Role of Brachytherapy in Head and Neck Cancer:

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What is Brachytherapy?

The term 'brachytherapy' derived from greek word brachio (short)

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A form of Radiotherapy that involves treatment with radioactive sources (usually sealed) in contact with or close to target tissue

2 distinct | charecteristics

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- High dose of radiation to the adjacent target volume
- Limiting dose to the surrounding healthy tissues

History

"Actually Radiotherapy started in the form of Brachytherapy"

1898 :

Marie & Pierre Curie isolated Radium and work on Brachytherapy started.

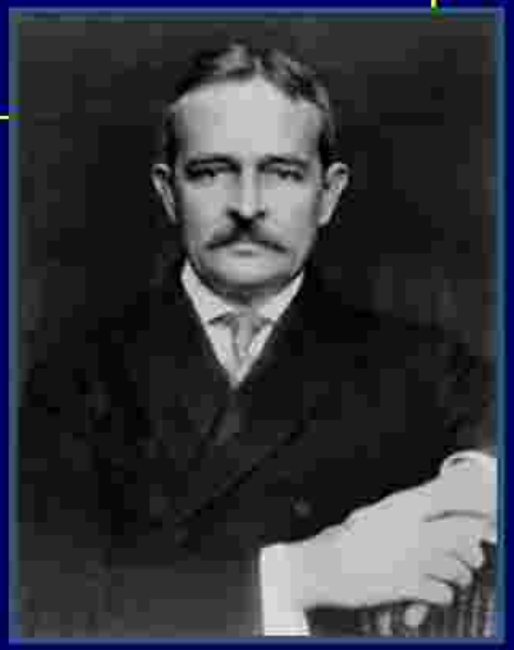
History

Robert Abbe (American surgeon):

First used Ra technique for treatment of cancer.

1920-30s : "*Quimby System*"

1934 : "Paterson-Parker"



History of Brachytherapy

- ***1950-60s*** :
  Advent of mega voltage type tele-therapy machines had provided treatment option with non-invasive procedure; EBRT treatment.
- So, there was decline in progress of interstitial Brachytherapy.

Brachytherapy was considered 'lost art'.

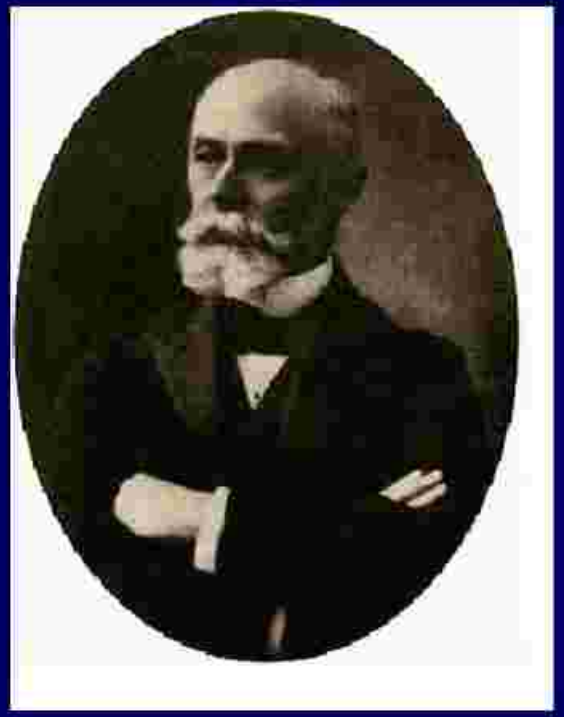
History

- *1964*: **Paris system**

  Bernard Pierquin et al. used Ir192 after-loading interstitial implant.

- *1980-90s* :

  HDR after-loading , computer planning & optimization came in use.



New possibilities in Interstitial and intracavitary Brachytherapy with advantages of HDR after-loading & computer optimization.

What is so special about Brachytherapy ?

It is the best conformal radiotherapy

Has been able to keep it's identity in the face of new challenge

Different applications of Brachytherapy in head and neck cancer

- Implant : Most common application sources placed directly into the target tissues as in oral cancer
- Intraluminal: single line source introduced into the lumen of a organ (ca nasopharynx)
- Mould: In cancer of lip ,BCC of face where sources placed over the skin or mucosal surface

Why Brachytherapy in Head & Neck Cancer ?

1. Total Dose Higher to the tumour with normal tissue sparing (Better therapeutic ratio)

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Better local control and less side effects

(In head and neck cancers, *failure is predominantly local or loco-regional*.)

3. More accessible sites, as in tongue, cheek etc.
4. Overall treatment time smaller and treatment finished before the repopulation starts

Indications of Brachytherapy in H & N Cancer

- As a sole modality: Radical treatment in early Cancer (>3 cm and node- negative) tongue, cheek, floor of mouth
- Used with EBRT: To boost the dose at site of greatest risk of recurrence
- As salvage treatment: In recurrent tumours

Contraindications of Brachytherapy

- Diffuse and extensive growth
- Distant metastasis
- Node-positive disease
- Tumors very close to or involving bone
- Not suitable for anaesthesia

Sites in Head & Neck region suitable for implant

1. Ant 2/3 tongue
2. Lip
3. Buccal mucosa
4. Floor of mouth
5. Soft palate.
6. Base of tongue as boost.
7. Tonsil

Selection of patients for Primary Implant .

- Early disease, >3 cms and node-negative
- No distant metastasis.
- Site accessible, superficial and away from bone
- Pt willing
- Radical treatment intent.
- Suitable for anesthesia.

Steps of Implant.....

Interstitial Treatment

Implant of catheters

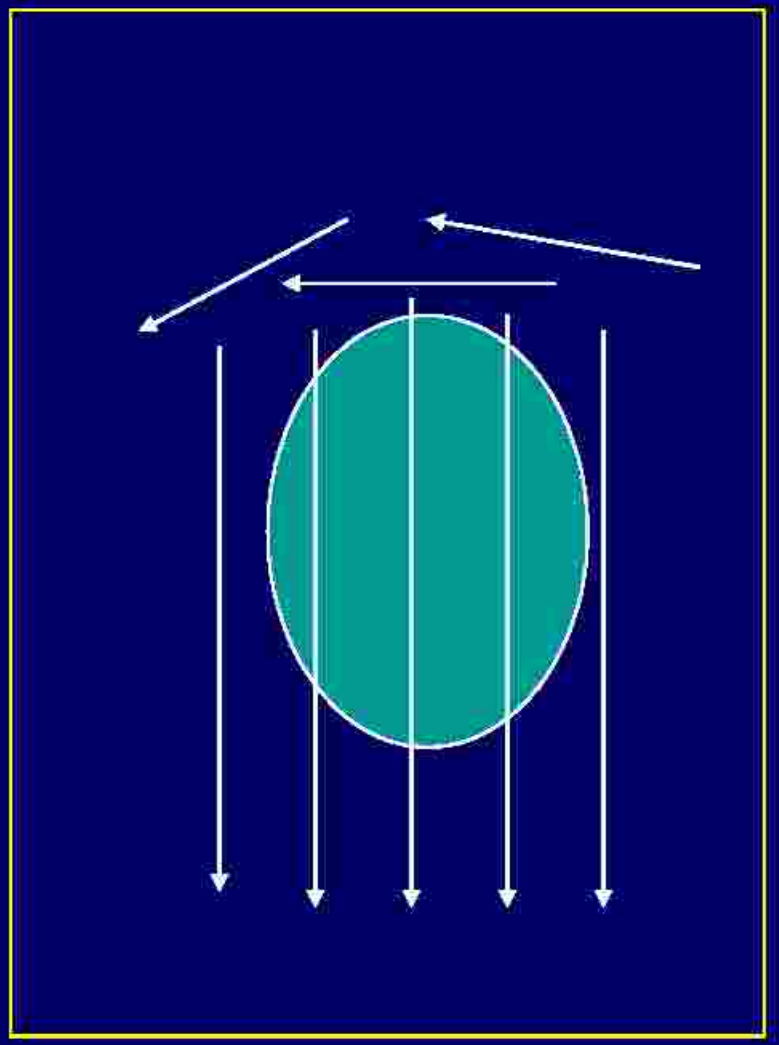
dosimetry

Role of Radiotherapist

Role of Physicist

Implant technique

Paterson-Parker system of Implant



- Pre loaded needles (cesium)
- Planar and volume implants
- Distribution of needles guided by the area and geometry of implant
- Crossing needles used often
- Neddle position parallel and interneedle distance 1 cm usually
- >1.5 cm thick target needs double-plane implant
- Dose calculated at 0.5 cm from each needle
- Basically implant guided and dose prescription based on the Paterson-Parker table.

Implant technique

Paris System of Implant :

1. Radioactive sources parallel & arranged so that their centres lie in same plane; ' central plane'.

2. Linear activity of each source wire uniform.

3. Radioactive sources are equidistant.

4. When multiple plane implant used, implants placed in such pattern that they maintain equilateral triangle or squares at central plane.

