possible nerve block anaesthesia is performed to avoid swelling in the target area. This is possible with a mentalis nerve block for the medial two thirds of the under lip or partial or total ring anaesthesia around the ear.

If local infiltration anaesthesia of the skin is used all visible and palpable tumour should be marked with a pen before the skin is infiltrated with lidocaine 1% or other local anaesthetic.

7.2 Afterloading techniques

Hypodermic Needle Technique

This technique uses double bevelled hypodermic needles (19 gauge) with an external diameter of 0.8 mm and an internal diameter of 0.5 mm. Available lengths vary from 2 to 10 cm (Fig 28.1). The needles are loaded manually with 0.3-mm Iridium wire (without inner tube), and pushed into place by a stiletto of adequate length (1 to 20 mm) (Fig 28.1)

![Fig 28.1: Hypodermic needles for interstitial implantation of skin tumours. A steel driving pin is used to insert the Ir 192 source wire to the correct position within the needle.](image)

Implantation can always be carried out under local infiltration, or nerve block anaesthesia. Single or double plane implants (squares or triangles) may be constructed.

The hypodermic needles are fixed in their configuration, by plastic tubes or templates. This technique is optimal for multiple plane implants (ex. lip cancer). The rigid fixed steel and template system prevents collapse of the sources due to lack of tissue support or the elasticity of soft tissues.
Hypodermic needles can also be used for all small volumes, in any site on the face such as nose, ears, and even eyelids. Even more difficult places, such as the internal canthus can be treated when the needles are bent to an appropriate curvature (Fig 28.2).

Fig 28.2: Basal cell cancer at the medial canthus (2A). Hypodermic needles, slightly bent to the curvature of the local anatomy were inserted under local anaesthesia (2B).

### 7.3 Silk wire technique

Silk wires with an outer diameter of 0.4-mm diameter can be used for implantation of small lesions, especially on the face where bending of the sources to conform to anatomic curvatures is desired, as for example in the case of superficial lesions of the nasal bridge, ala nasi, lower eyelid, and upper lip. However, this technique requires more preparation of the applicator than for other techniques. From a braided silk thread (diameter 4.0 and 75 cm length) the central core wire is removed. Into the central space a steel wire of 0.3 mm is introduced, and then dipped in a bath of synthetic resin. After drying, the steel wire is removed, and replaced by a radioactive Iridium wire (0.3-mm diameter) of appropriate length, which is knitted on to the silk thread. Immediately after the needle implant, the loaded silk wire, which is kept in a lead container, is drawn into the skin (Fig 28.3). Once in place the non-radioactive part is cut, and the ends are tied together and taped to the skin.

Fig 28.3: The silk wire implantation technique with immediate afterloading.
7.4 Small nylon tube technique

In this technique a small nylon tube (external diameter 0.8-mm) is pulled over a metal wire of 0.2 - 0.3-mm diameter and brought into place as in the former technique. A 2.0 silk wire may also be used as a vector for the nylon tube. The end of the wire is then pushed into the nylon tube with a stiletto. It is sealed by crimping the tube with the tip of a needle-nosed forceps, heated briefly in a flame. Afterloading with radioactive sources is carried out after dosimetry has been calculated.

7.5 Mats

Mats are constructed with classical nylon tubes (diameter 1.6 - 1.9 mm) and strips of Scotch tape (Fig 28.4). This allows the treatment of large flat or slightly curved skin areas such as the forehead, legs, and the back. The mats are simply taped to the skin. No anaesthesia is needed. Mats of different size and inter source spacing can be constructed. They can be cleaned, re-sterilised and used several times.

Fig 28.4: Custom made mats of scotch-tape and plastic tubes (4A) can be applied on hard curved surfaces as the forehead (4C,D) or legs (4B).

These applicators can be used with LDR, PDR or HDR micro-source afterloading machines.

They are not suitable for very curved areas, or areas where skin may move during treatment (such as the peri-oral area, shoulder, groin....).
7.6 Moulds

Individual off prints can be taken from different anatomical areas to construct a mould (Fig 28.5), containing plastic tubes for manual or micro-source LDR, PDR or HDR afterloading: these moulds allow contact brachytherapy of several anatomical tumour sites, including irregular shaped areas such as the external ear.

