Review of Head and Neck Brachytherapy

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Purpose

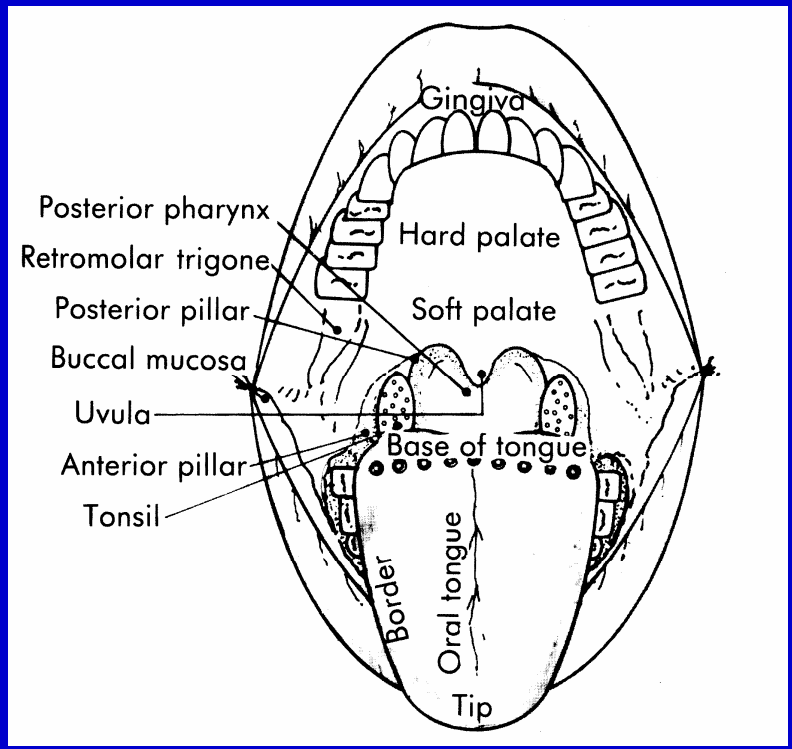
- Review of sources and dosimetry techniques relevant to head and neck brachytherapy
- Review of common needle insertion techniques for head and neck brachytherapy
- Review of treatment complications and considerations in their minimization
- Specific treatment techniques and dosimetry

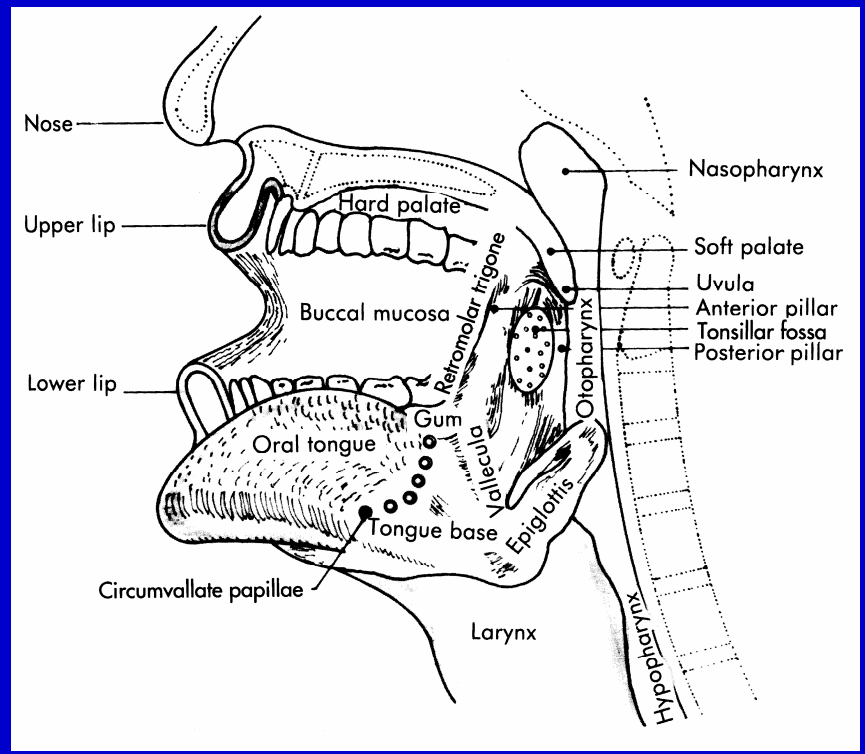
Outline

- Sources and Dosimetry Techniques
- Target Delineation and Implant Techniques
- Treatment Complications and Pretreatment Dental Evaluation
- Clinical Sites
- Summary

Heck and Neck Cancers

- **Oral Cavity: base of tongue, oral tongue, floor of mouth, lip, and buccal mucosa**
- **Oropharynx**
- **Nasopharynx**
- **Nasal vestibule**