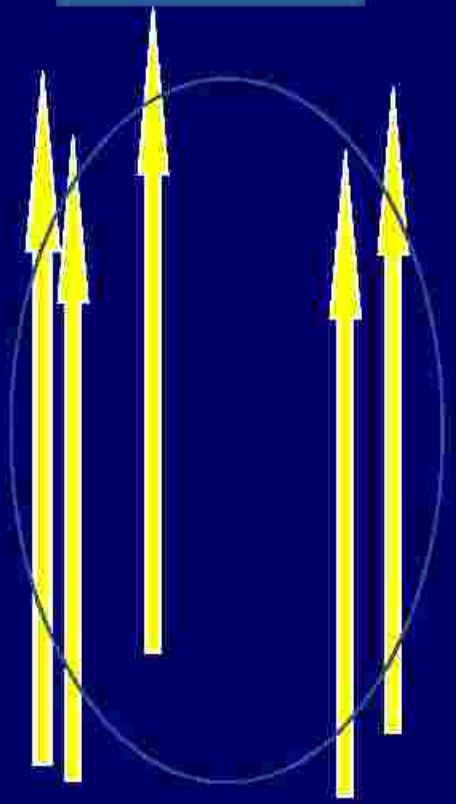
Implant technique

Implant -I

Implantation done following Paris System of implant

Excellent Implant

Implant -II

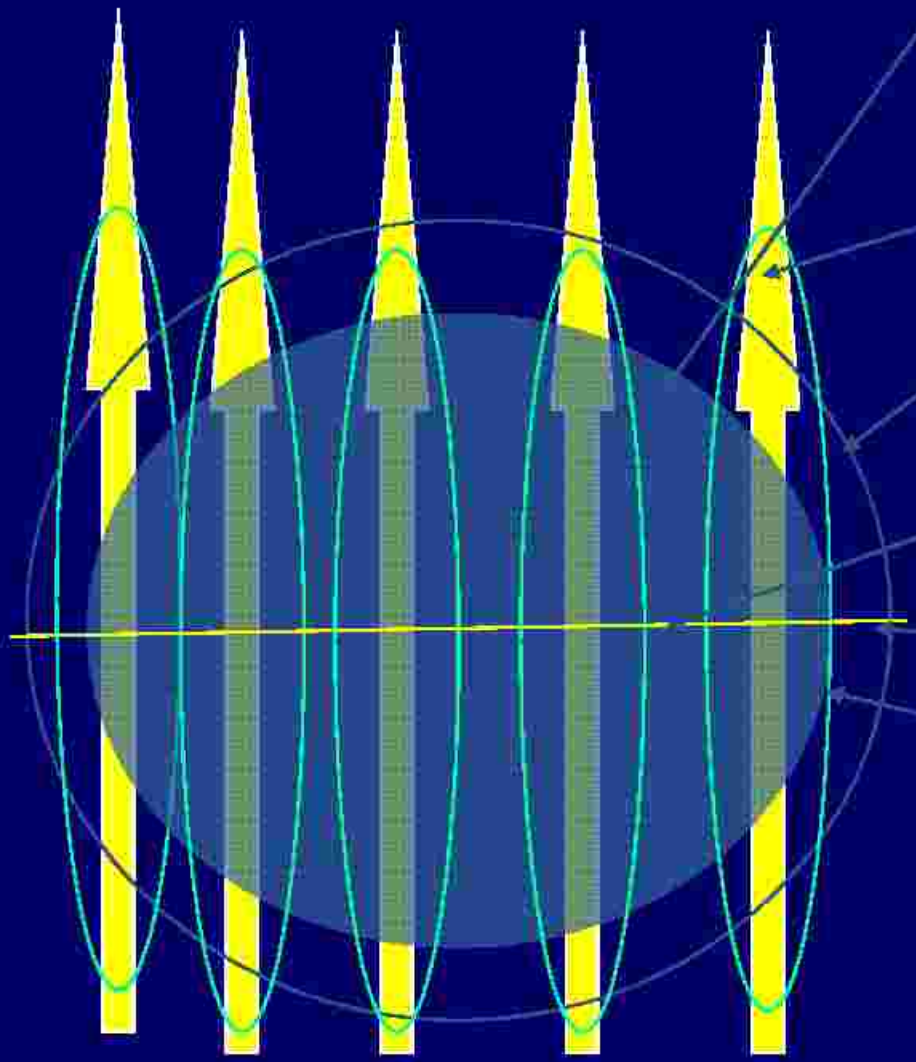


Needles not equidistant & not in same plane.

Sub-optimum Implant

Dosimetric Consideration

Dosimetric Consideration



GTV

Needles

Ref Vol./PTV

Basal dose.

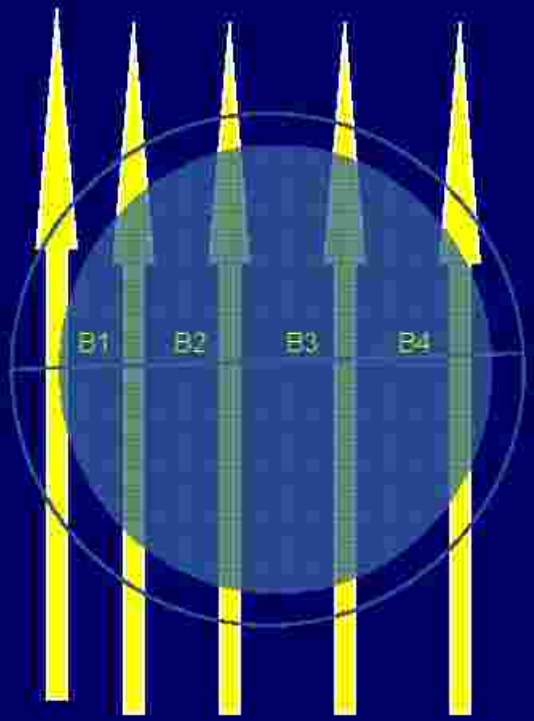
Central plane.

High dose vol.

Mean Central Dose

Min Target Dose

Dosimetric Consideration



Definitions :

Reference volume = 85% of basal dose iso-dose curve covering the volume.

Central plane = plane perpendicular to the direction of sources formed by the centers of each sources.

MCD = mean basal dose at central plane

MTD = minimum tumor dose at the periphery of CTV.

Basal Dose = dose at central plane mid point between two equidistant sources.

Treated Volume = volume covered by ref. iso-dose.

High dose Vol = V_{150} iso-dose volume.

Low dose Vol = V_{90} iso-dose volume.

Dose Prescription =

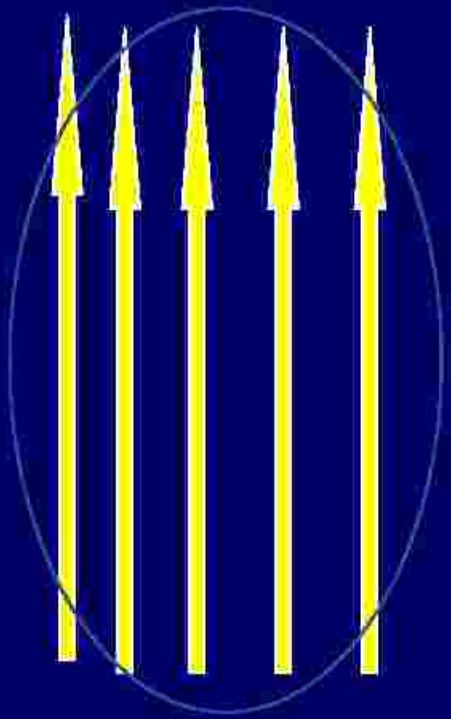
- Reference vol should cover the CTV adequately.
- No high dose or low dose volume within the CTV.
- less normal tissue irradiated.

Changes in Modern day Implant

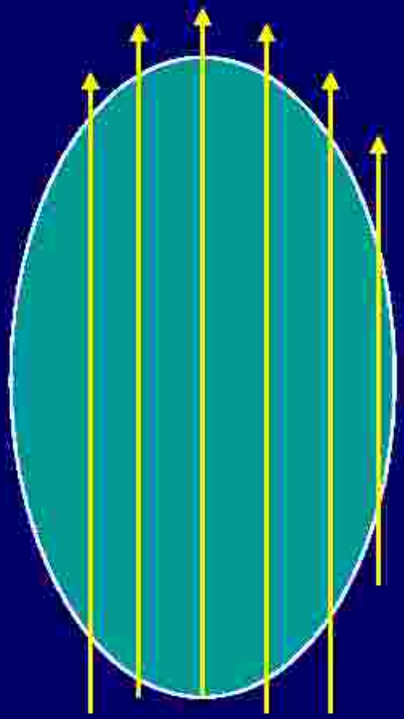
- Computer isodose calculations
- Dwell-weight optimisation of single high-activity stepping source
- Utilisation of 3D image to define target volumes

Basically changed from implant guided to image guided dosimetry

Implant -A



Implant-B

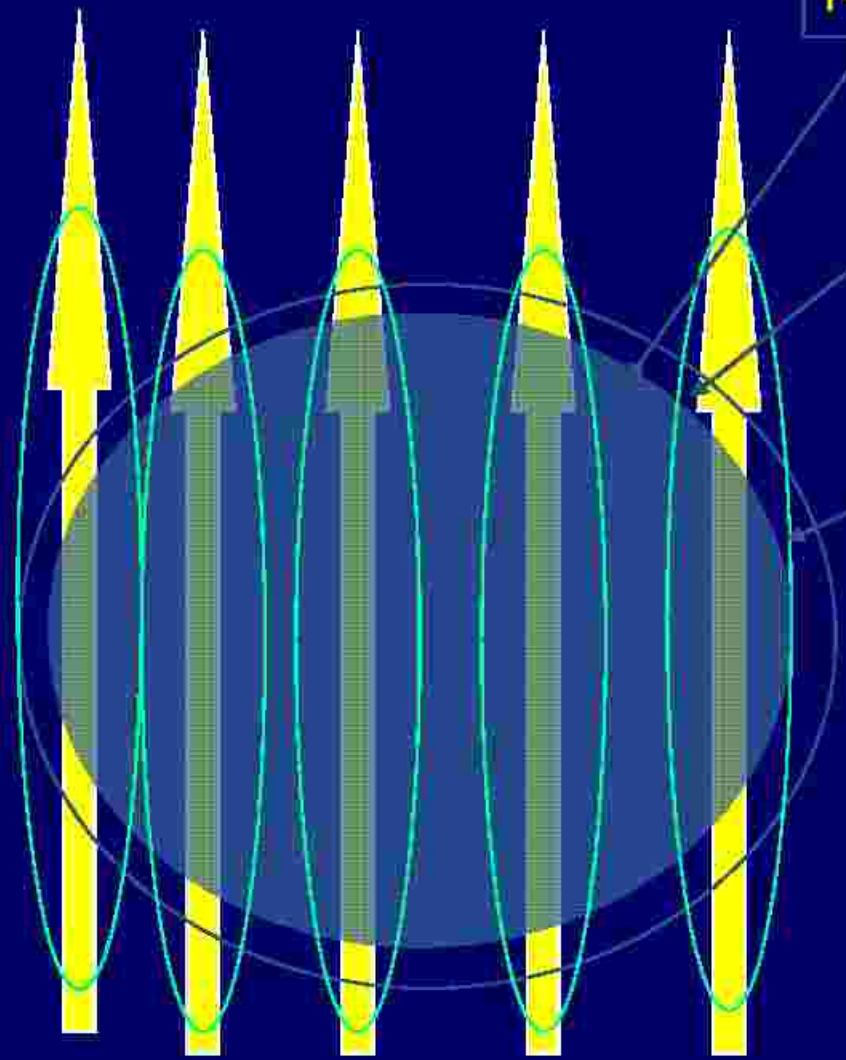


- All needles parallel.
- Uniform dose rate.
- All needles equal distance.