7.7 Surface contact applicators

Several surface contact applicators are available for use with LDR, PRR or HDR afterloaders (fig 28.5).

![Surface applicators for HDR brachytherapy of skin cancers.](image)

7.8 Guide gutter technique

This is a very rapid and simple manual afterloading technique that is carried out under local anaesthesia. Double or single guide gutters exist in various lengths (3 - 5 cm) and shapes (straight or curved). They may be a practical solution for implants of the nasal vestibule, the bridge providing a good coverage of the target volume at the nasal rims. After local anaesthesia, the gutters are put in place. After control of the positioning, a mersilene wire is placed under the bridge and the radioactive hairpins (Iridium of 0.5-mm thickness) are slid into the gutters. The gutters are then removed and the hairpin(s) sutured with the mersilene wire (Fig 28.6).

![The guide gutter technique for implantation of the nasal vestibule.](image)
7.9 Classic plastic tubes 'henschke'

Classic plastic tube implants (1.6 to 1.9 mm external diameter) can be used for large lesions of the perioral area, the cheek and the shoulder region.

Because of the large volume that has to be anaesthetised, general anaesthesia is usually required.

8 Dosimetry

Orthogonal films are taken to register the exact source positions. Usually computer dose calculations are done. For single plane implants with parallel, straight lines, dosimetry can also be carried out manually, with or without tomographic determination of the source position in the central plane of the implant. Mean Central Dose is determined. The prescribed dose to the Minimal Target Dose usually corresponds to 85% of the MCD (Paris System).

9 Dose, Dose Rate, Fractionation

The prescribed dose is 60 Gy at the 85% reference isodose, at dose rates between 30 to 90 cGy/h. Usually a dose rate of 45 to 70 cGy/h should be aimed at. Therefore, the linear activity of Iridium sources should be in the range of 5.5 to 7.7 cGy/hr linear Air Kerma rate at 1 meter. Depending on the linear activity and the source spacing and length it will take 4 to 6 days to deliver the required dose. Although doses up to 70 Gy can be given in some large tumours, without unacceptable sequelae, the increase in cosmetic damage is greater than the gain in local control expected from a dose increase above 60 Gy (6,15,16).

10 Monitoring

Moist desquamation develops 1 week after implantation in the mucosa and after ± 12 days in the cutaneous areas. The reaction is maximal at about three weeks, and heals progressively (depending on the area) in 5 to 8 weeks. No special care is required, except for daily cleaning and application of a topical antiseptic. Local application of silicone-coated wound dressing, seems to be a good alternative to treat larger zones of moist desquamation.

11 Results

11.1 Local control rates

With doses of 60 - 65 Gy local control is excellent for T1 - T2 skin cancers. Five-year recurrences rates range from 1 to 5% for non-melanoma skin cancers of the nose (6,8,16) and nasal vestibule (3,14,16,19), the eyelids (7,11), and the pinna (9,17) (Table 28.1A). However, if the patient is treated for a recurrent tumour after previous surgical resection, the recurrence rate is higher, ranging from 6 to 13%. (7,8,12,15,16)
The results obtained with brachytherapy are comparable to those obtained with external radiotherapy (contact therapy or electron beam irradiation) for non-melanoma skin cancers. With external radiotherapy, local control rates between 93 - 97.5% have been reported (1,4,5,10,13,20) (Table 28.2).