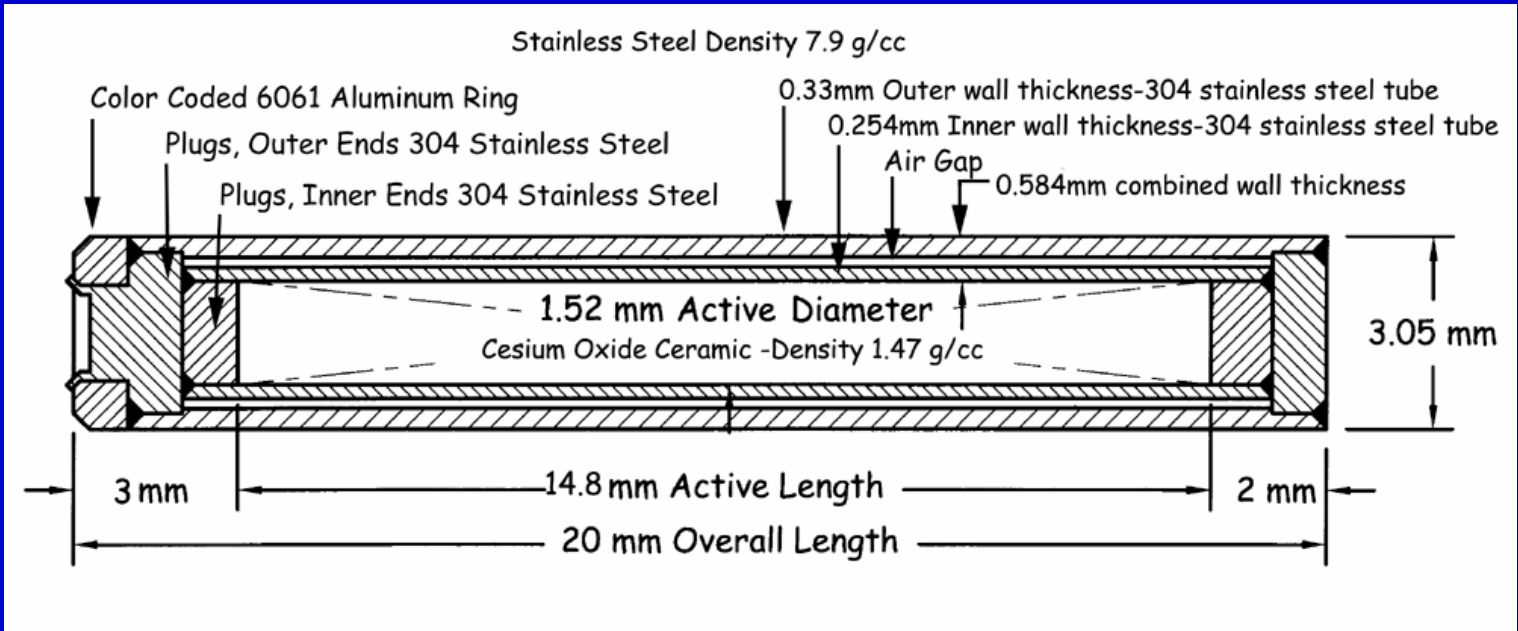




Cs-137 Sources

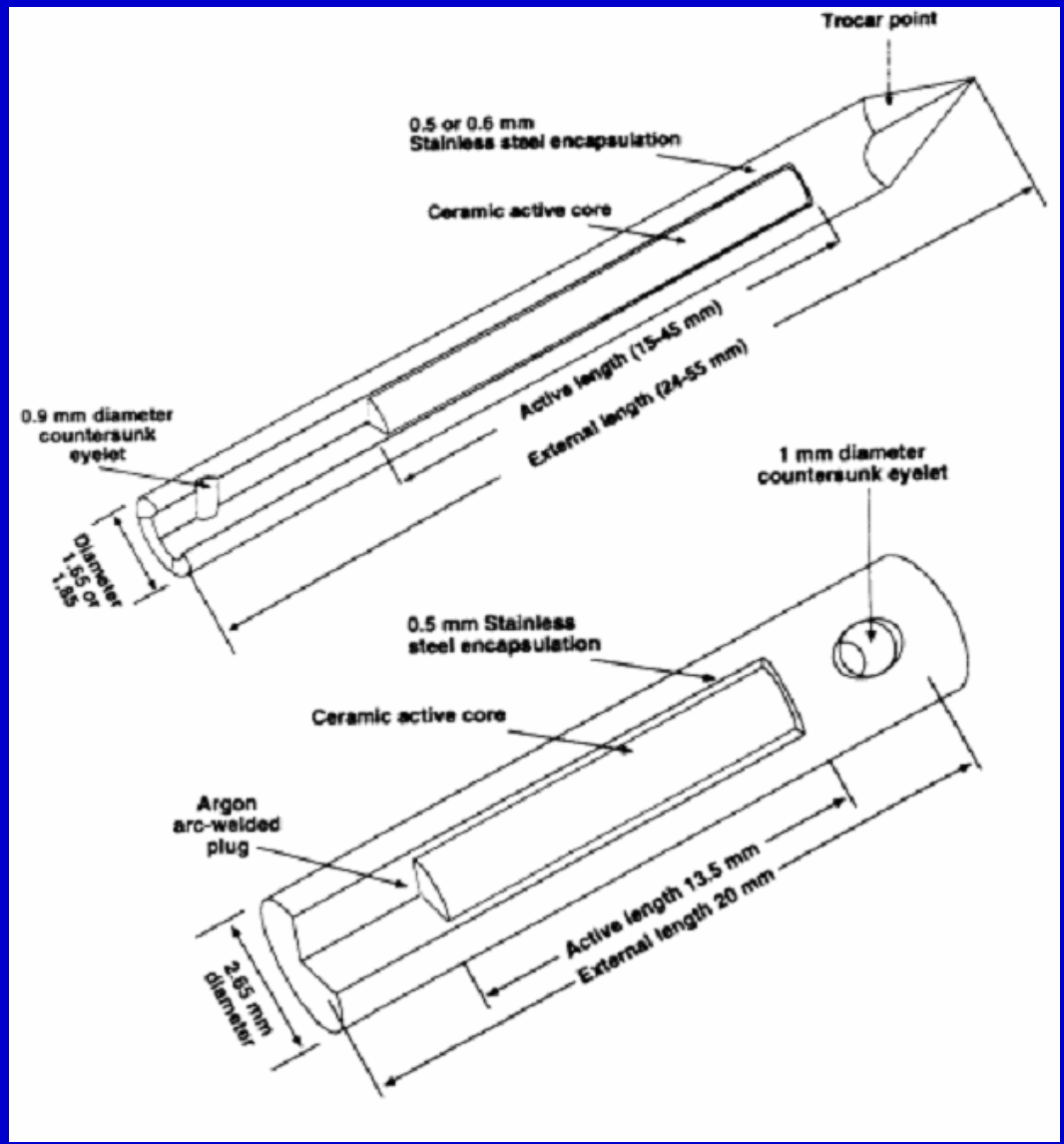
- **Cs-137 tubes and needles**
  - **Cs-137 needles no longer commercially available in the United States**
  - **IPL Cs-137 tubes available - reference quality data set not available**
  - **Large inventory in clinics**

IPL Cs-137 tube



Cs-137 Tubes and Needles

- Published dosimetry dataset available for many source designs
- Needles available in various linear strengths and lengths



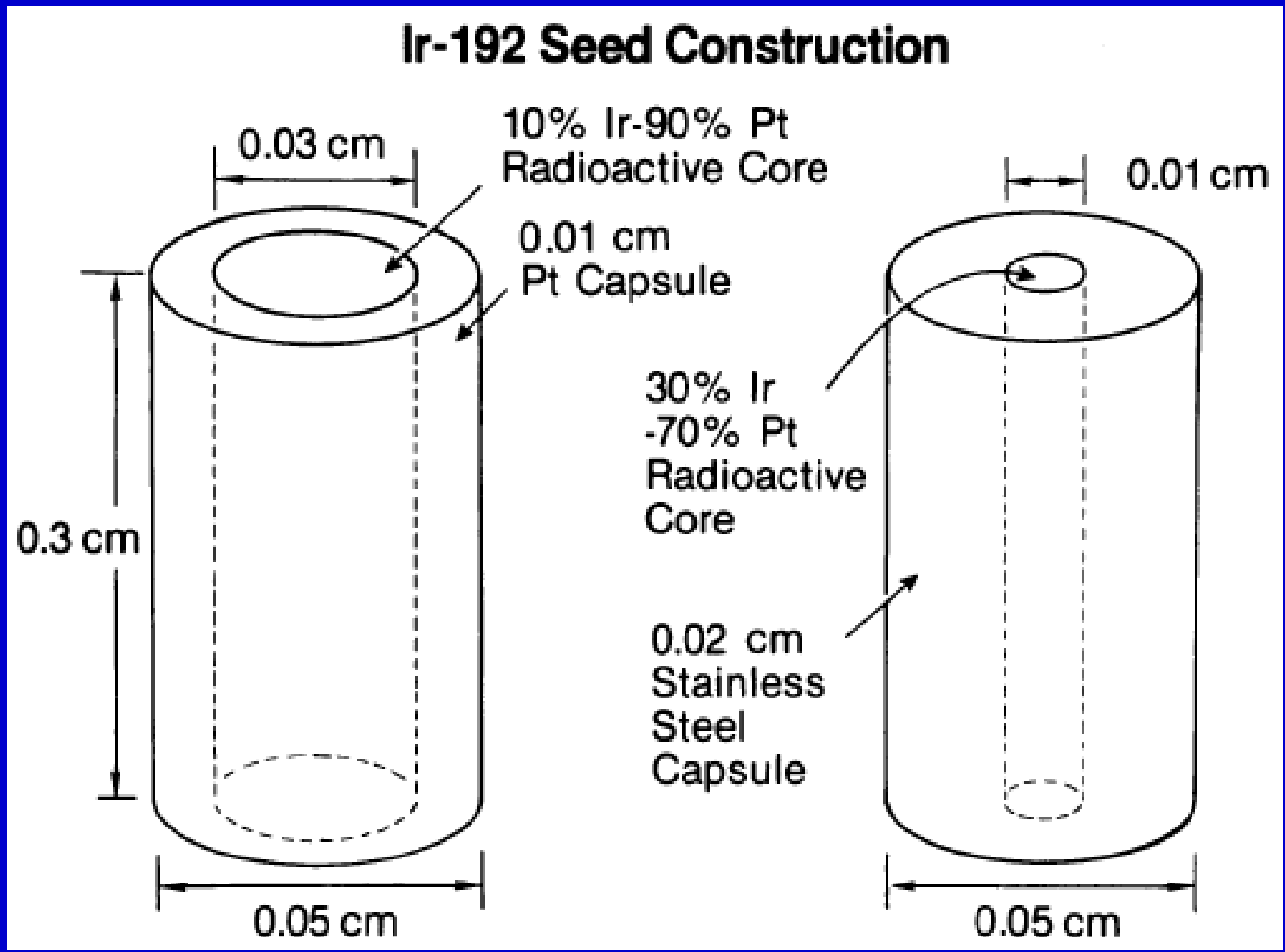
Ir-192 LDR Sources

- **Ir-192 seeds in ribbons**
  - **Available from Best Medical and Alpha-Omega in the United States**
  - **Dosimetry data for Best source in TG43 report**
  - **Monte Carlo data for Alpha-Omega source by Ballester *et al* (2004) in comparison with Best Medical seeds**

Dose Rate Constant ($cGy\text{-}hr^{-1}\text{-}U^{-1}$)
Comparison of Ir-192 Seeds

TG43 Best	Ballester Best	Ballester Alpha-Omega
1.12	1.112	1.111

Best (stainless steel) vs. Alpha-Omega (platinum) Ir-192 Seeds



Best vs. Alpha-Omega Ir-192 Seeds: Comparison of Radial Dose Function and Anisotropy Factors (Ballester *et al*)

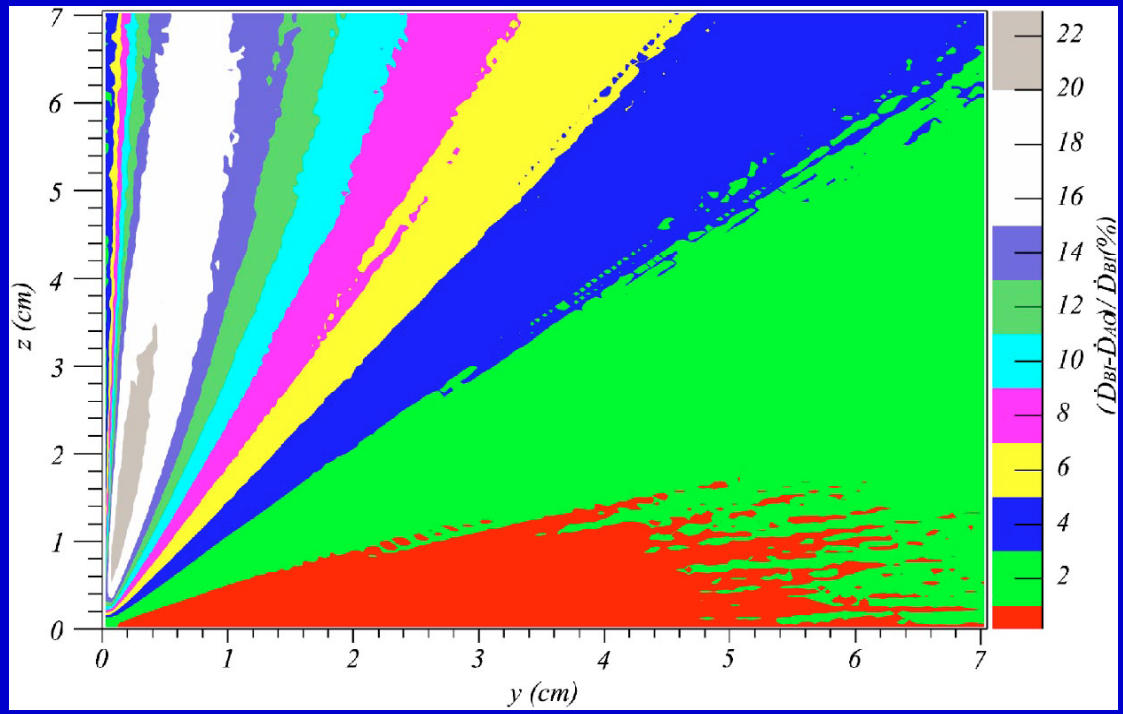
TABLE V. Radial dose function for the Alpha-Omega (AO) and steel-clad (BI) seeds.