Both implant : Rules of Paris system implant followed

But both the implants same ?

Implant -A



PTV completely covered by Ref. Vol

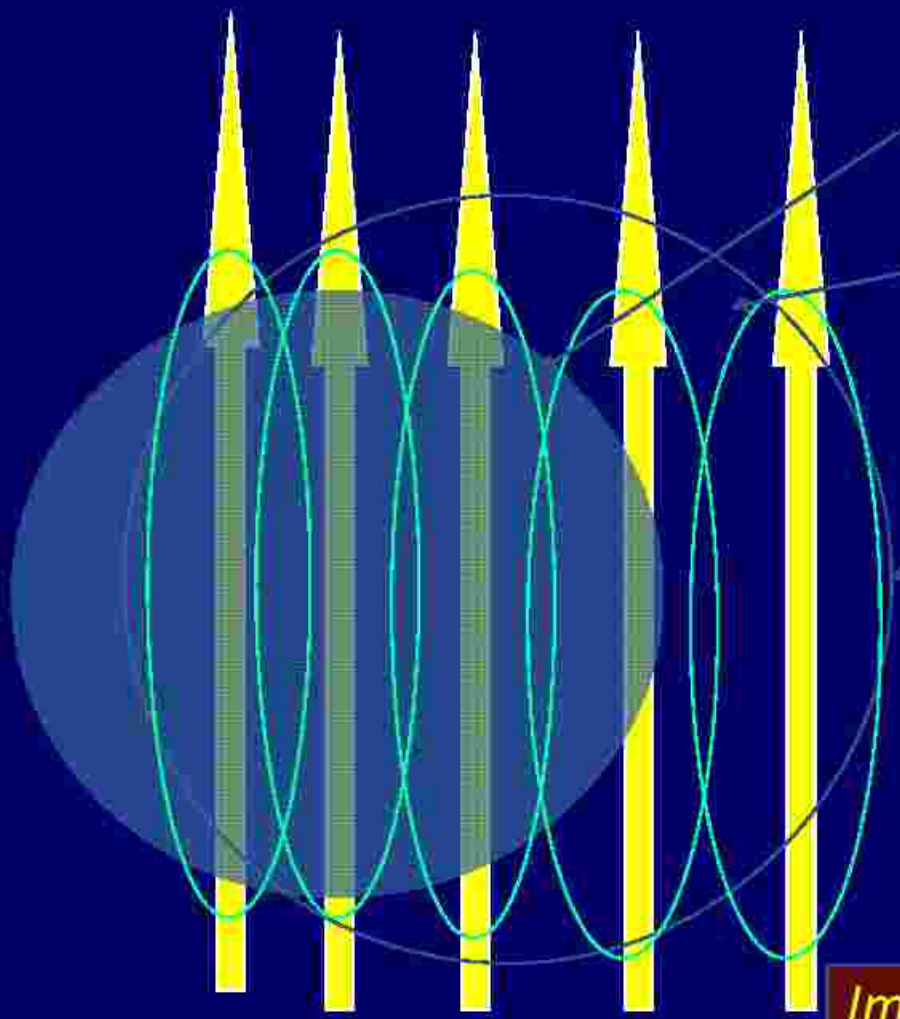
Less normal tissue in Ref Vol.

High dose vol. minimal

Implant:

- Well Conformed.
- Excellent dose uniformity

Implant -B



GTV coverage by Ref. Vol not adequate

more normal tissue in Ref Vol.

High dose vol. unacceptable.

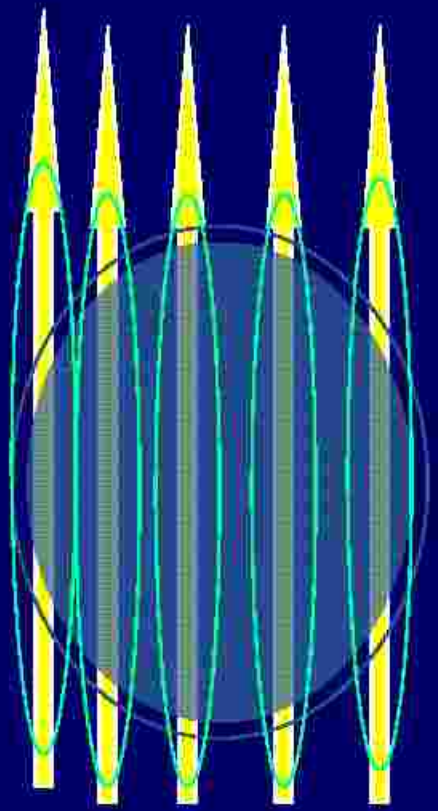
Photon energy higher.

Source characteristic different.

Implant:

- Not Conformed.
- Significantly high dose non-uniformity

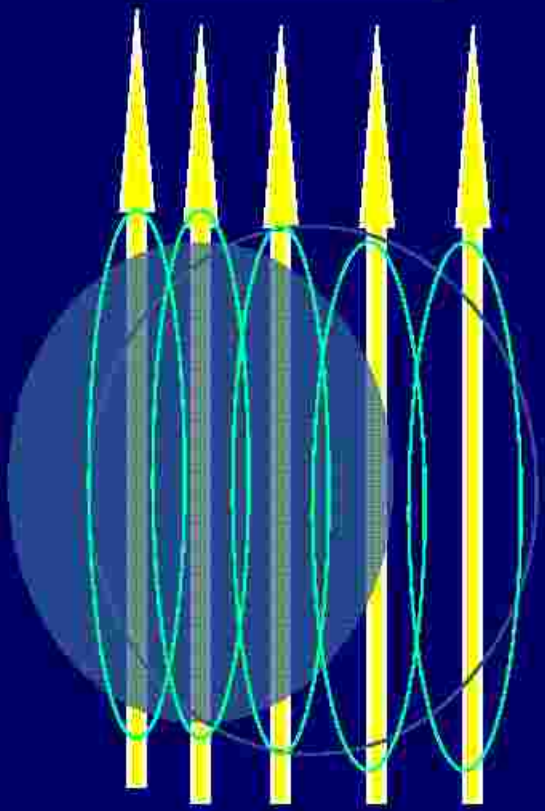
Implant -A



Optimal Implant.

Excellent conformity
& Homogenicity.

Implant -B



Sub-Optimal Implant.

Not well conformed
& non-homogenous

So, though implant rules are well maintained,
both the implants are not same on dosimetric consideration

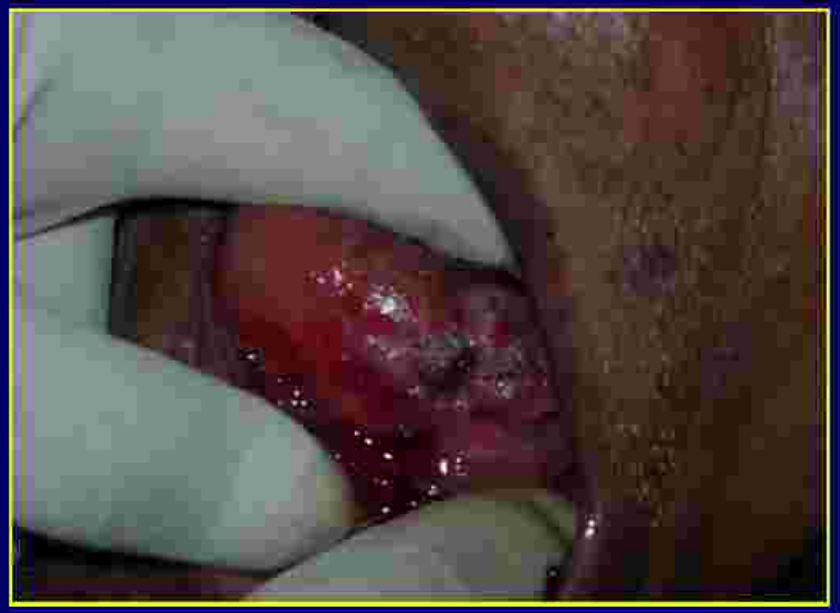
So, quality of implant depend not only on how the needles are placed in the target volume, but also on the dosimetric characteristics of the source & relative position of catheters in relation to target volume.