**Table 28.1: Local control after brachytherapy for skin cancer**

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>TUMOR LOCALISATION</th>
<th>n</th>
<th>TREATMENT</th>
<th>FUP</th>
<th>LOCAL CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guix (2000) (12)</td>
<td>Face</td>
<td>136</td>
<td>HDR brachy</td>
<td>5y</td>
<td>99% if primary treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87% if recurrence</td>
</tr>
<tr>
<td>Maes (2001) (15)</td>
<td>Face</td>
<td>173</td>
<td>Iridium 192</td>
<td>45 months</td>
<td>95%</td>
</tr>
<tr>
<td>Debois (1994) (8)</td>
<td>Nose</td>
<td>370</td>
<td>Cesium 137</td>
<td>2y</td>
<td>97% if primary treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>94% if recurrence</td>
</tr>
<tr>
<td>Crook (1990) (6)</td>
<td>Nose</td>
<td>468</td>
<td>Iridium 192</td>
<td>5y</td>
<td>97.5%</td>
</tr>
<tr>
<td>GEC (1989)</td>
<td>Nose</td>
<td>1676</td>
<td>RT</td>
<td>min 2y</td>
<td>95% if primary treatment</td>
</tr>
<tr>
<td>Daly (1984) (7)</td>
<td>Eyelid</td>
<td>165</td>
<td>Iridium 192</td>
<td>5y</td>
<td>97% if primary treatment</td>
</tr>
<tr>
<td>Gambaro (2001) (11)</td>
<td>Eyelid</td>
<td>50</td>
<td>Iridium 192</td>
<td>median 82 months</td>
<td>96%</td>
</tr>
<tr>
<td>Mazeron (1986) (16)</td>
<td>Ear</td>
<td>70</td>
<td>Iridium 192</td>
<td>mean 5y</td>
<td>99%</td>
</tr>
<tr>
<td>Baris (1985) (3)</td>
<td>Nasal vestibule</td>
<td>22</td>
<td>Iridium</td>
<td>2y</td>
<td>96.4%</td>
</tr>
</tbody>
</table>

**Table 28.2: Local control after external beam RT for skin cancer**

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>TUMOR LOCALISATION</th>
<th>n</th>
<th>TREATMENT</th>
<th>FUP</th>
<th>LOCAL CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locke (2001) (13)</td>
<td>all skin</td>
<td>531</td>
<td>external RT</td>
<td>median 6y</td>
<td>93% if primary treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80% if recurrence</td>
</tr>
<tr>
<td>Abatucci (1989) (1)</td>
<td>Face excl. Lip/ear/eyelid</td>
<td>675</td>
<td>contact RT</td>
<td>min 2y</td>
<td>96%</td>
</tr>
<tr>
<td>Childers (1994) (5)</td>
<td>Nose</td>
<td>26</td>
<td>contact RT</td>
<td>9y</td>
<td>96%</td>
</tr>
<tr>
<td>Fitzpatrick (1984) (10)</td>
<td>Eyelid</td>
<td>1166</td>
<td>external RT</td>
<td>5y</td>
<td>95% if BSC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93% if SCC</td>
</tr>
<tr>
<td>Schlienger (1996) (20)</td>
<td>Eyelid</td>
<td>850</td>
<td>external RT</td>
<td>5y</td>
<td>97.5%</td>
</tr>
<tr>
<td>Buatois (1996) (4)</td>
<td>Eyelid</td>
<td>52</td>
<td>contact RT</td>
<td>median 4y</td>
<td>94%</td>
</tr>
</tbody>
</table>
11.2 Complication rates

In general, an excellent or a good cosmetic result (Fig 28.7) is obtained in 78 to 92% of patients after brachytherapy (6,15,11,17). Complication rates range between 0 and 13% (Tables 3) and are similar to those often external beans (3,6-8,11,15-17). Complications are dose and dose rate dependent. For small tumours (T1-T2) a dose of 60 Gy should therefore be recommended. Higher doses result in only a small increment in local control, but a significant rise in complications (6,15,16).

![Fig 28.7: Basal cell carcinoma of the right lower eyelid in a 76-year old woman (7A)
Results 3 years after hypodermic needle implant (7B)](image)