Distance r (cm)	$g_L(r)$ AO[a]	$g_L(r)$ BI[b]
0.25	0.999	0.988
0.5	0.998	0.995
0.75	1.000	0.997
1	1.000	1.000
1.5	1.004	1.004
2	1.006	1.008
3	1.007	1.010
4	1.004	1.009
5	1.000	1.005
6	0.993	0.999
7	0.983	0.990
8	0.970	0.977
10	0.938	0.945
12	0.896	0.904
15	0.823	0.834
20	0.691	0.697

TABLE VI. Anisotropy factors $\phi_{an}(r)$ for the Alpha-Omega and steel-clad seeds.

Distance r (cm)	$\phi_{an}(r)$ AO[a]	$\phi_{an}(r)$ BI[b]
0.25	1.134	1.155
0.5	1.005	1.027
0.75	0.982	1.005
1	0.974	0.997
1.5	0.969	0.991
2	0.967	0.988
3	0.968	0.988
4	0.970	0.989
5	0.970	0.991
6	0.971	0.991
7	0.972	0.991
8	0.973	0.991
10	0.974	0.992
12	0.976	0.993
15	0.979	0.991
20	0.979	0.994

Dose Distribution Differences of Best vs. Alpha-Omega Ir-192 Seeds (Ballester *et al*)



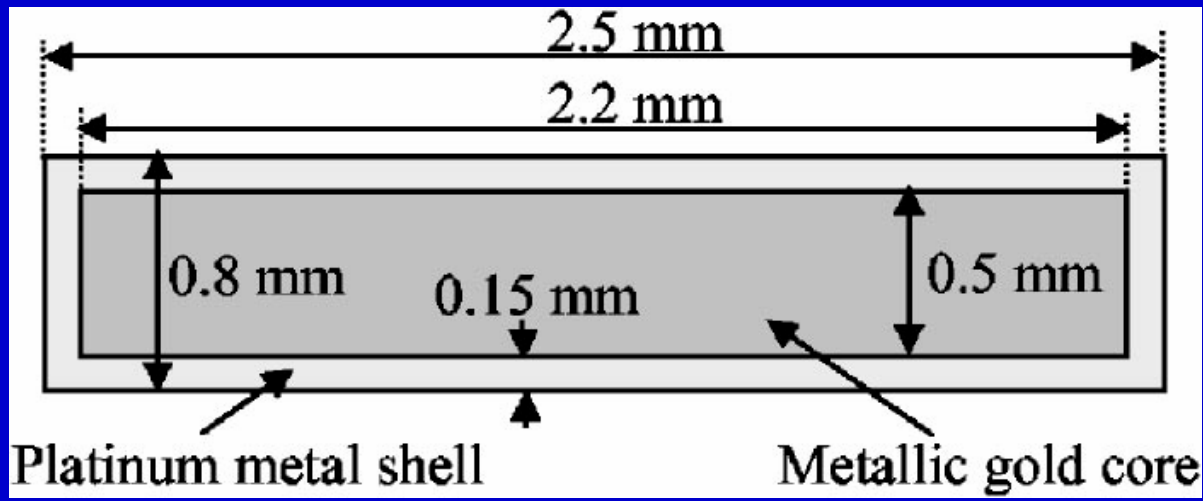
Ir-192 HDR/PDR Sources

- **Ir-192 HDR/PDR sources**
  - **Nucletron Classic HDR/PDR sources: Williamson and Li (1995)**
  - **Nucletron V2 HDR source: Daskolov *et al* (1998)**
  - **Nucletron V2 PDR source: Karaisos *et al* (2003)**
  - **VariSource HDR source: Angelopoulos *et al* (2000)**
  - **GammaMed HDR sources: Ballester *et al* (2001)**
  - **GammaMed PDR sources: Perez-Catalayud *et al* (2001)**

Other Sources

- **Ir-192 wires: Karaiskos *et al* (2001), Ballester *et al* (1997), Perez-Catalayud *et al* (1999) for various lengths**
- **Au-198: Meisberger *et al* (1968), Dauffy *et al* (Med. Phys. 32(6), 2005)**
- **I-125 seeds: AAPM TG43-U1 (Rivard *et al*, 2004)**

Best Medical Au-198 seeds

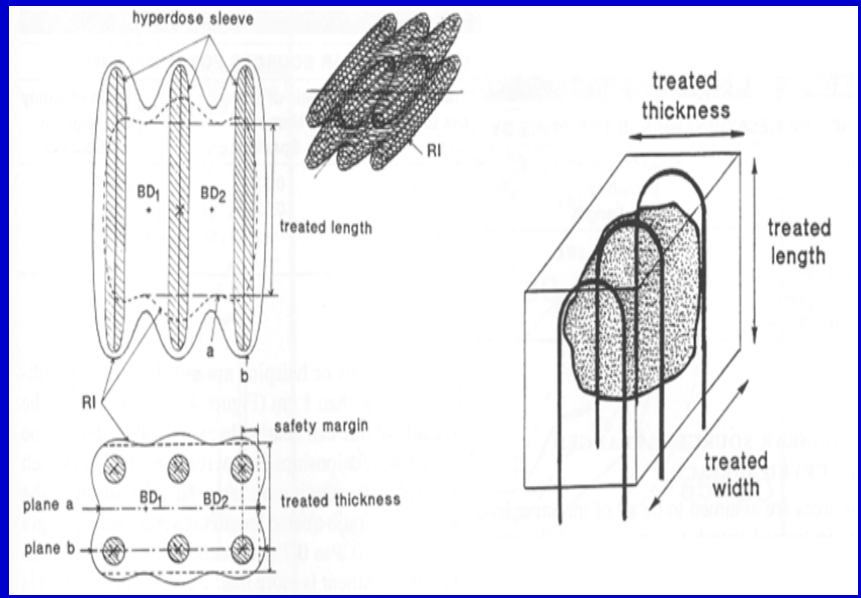


Dosimetry Systems

- Manchester, Quimby, and Paris systems typically used for preplanning
- Paris system for Ir-192 hairpins or looping catheters most applicable to H&N brachytherapy
  - Standard Paris system limits hotspots by using no larger than 2.2 cm catheter spacing
  - Catheter spacing larger than 1.4 cm has been shown to increase complications

Paris System for Ir-192 Hairpins or Looping Technique

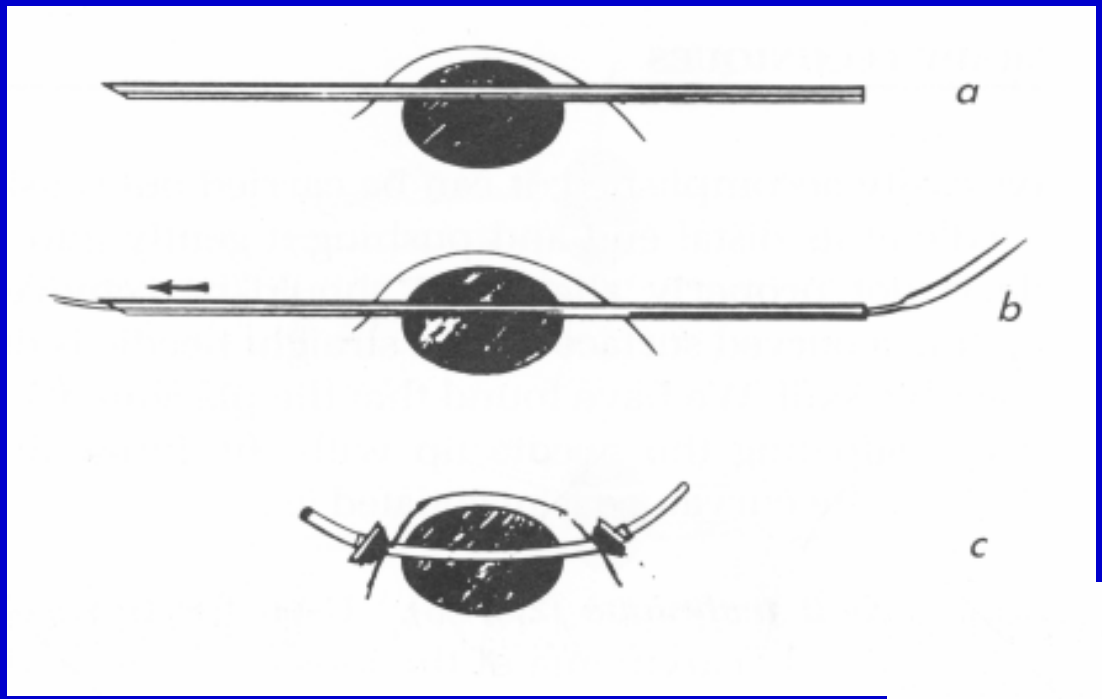
- Tx'ed Length = 0.8 X active length
- Tx'ed thickness = 1.55 x leg spacing of hairpins
- Tx'ed width = Distance between distal-most hairpins + 0.5 x leg spacing of hairpins