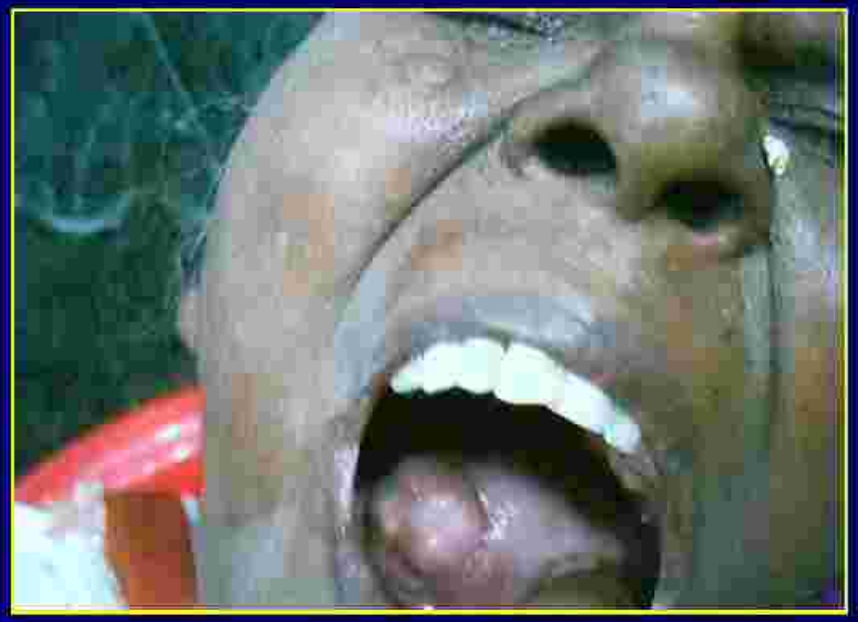
Dosimetric definitions:

For assessment of quality of implant

- Homogenicity Index (HI)(ICRU 58): MCD x 100 / MTD
- High dose vol (V_{150}) & low dose vol (V_{90})
- Coverage Index (CI) : TV $_{ref}$ x 100 / PTV
- Conformity Index (ICRU 62) : PTV X100 / TV
- DNR : V150/ V_{ref}
- CDVH.
- ODR.
- Conformity number (CN).

How planning for an implant done ?



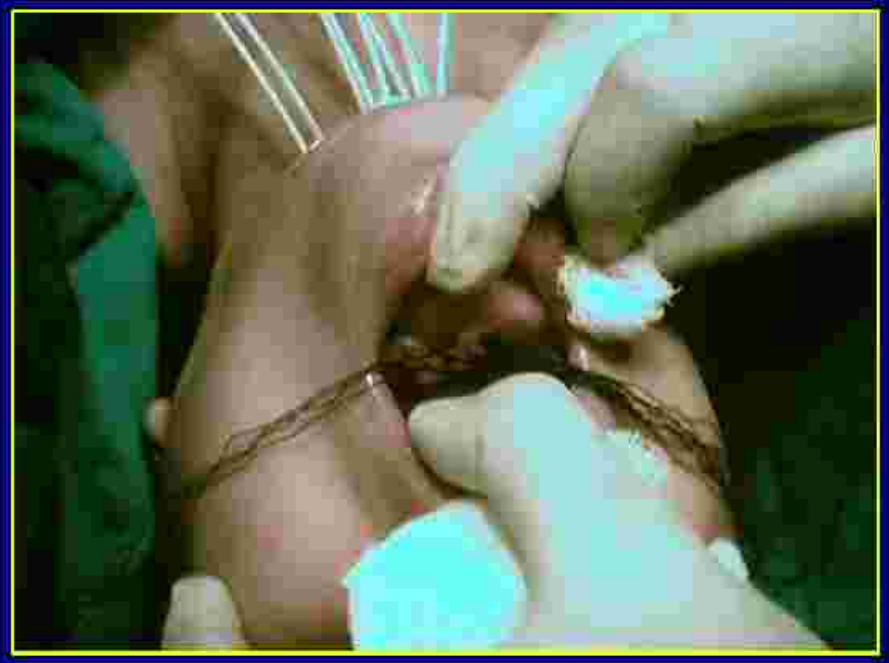


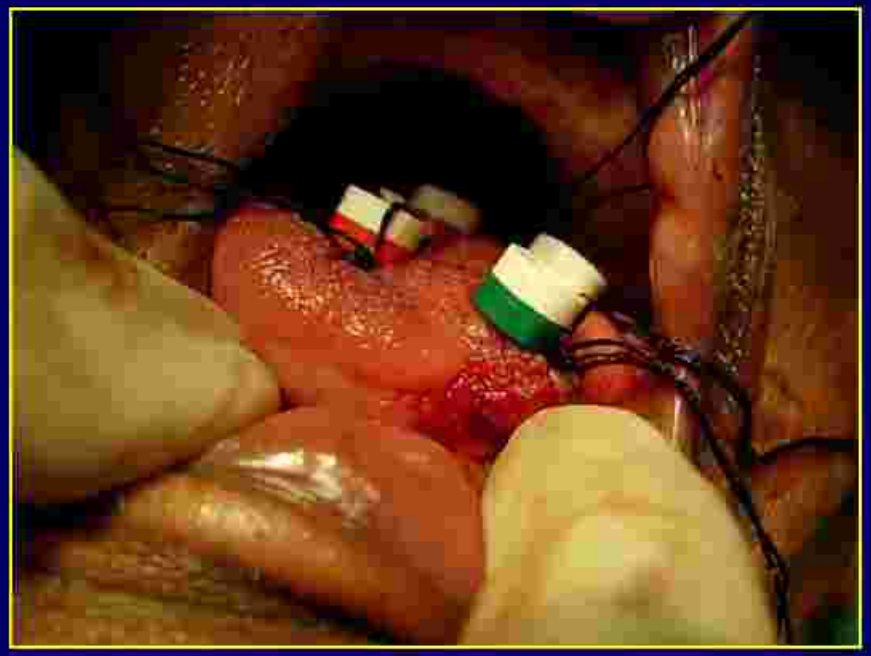
Physical examination & staging

Pre- implant assessment & planning for implant

Our Experience :

Interstitial Implant done.



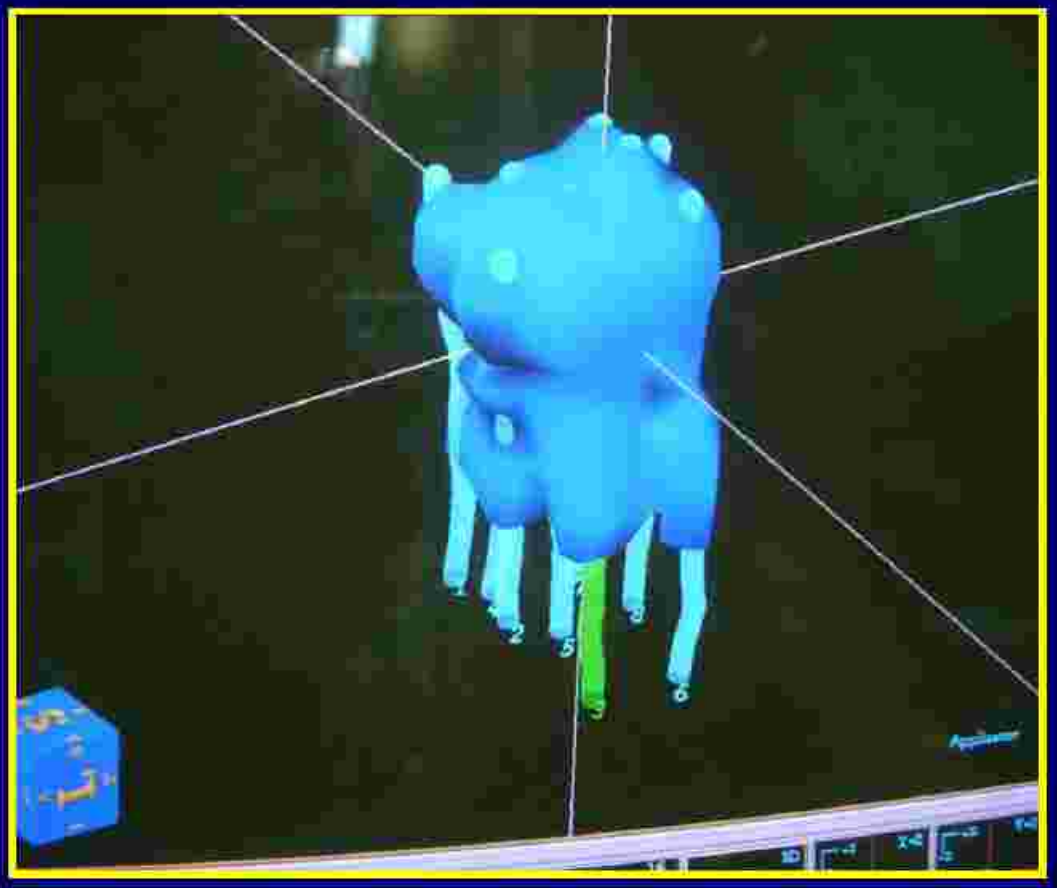


- Catheters are placed according to Paris System rules.
- Number and position of catheters placed according to tumor volume.
- No bleeding point ensured.
- Catheter ends are fixed to prevent displacement.