Table 28.3: Complications after brachytherapy for skin cancer

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>TUMOUR LOCALISATION</th>
<th>N</th>
<th>TREATMENT</th>
<th>GOOD COSMESIS</th>
<th>COMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guix (2000) (12)</td>
<td>Face</td>
<td>136</td>
<td>HDR brachy</td>
<td>0 % (at 6m-1y)</td>
<td></td>
</tr>
<tr>
<td>Maes (2001) (15)</td>
<td>Face</td>
<td>173</td>
<td>Iridium 192</td>
<td>89 %</td>
<td>3.60 %</td>
</tr>
<tr>
<td>Debois (1994) (8)</td>
<td>Nose</td>
<td>370</td>
<td>Cesium 137</td>
<td>3 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Crook (1990) (6)</td>
<td>Nose</td>
<td>468</td>
<td>Iridium 192</td>
<td>94 %</td>
<td>2 %</td>
</tr>
<tr>
<td>GEC (1989)</td>
<td>Nose</td>
<td>167</td>
<td>RT</td>
<td>93 % if primary treatment 87 % if recurrence</td>
<td>2 %</td>
</tr>
<tr>
<td>Daly (19%84) (7)</td>
<td>Eyelid</td>
<td>165</td>
<td>Iridium 192</td>
<td>13 % if primary treatment 31 % if recurrence</td>
<td></td>
</tr>
<tr>
<td>Gambaro (2001) (11)</td>
<td>Eyelid</td>
<td>50</td>
<td>Iridium 192</td>
<td>92 %</td>
<td>4 % cataract; 20 % chronic conjunctivitis; 6% ectropion; 25% stenose lacr duct</td>
</tr>
<tr>
<td>Mazeron (1986) (16)</td>
<td>Ear</td>
<td>70</td>
<td>Iridium 192</td>
<td>&lt; 4 cm: 78 %</td>
<td>13% transient ulcers 4% necrosis</td>
</tr>
<tr>
<td>Baris (1985) (3)</td>
<td>Nasal vestibule</td>
<td>22</td>
<td>Iridium</td>
<td></td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 28.4: Complications after external beam RT for skin cancer

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>TUMOUR LOCALISATION</th>
<th>N</th>
<th>TREATMENT</th>
<th>GOOD COSMESIS</th>
<th>COMPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locke (2001) (13)</td>
<td>All skin</td>
<td>531</td>
<td>Extreme RT</td>
<td>92 %</td>
<td>5.80 %</td>
</tr>
<tr>
<td>Abatucci (1989) (1)</td>
<td>Face Excl. lip/ear/eyelid</td>
<td>675</td>
<td>Contact RT</td>
<td>90 %</td>
<td>3 %</td>
</tr>
<tr>
<td>Childers (1994) (5)</td>
<td>Nose Excl. lip/ear/eyelid</td>
<td>26</td>
<td>Contact RT</td>
<td>81 %</td>
<td></td>
</tr>
<tr>
<td>Schlienger (1996) (20)</td>
<td>Eyelid</td>
<td>850</td>
<td>External RT</td>
<td>5.7 %</td>
<td></td>
</tr>
<tr>
<td>Buatois (1996) (4)</td>
<td>Eyelid</td>
<td>52</td>
<td>Contact RT</td>
<td>96 %</td>
<td>0 %</td>
</tr>
</tbody>
</table>

For larger tumours, local control rates remain good, but complication rates are higher (5.5% skin necrosis for lesions larger than 2 cm) and cosmetic outcome is less favourable, because of skin destroyed by the tumour and retraction of the healing scar occurs afterwards (Fig 28.8).

![Fig 28.8: Basal cell carcinoma of the internal canthus (8A) and results 3 years after hypodermic needle implant. The tumour has disappeared but there is a niche where there has been deep tumour invasion (8B).](image)

The risk of complications is highest for tumours on the pinna (4 - 18.5% persistent ulcers) because of poor blood supply. It has been suggested that for basal or squamous cell carcinomas on the pinna, maybe a dose of 55 Gy may be sufficient, since these tumours show very good local control (100%) after a dose of 60 - 66 Gy but a high risk of complications (permanent ulcers 18.5%) (15).

One published randomised study that compares surgery with radiotherapy (brachytherapy or external radiotherapy) for basal cell carcinomas of the face (2). Surgery appeared to be better than radiotherapy, both in terms of local control rate and cosmetic outcome. The 4-year actuarial local control was 99.3% in the surgical group compared to 93.5% in the radiotherapy group. However, in 30% of the surgical cases, general anaesthesia was used and in 46%, flap reconstructions were needed. In 91% of the treatments, systematic frozen section examination was performed and in 42% additional excisions were needed.
These very good results are thus obtained with complex surgical procedures which are in fact not feasible in the majority of typically older patients who present with non-melanoma skin tumours (in this study the patients who were not fit for general anaesthesia were excluded). The cosmetic outcome was good in 87% of surgical treatments versus 69% in the radiotherapy group (5% necrosis). However, the brachytherapy dose was very high (66 - 70 Gy), which may explain the worse cosmetic results in the radiotherapy group.

Only very few studies are available that report the results of high-dose rate brachytherapy with custom-made surface moulds for skin tumours, but the results appear to be very favourable with 5-year actuarial local control rates of 98% and without severe late complications. (12,21)

12 References