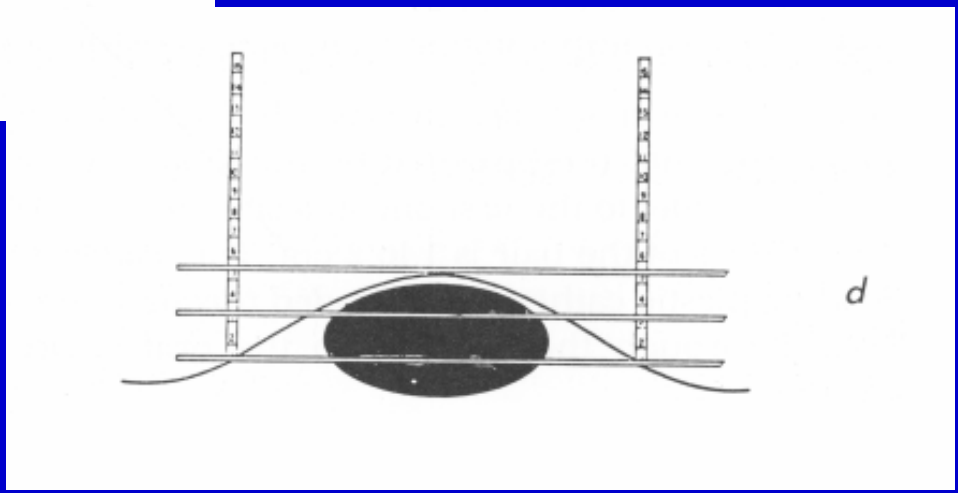
H&N Brachytherapy Dose Prescription and Target Definition

- **Typically delivered in combination with external beam radiotherapy**
  - **Total dose ~ 70 Gy**
- **Dose rate**
  - **Standard Manchester system @ 45 cGy/hr**
  - **Paterson (1952): Modify total Rx dose based on dose rates**
  - **Pierquin *et al* (1973, 1997) and Parsons (1994): No Rx dose change for dose rates between 30 to 80 cGy/hr**
  - **Pernot *et al* (1997): Dose rates higher than 70 cGy/hr related to high incidence of soft tissue and bone necrosis**
- **Target definition: CTV + up to 1 cm margin**

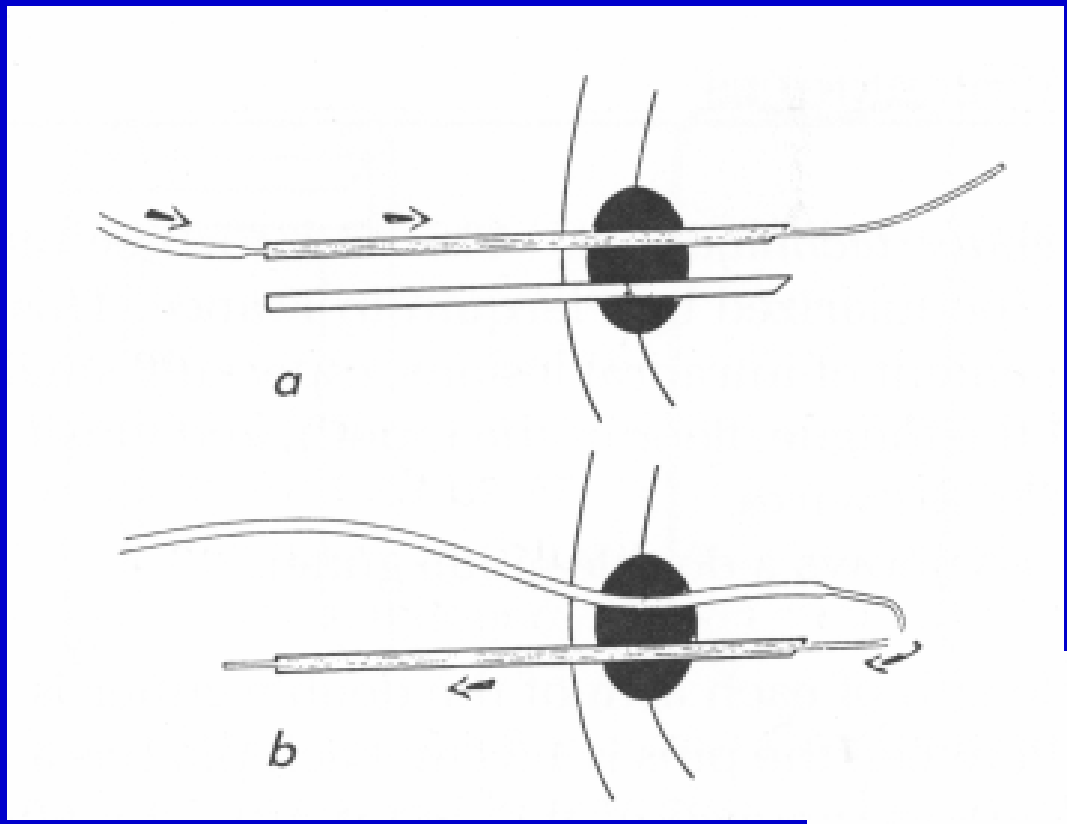
Implant Techniques – Standard Through-and-Through



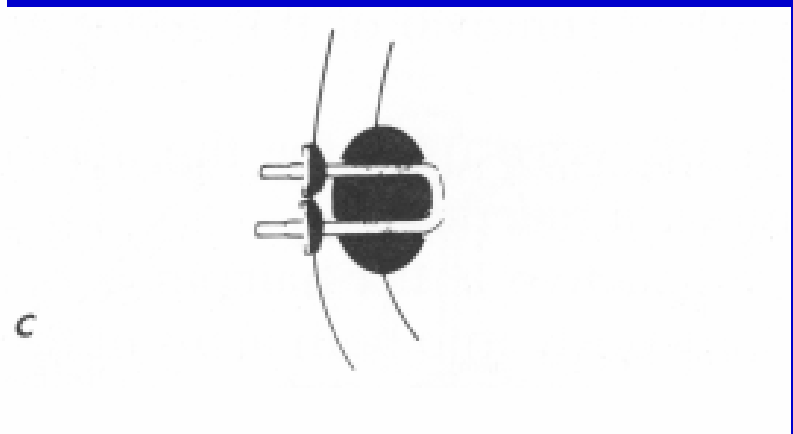
Entrance and exit sides need to be selected carefully for ease of access and catheter care



Implant Techniques – Looping

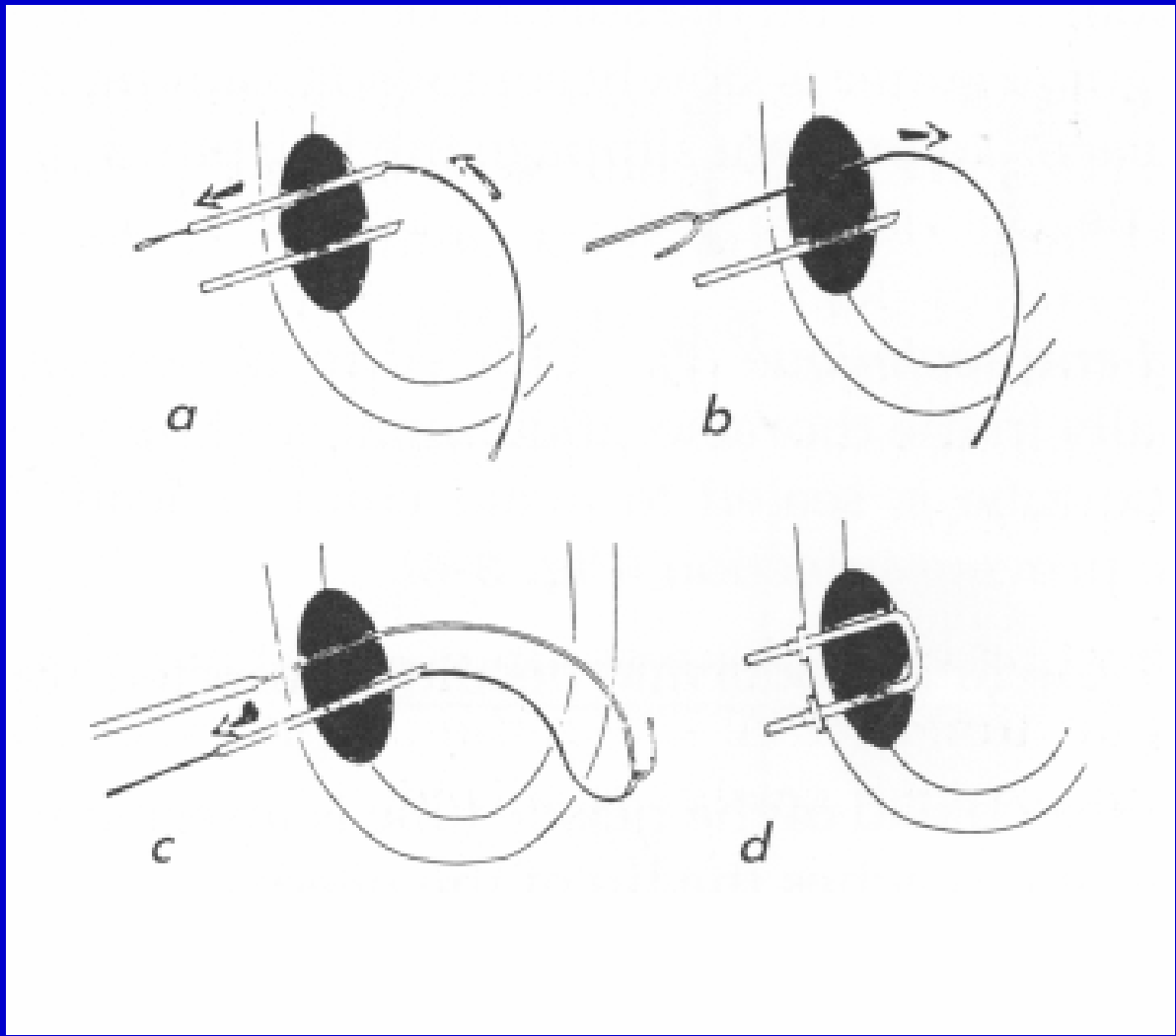


- Looping over superficial tumor.
- Need access for removal of 1st needle.