TPS Planning & Dosimetric Consideration

Our Experience :

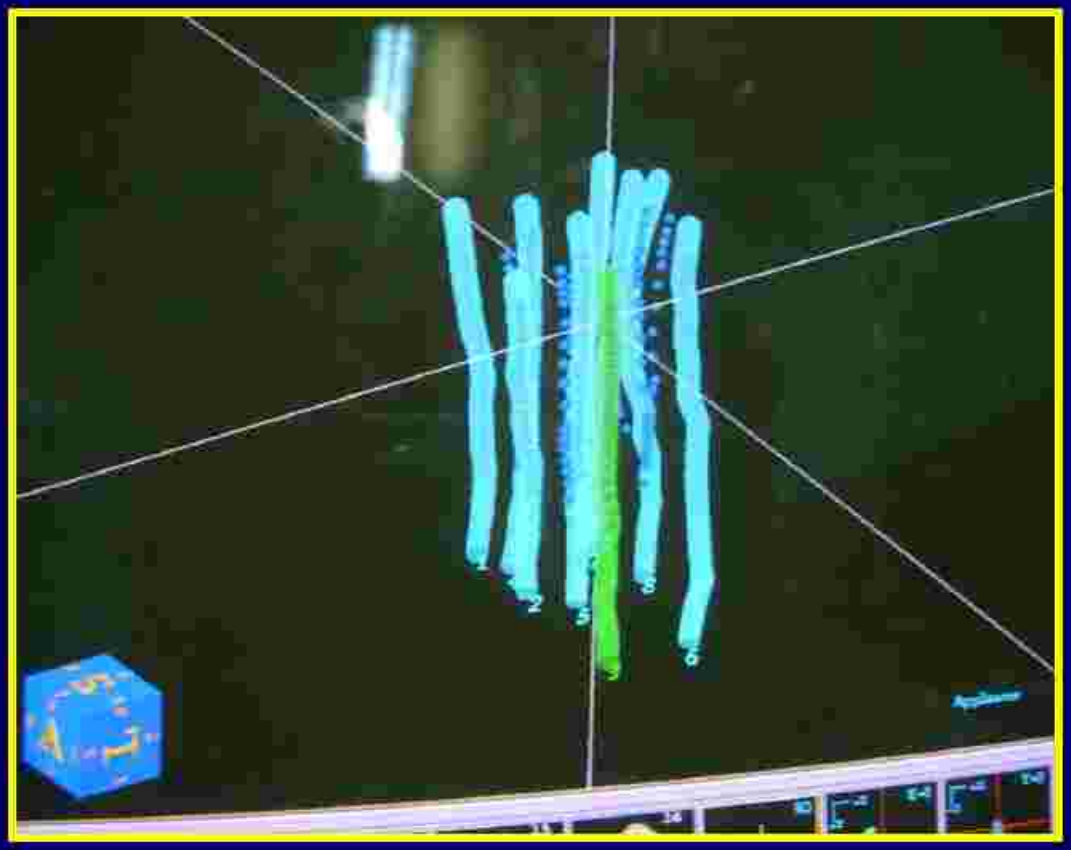
1



Tumor Volume defined

2

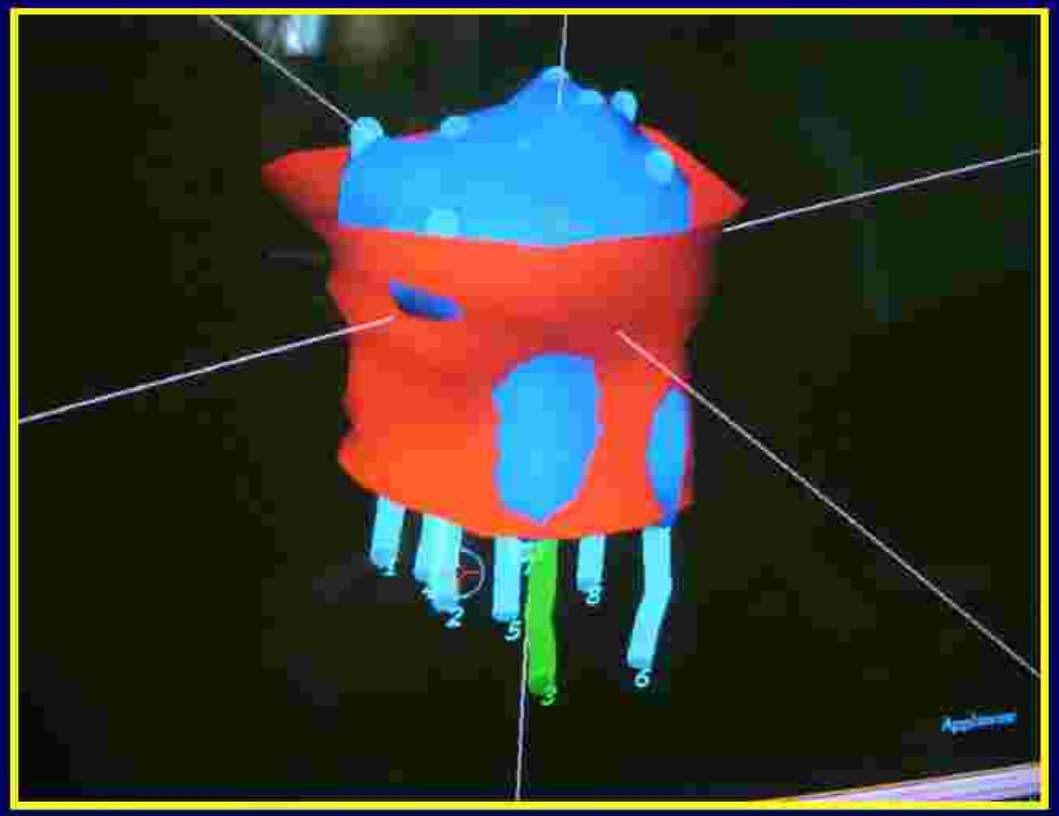
Our Experience :



Catheters reconstructed

Our Experience :

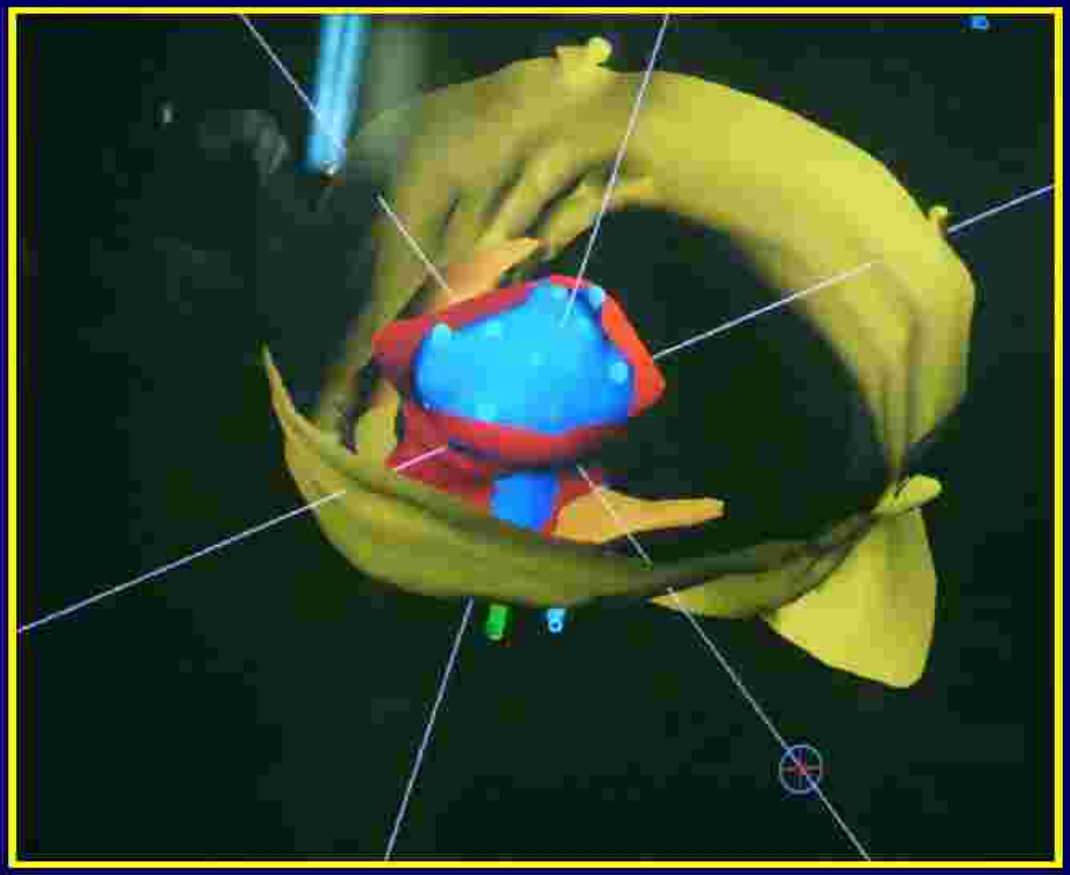
4



CTV defined

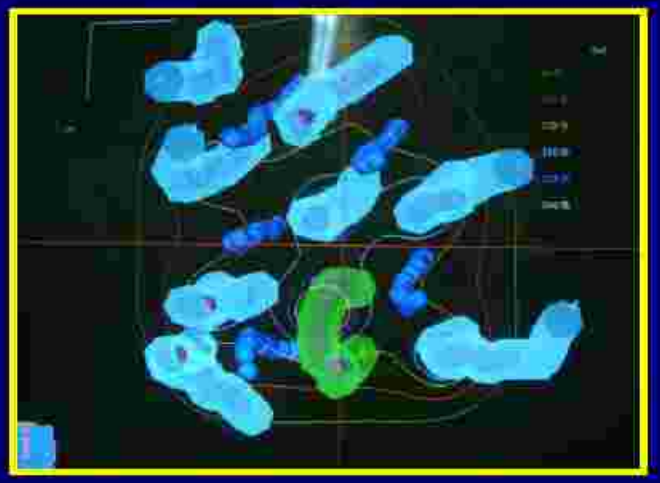
Our Experience :

5



Treatment Vol defined

6



- Iso-dose curves plotted .
- Homogenicity & Conformity factors taken care.
- Dose received by normal tissue taken care.

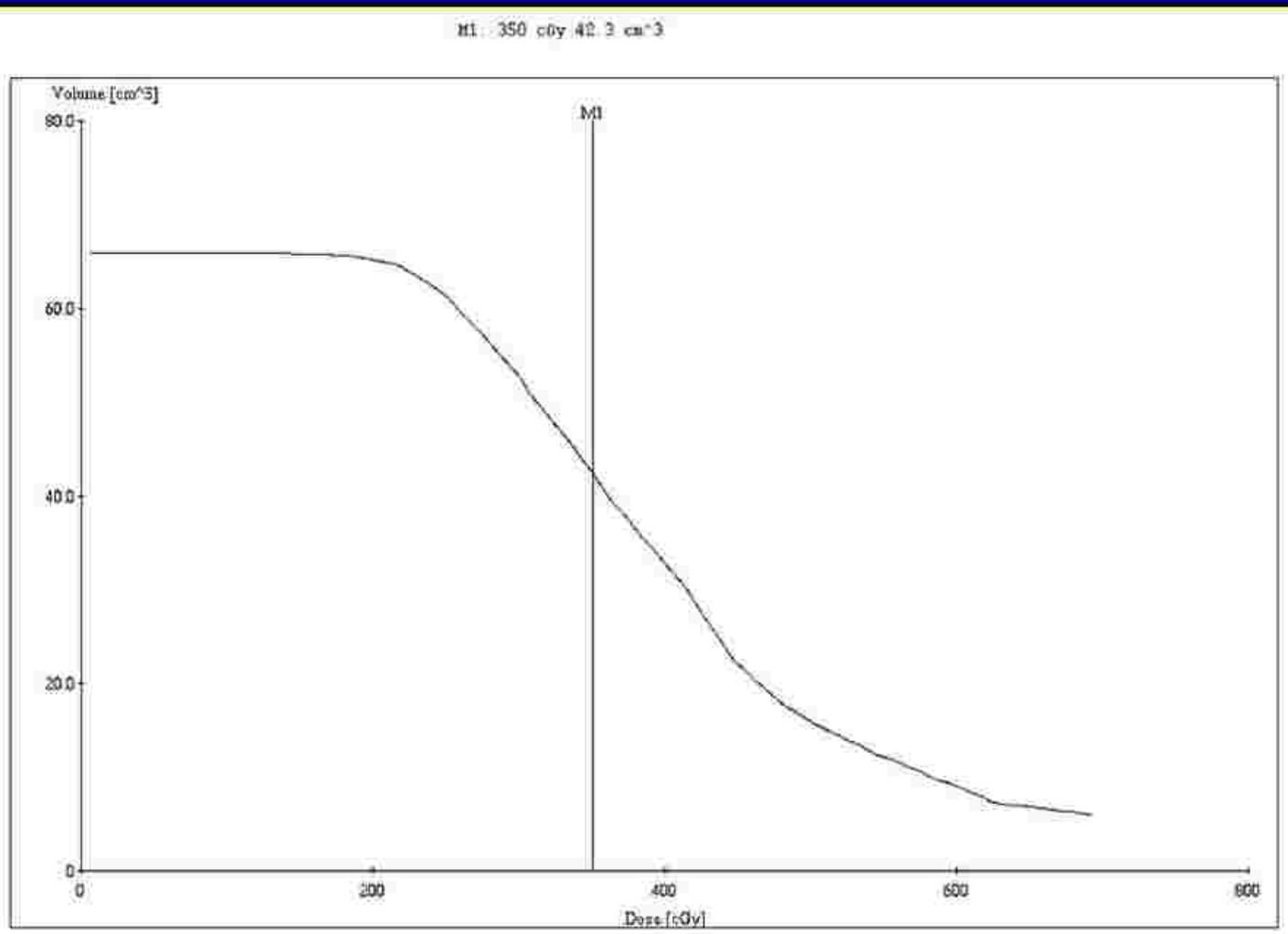
Dose considerations

Different dose rates used in brachytherapy:
(As per ICRU report 38)

- Low dose rate (LDR): 0.4-2.0 Gy/h
  (Cesium 137 needles, Iridium wires)
- Medium dose rate (MDR): 2-12 Gy /h
- High dose rate (HDR): > 12 Gy/h
  (Iridium 192, Cobalt 60)

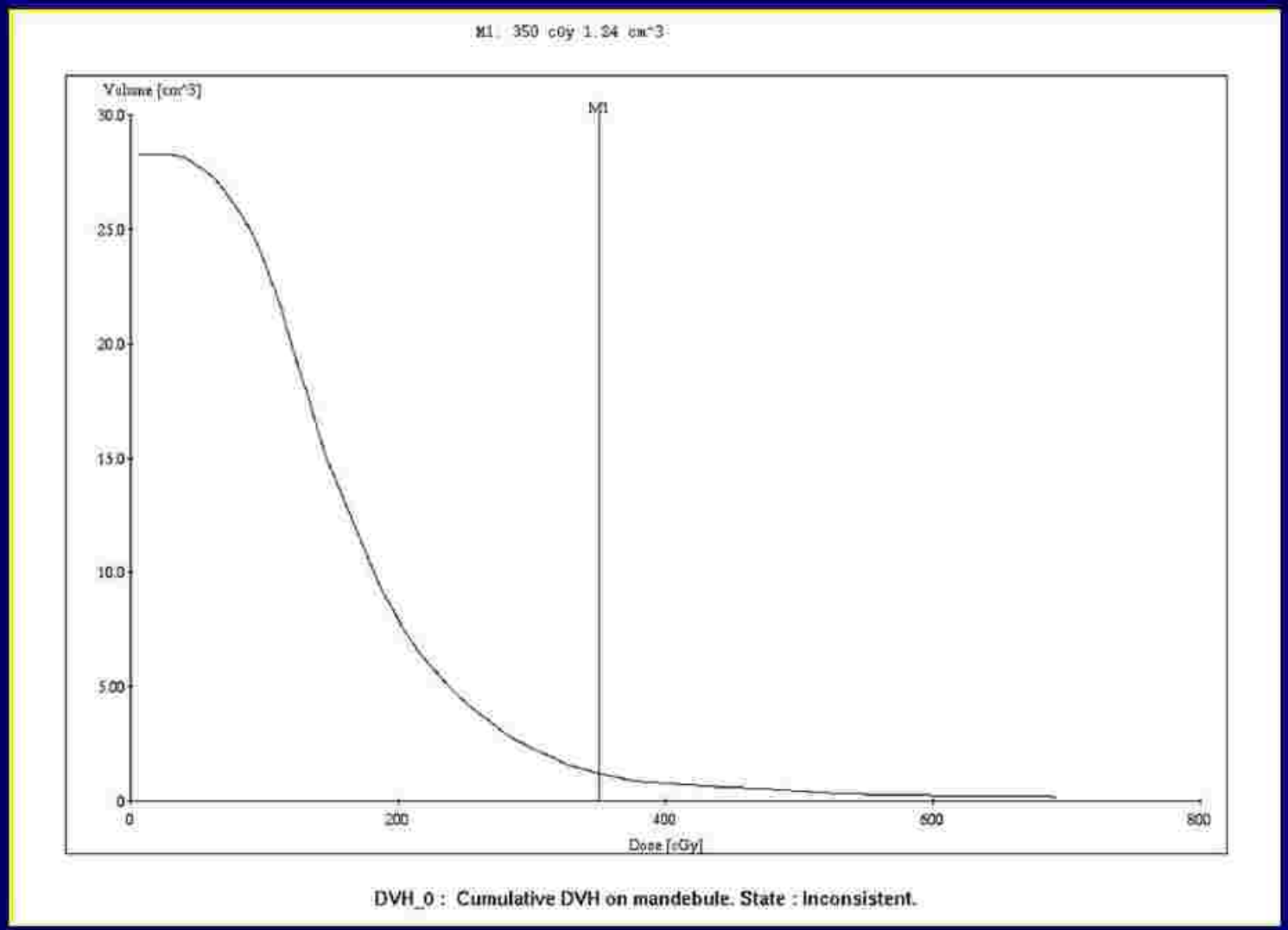
Dose and number of fractions by HDR

- Varies according to site, T stage and treatment objective, whether alone or with EBRT
- *The total HDR dose should be biologically equivalent to LDR*
- To decide no. of fractions, L-Q model is used
- *In mouth cancer, LDR dose of 60 Gy (in 6 days) is eq. to 45 Gy HDR, which may be given in 7-10 fractions*
- Total duration of therapy (EBRT + HDR) should be kept within 8 wks, to minimize repopulation
- *Interval between HDR fractions should be 6 hrs minimum, to allow repair of normal tissue*
- Every institution has it's own protocol considering the radiobiology, tumour details and other logistics as well



DVH_3 : Cumulative DVH on target. State : Consistent.

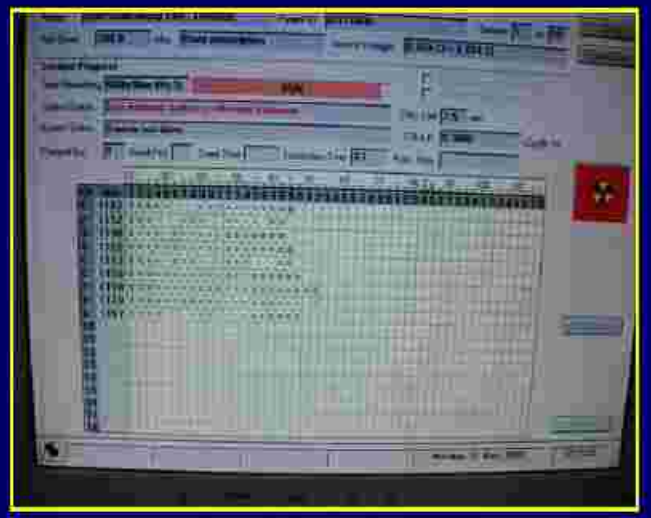
CUMULATIVE DVH OF TARGET



DVH_0 : Cumulative DVH on mandebule. State : Inconsistent.