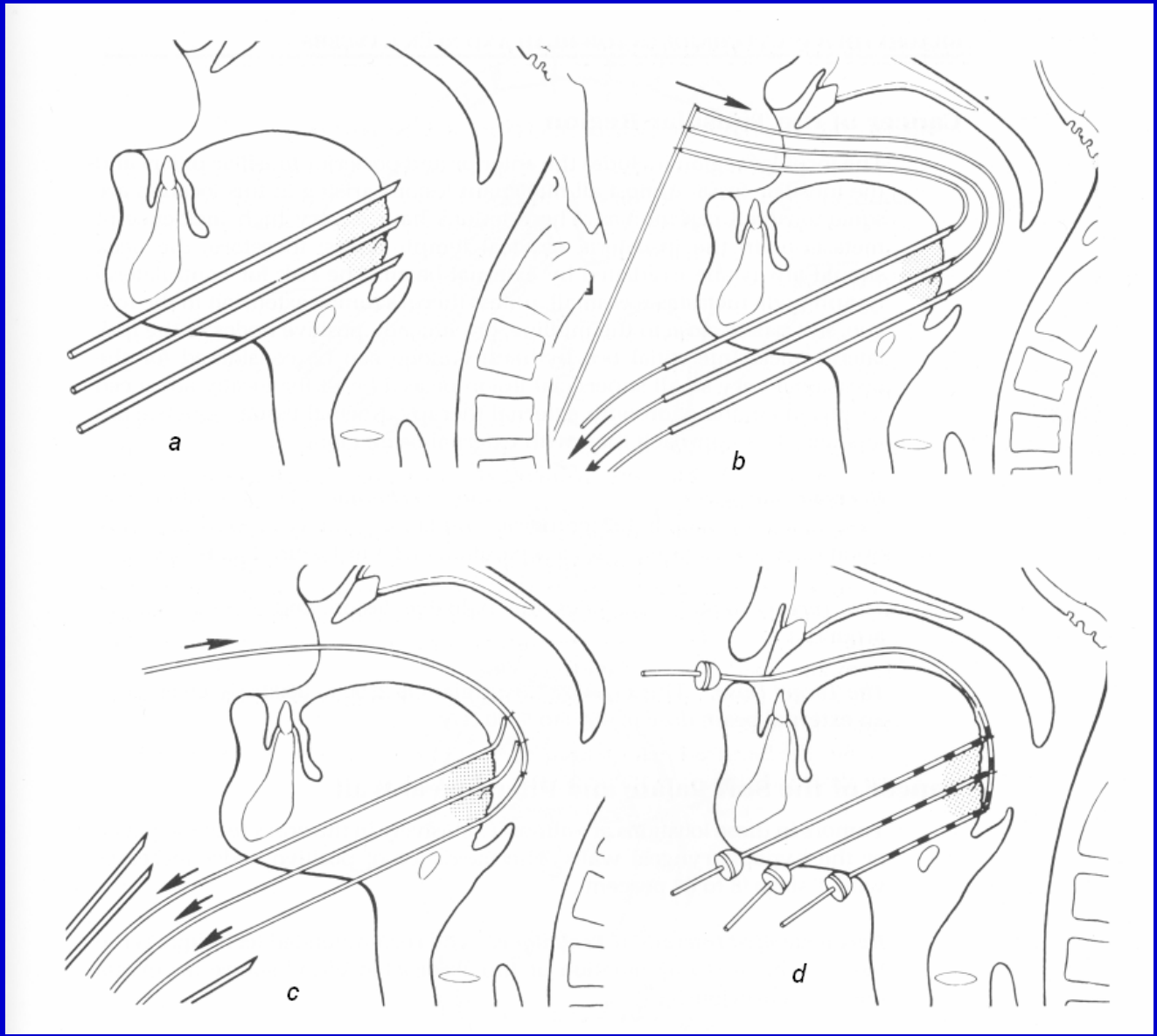


Implant Techniques – Looping with Wire

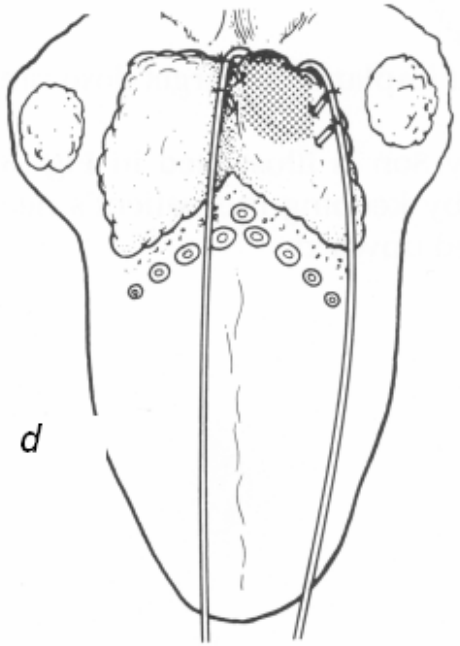
Use a wire to pull catheter through tissue following removal of 1st needle