CUMULATIVE DVH OF MANDIBLE

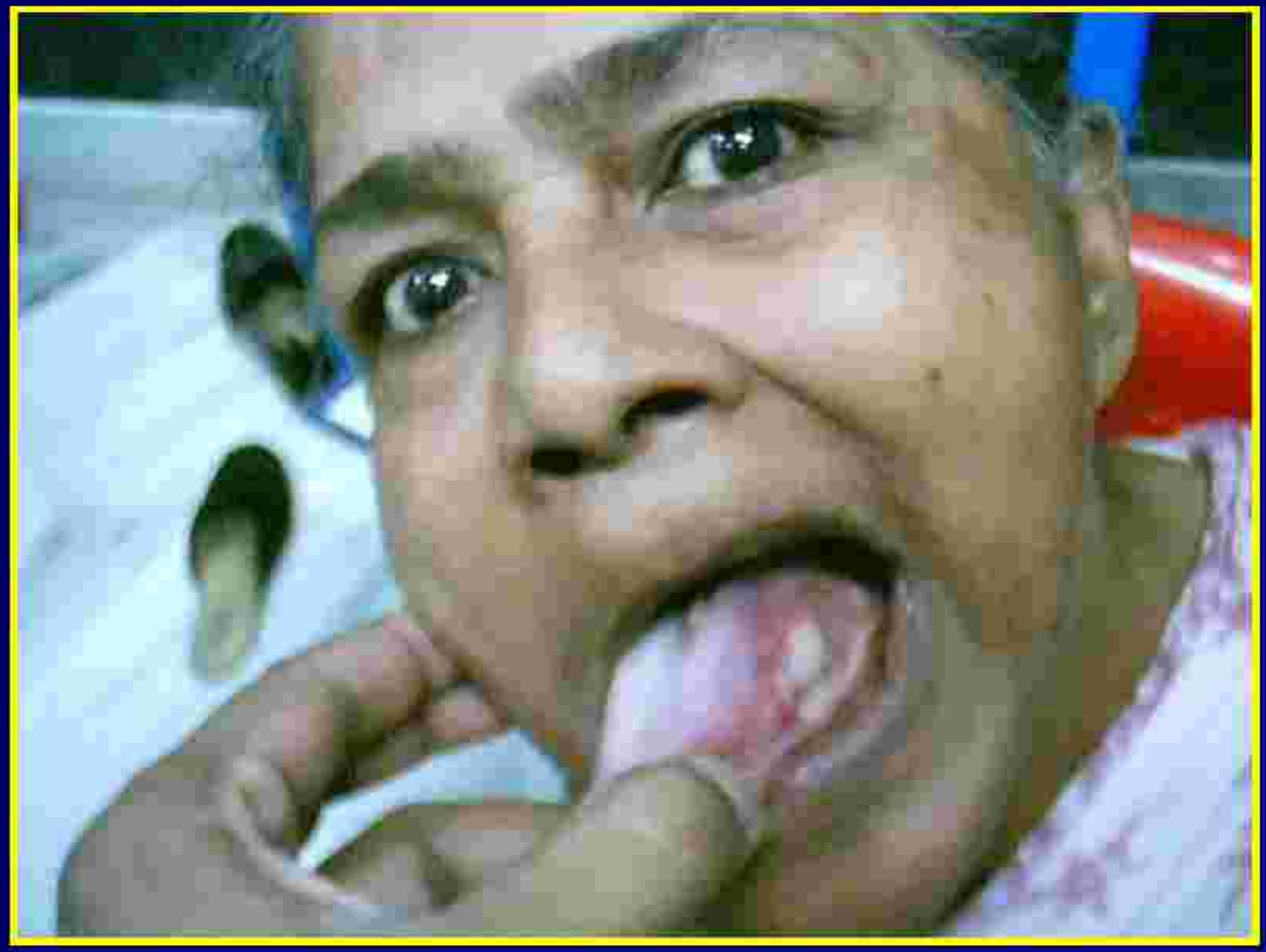
Our Experience :



Treatment given

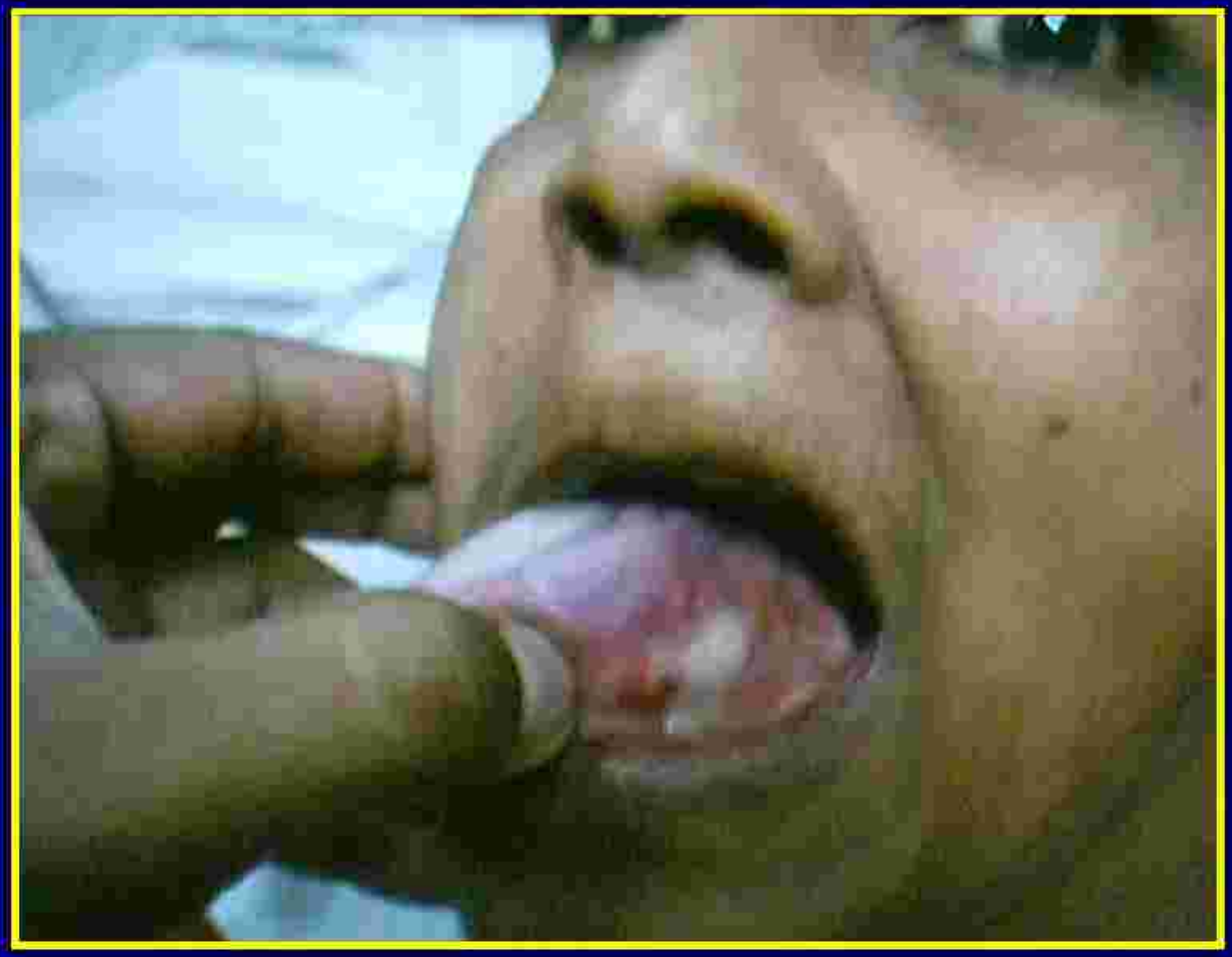
FOLLOW UP : TONGUE

Our Experience :



POST IMPLANT

Our Experience :