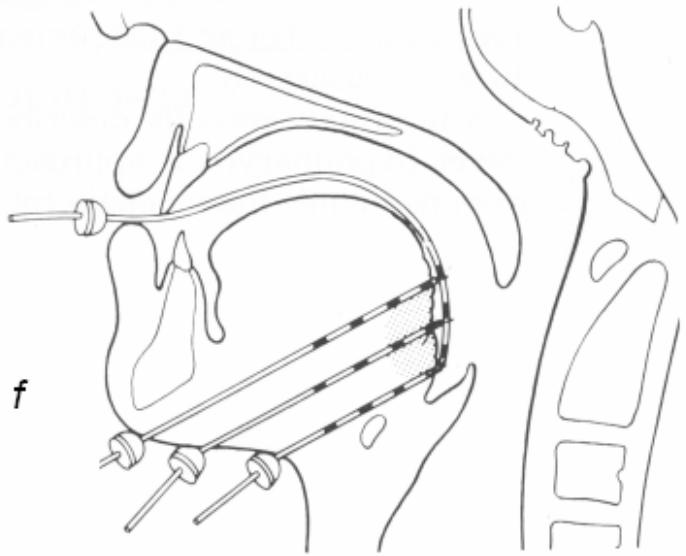


Implant Techniques – Non-looping

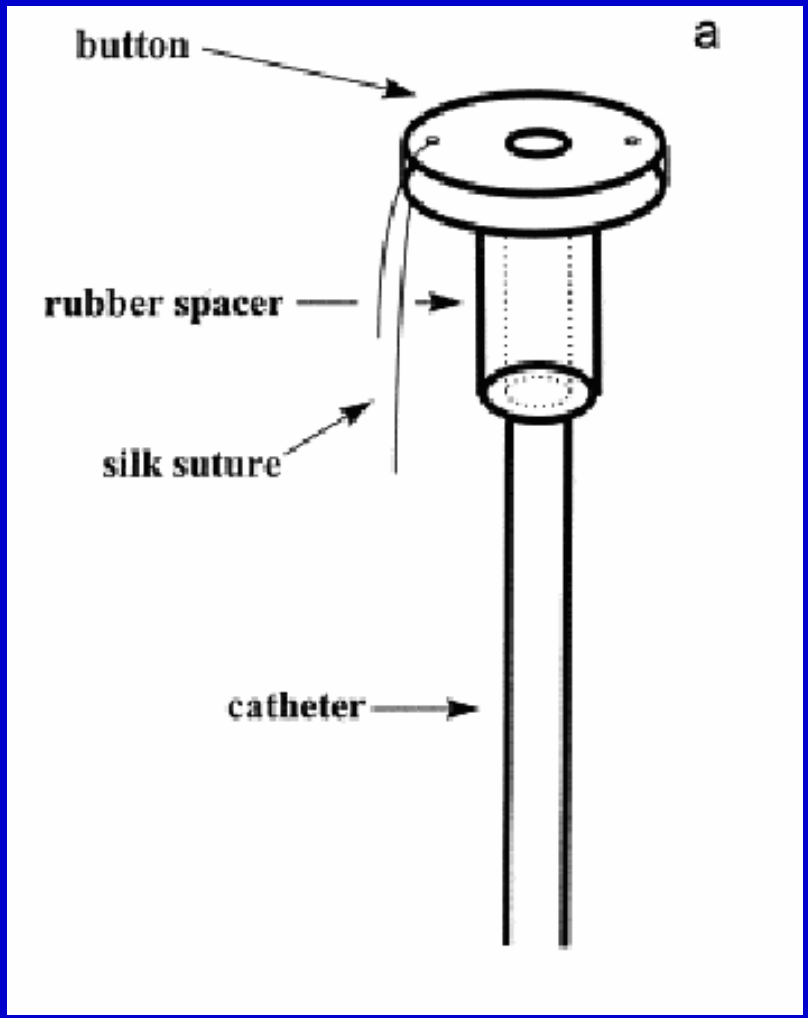


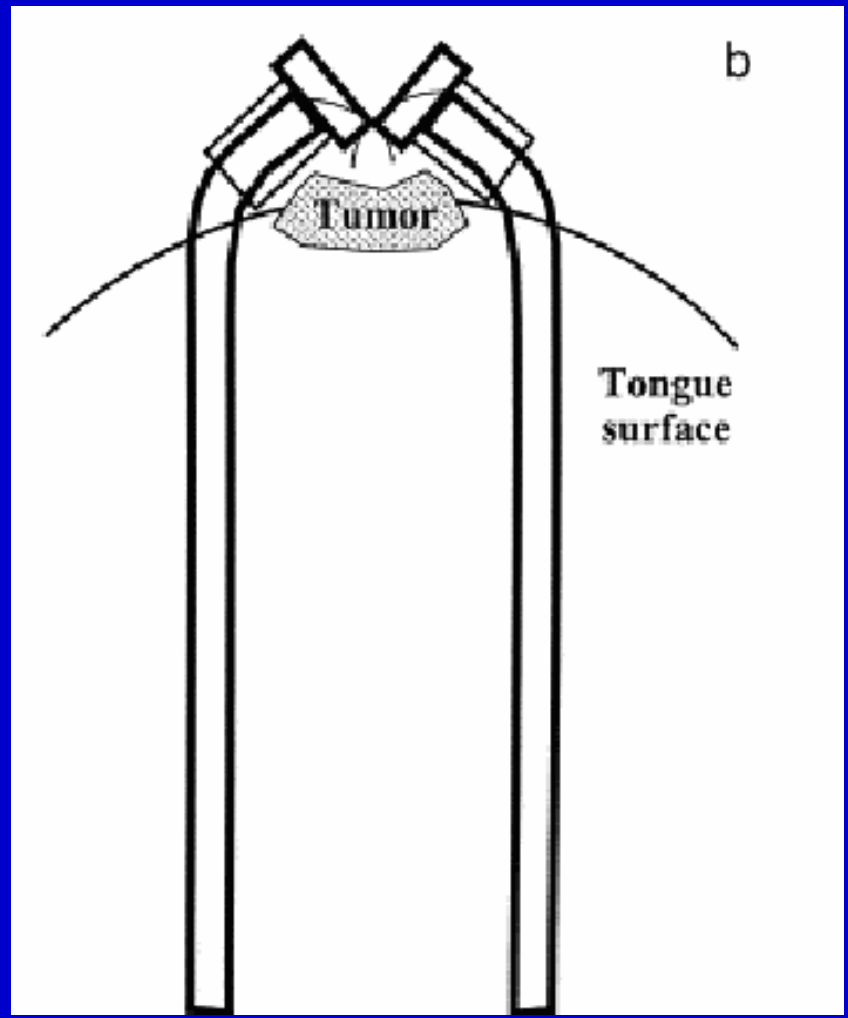
Implant Techniques – Non-looping





Implant Techniques – Non-looping for HDR





Treatment Complications

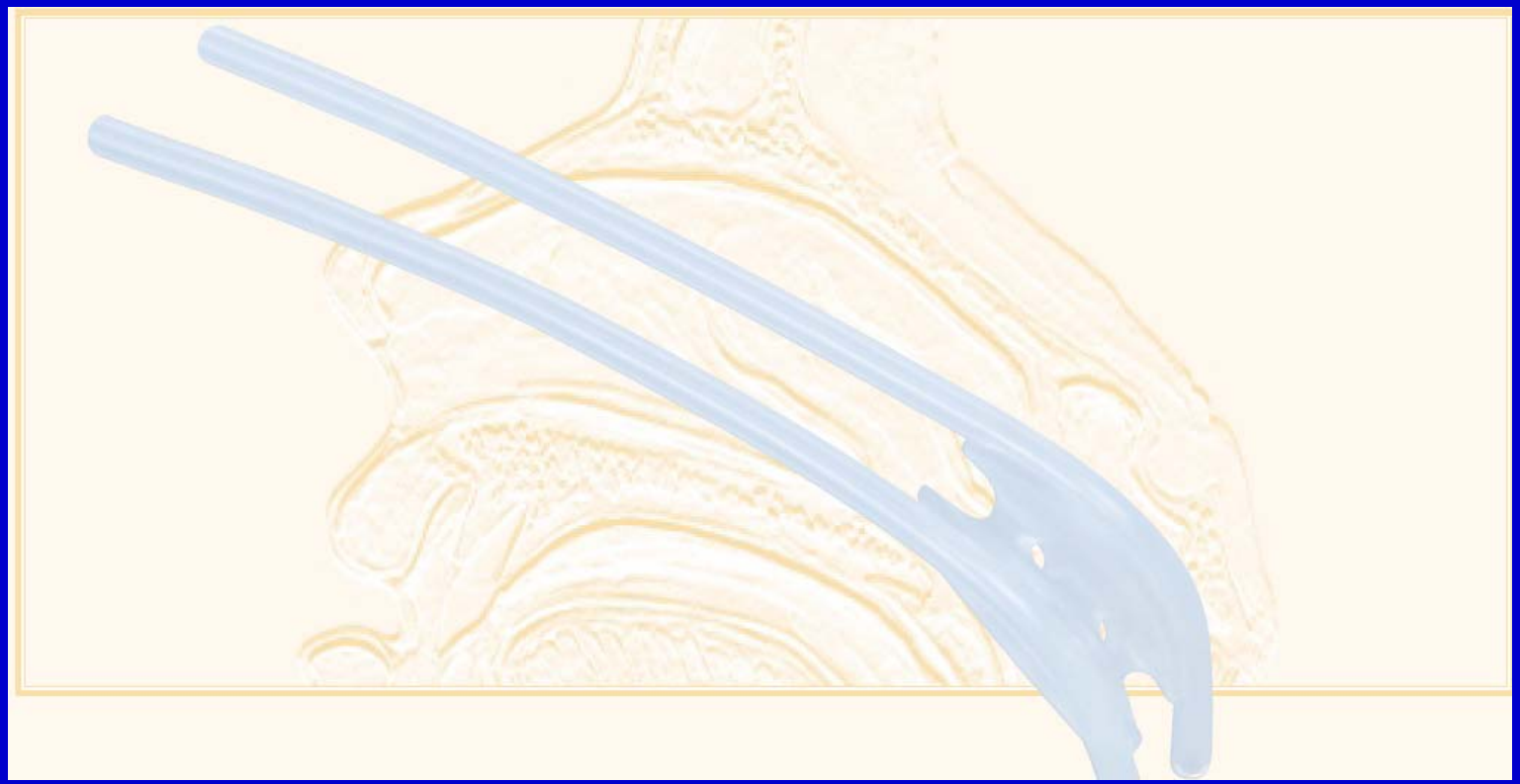
- **Soft tissue and bone necrosis**
  - **Soft tissue necrosis: Up to 20% (Parsons *et al*, 1994)**
  - **Bone necrosis: Up to 6% (Mendenhall, 2004)**
  - **Rate of necrosis increases with increased dose**
    - » **Steep increase at ≥ 66 Gy (Jereczek-Fossa and Orecchia, 2002)**
    - » **High bone necrosis at ≥ 60 Gy and larger than 55 cGy/hr (Fujita *et al*, 1996)**
  - **Rate of necrosis increases with ≥ 12 cm^2 treated surface area (Pernot *et al*, 1997)**
- **Rate of necrosis can be reduced by**
  - **Use of spacers between target and normal tissue**
  - **Use of lead shields between implant and gingiva**

Treatment Complications

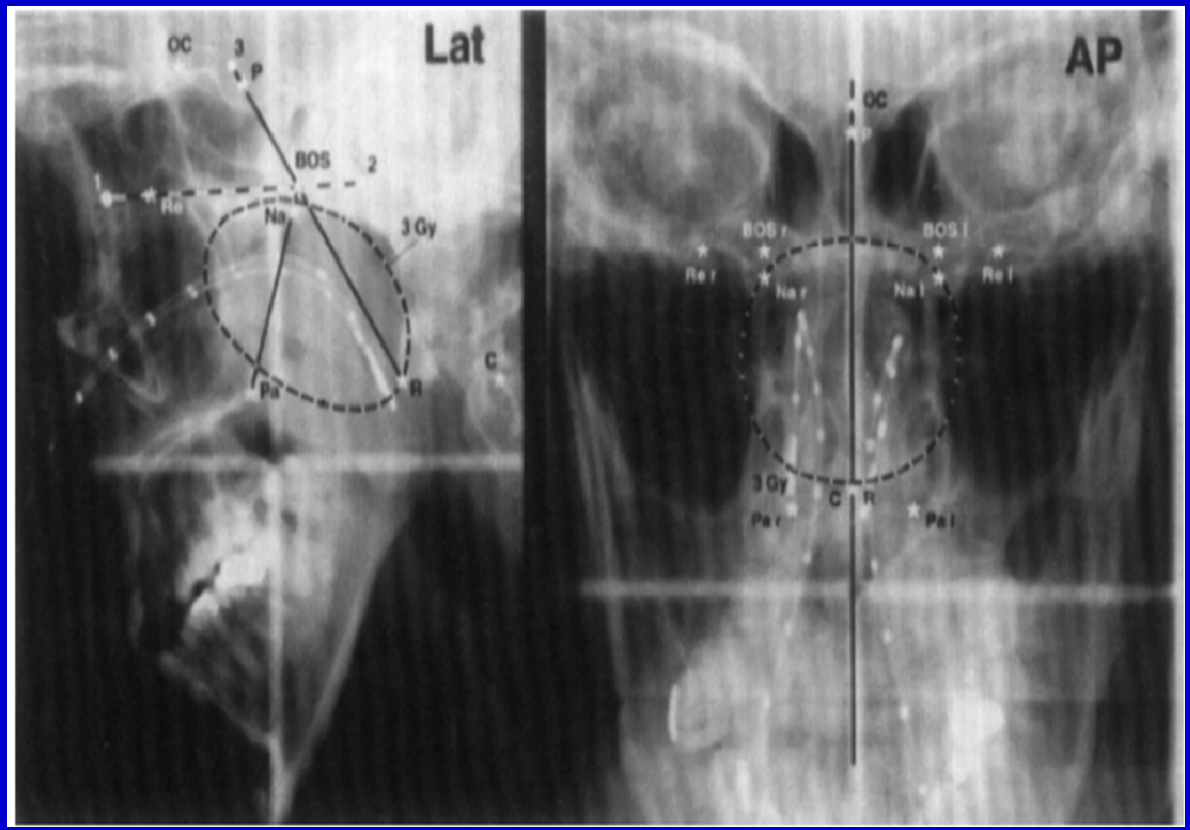
- **Skin fibrosis**
  - **Limit skin dose to less than prescription dose**
- **Pretreatment dental evaluation**
  - **Teeth in poor health correlates with increased rate of soft tissue and bone necrosis**
  - **Pretreatment dental evaluation necessary**
    - » **Teeth in poor health extracted at 14 – 21 days prior to treatment**

Specific Sites - Nasopharynx

- **Intracavitary treatment using commercial or custom applicators**
- **Levendag (1997) technique: Recommended by ABS. 3Gy/fx BID. # fx and EBRT based on stage**



Levendag Technique for Nasopharynx



Oral Cavity

- **Use of template when applicable**
- **Lead shielding to mandibles**

Table 2a. HDR brachytherapy as sole treatment for oral cavity cancers

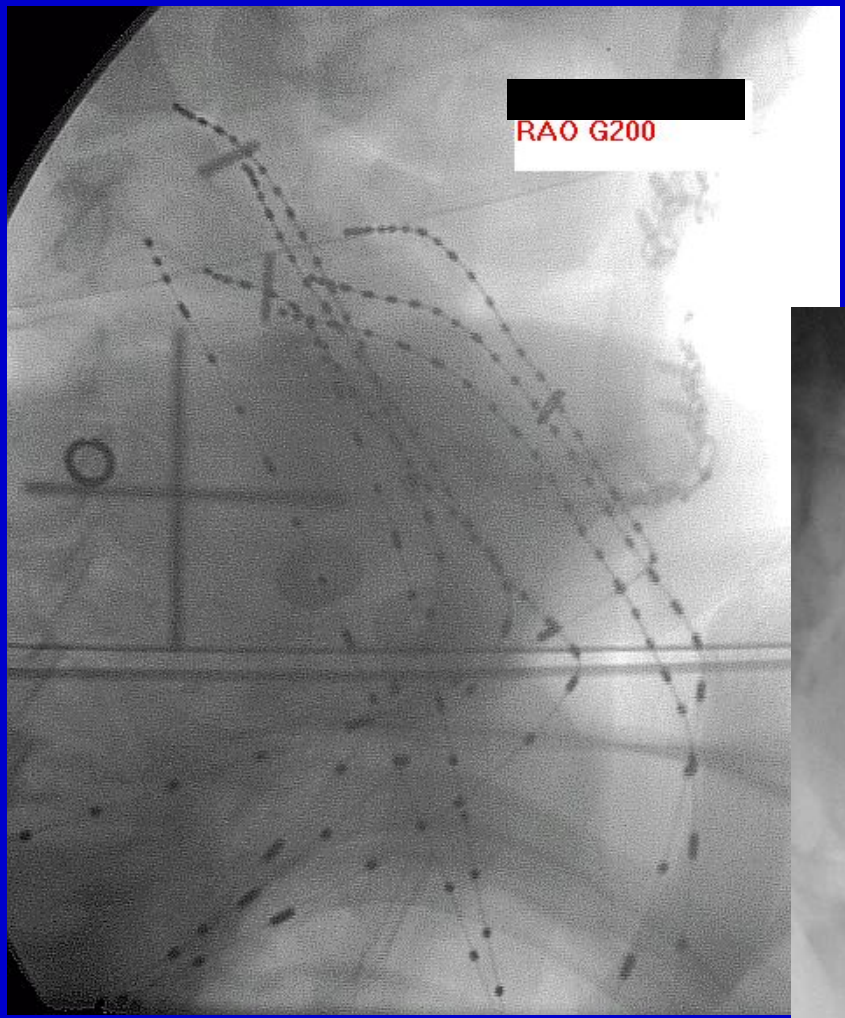
EBRT	Fx Size (Gy)	# fx	Equiv. dose (Gy)	# pts.	L.C.
0	3	20	65	3	—
0	6.5	7	63	27	53%
0	6	10	80	14	100%
0	4.5–5	10	54–63	13	90%
0	5.5–6	10	71–80	13	100%

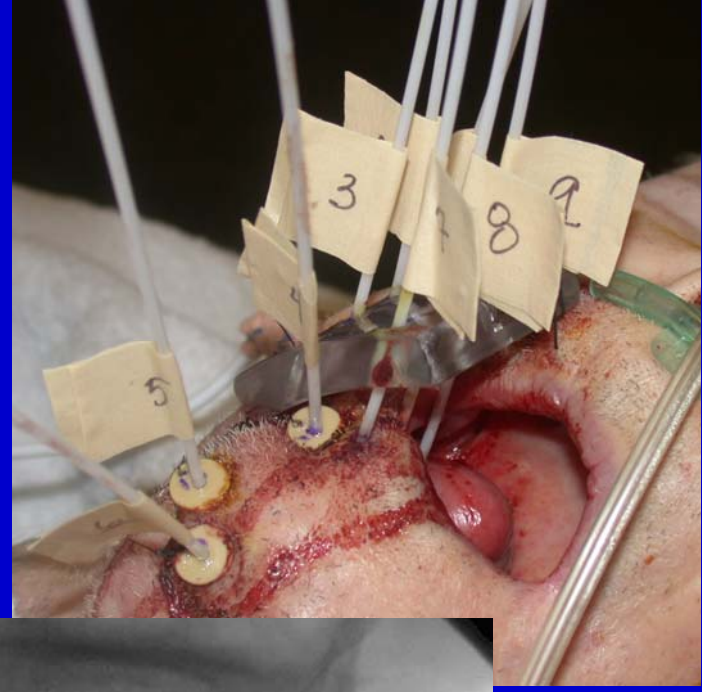
Table 2b. HDR brachytherapy as boost treatment for oral cavity cancers

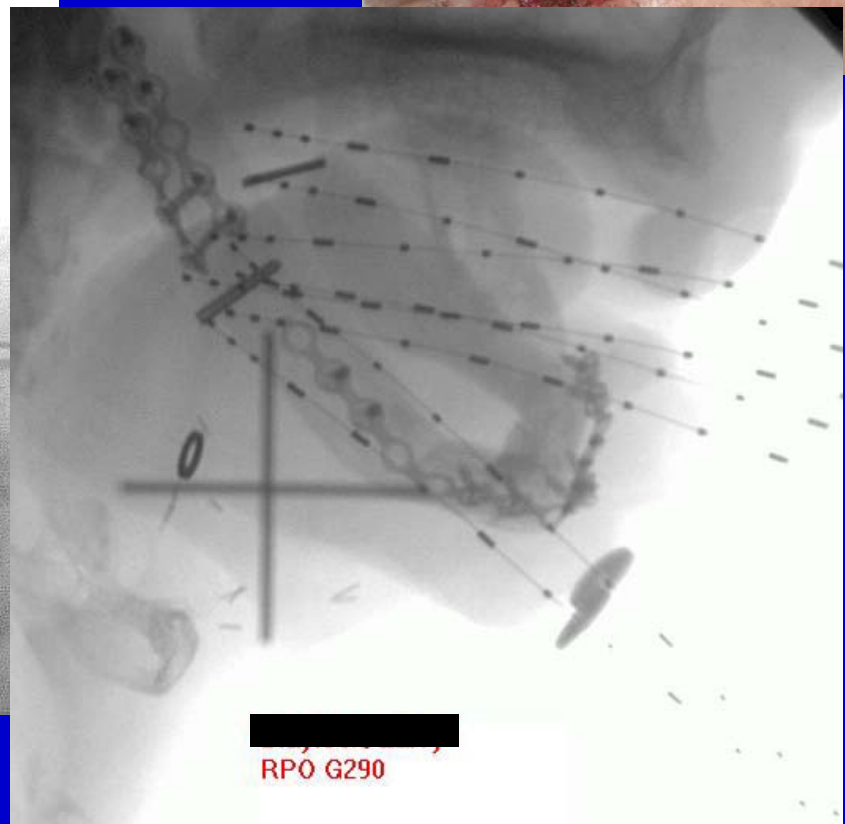
EBRT dose (Gy)	HDR dose/fx (Gy)	# fx	Equiv. dose* (Gy)	# Pts.	L. C.	Survival
50	2.7	6	67	12	79%	45%
40–48	3	7	63–71	18	80%	

Abbreviations: Fx = fractions; equiv. = equialent; Pts. = patients; L. C. = local control; HDR = high dose rate; EBRT = external beam radiation therapy.

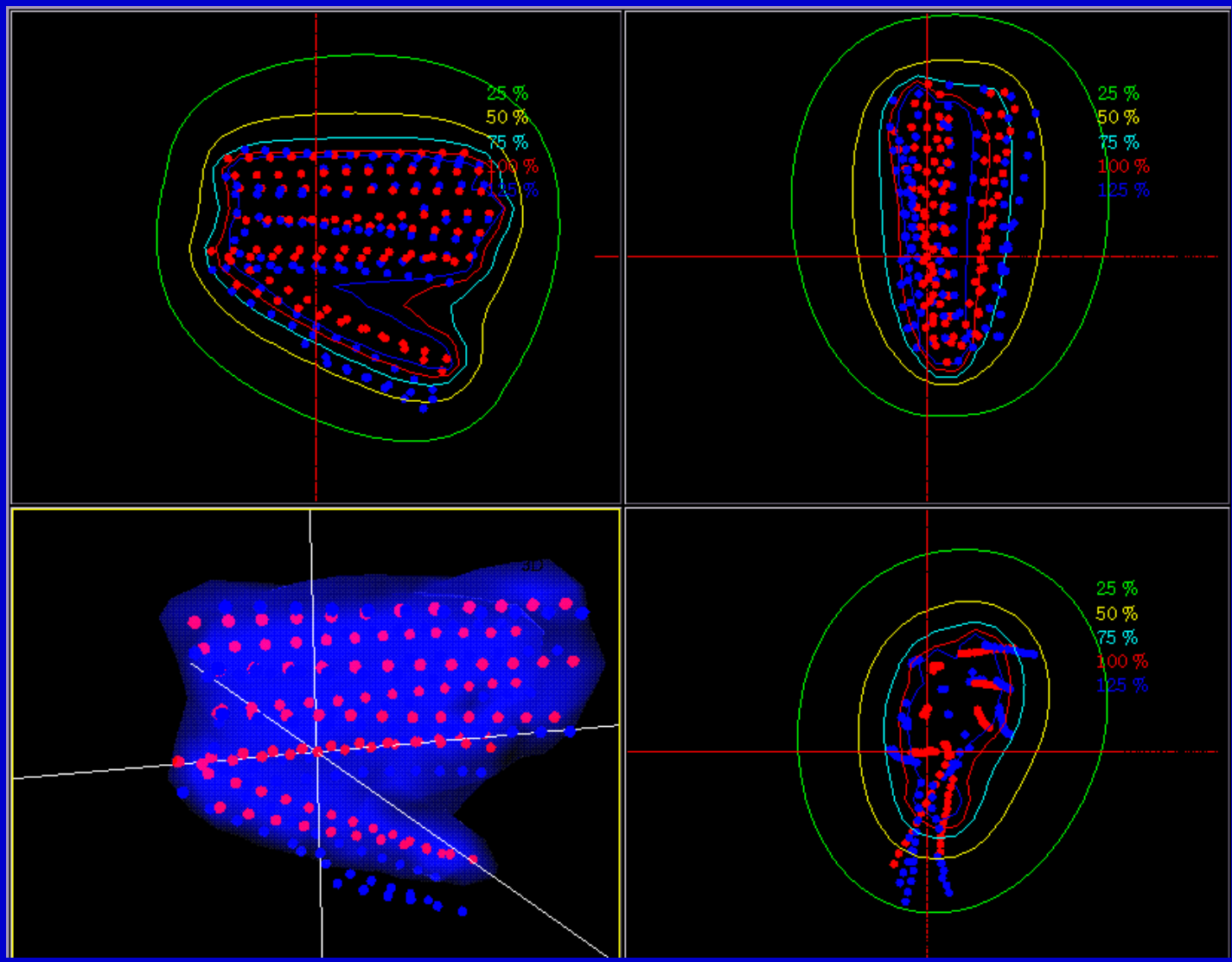
Use of templates to improve accuracy







Use of Templates

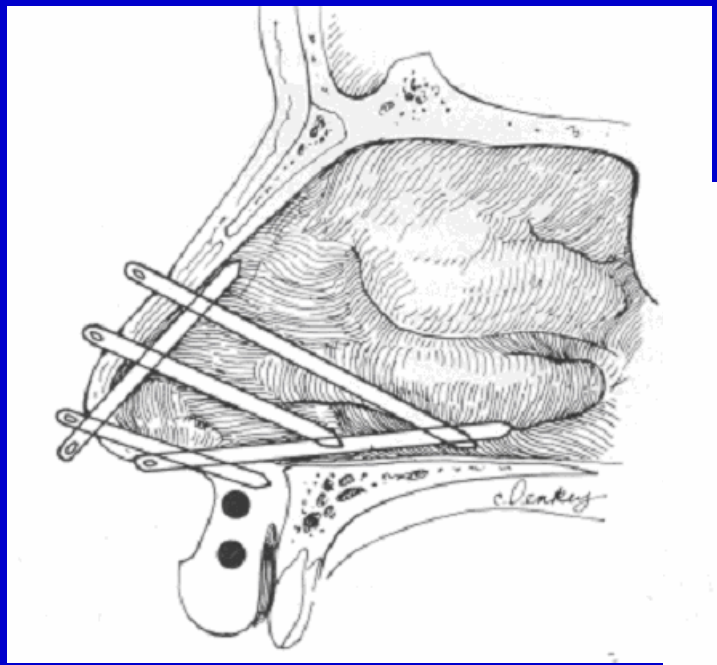


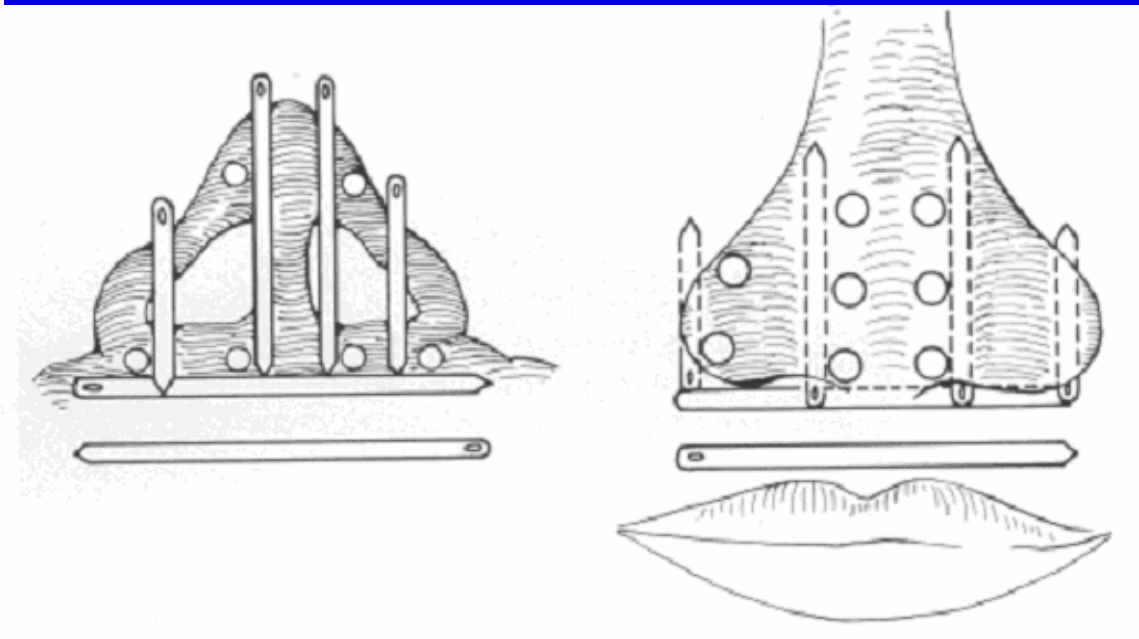
Lip

- Cross needles often necessary for LDR implants
- Use lead shield for gingiva
- LDR: 35 Gy @ 5 mm brachytherapy + 30 Gy EBRT (Million *et al*, 1994)
- HDR: 5 – 5.5 Gy/fx BID X 8 – 10 fx's, totaling 40.5 -45 Gy brachytherapy alone (Guinot *et al*, 2003)

Nasal Vestibule

- 55 – 75 Gy brachytherapy alone
- Does not follow Manchester system
- Potentially high dose rate (~ 80 cGy/hr)





Summary

- Classical implant systems commonly used for H&N brachytherapy
  - May need smaller spacing for Paris system
- High dose rate may correlate with increased soft tissue and bone necrosis rates
  - Limit dose rate
  - Use spacers and shielding for normal tissue
- Select appropriate implant technique and use of templates