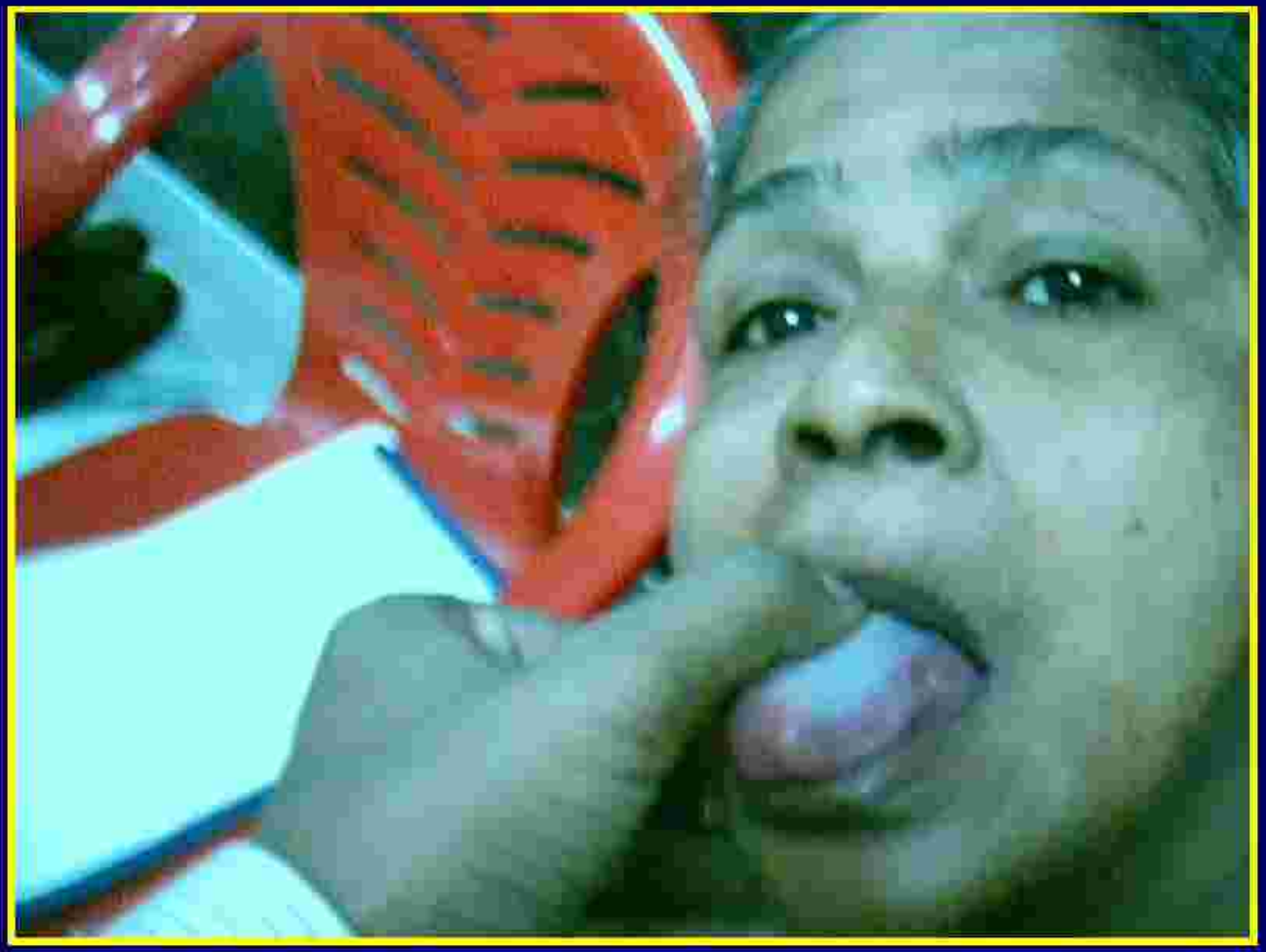


3 MONTH

Our Experience :

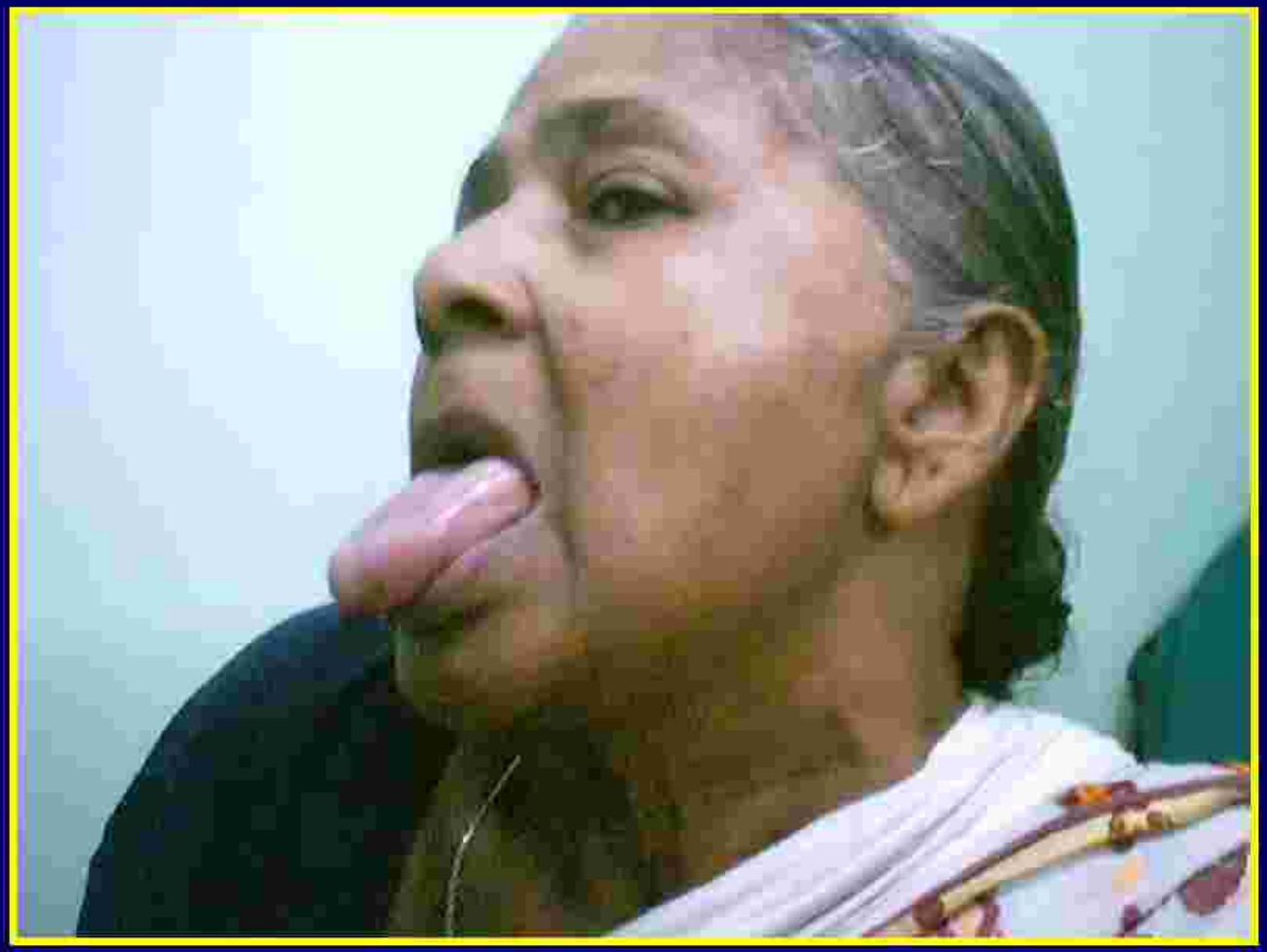
6 MONTH

Our Experience :



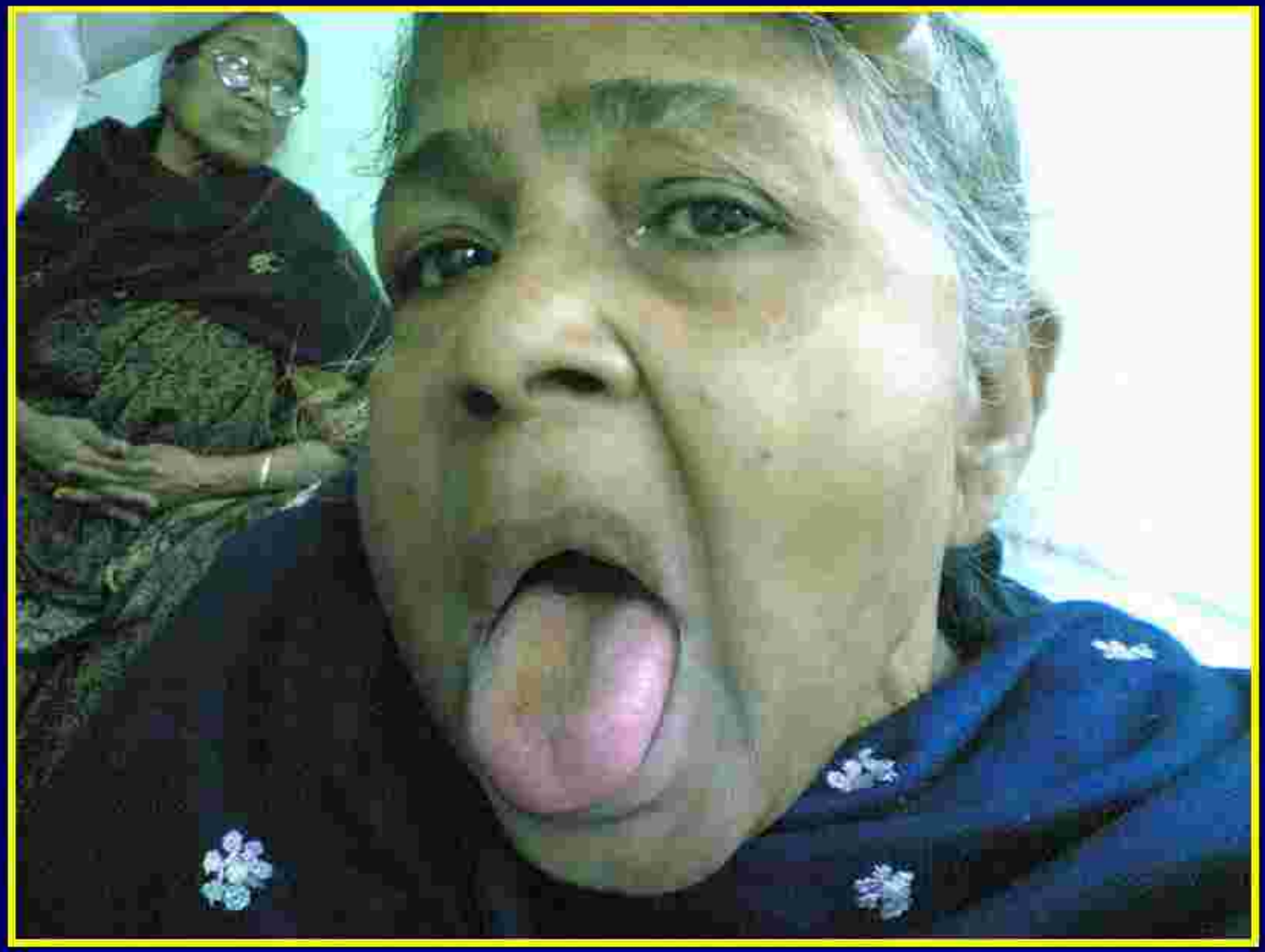
12 MONTH

Our Experience :



15 Month

Our Experience :



18 Month

Local Control Rates in Oral Cancer at different stages by Surgery or RT alone

Oral tongue	T1	T2	T3	T4
RT Alone (Curie)	86%	80%	68%	NR
RT alone (Pernot et al)	93%	65%	49%	NR
RT alone(MD Anderson)	80-90	60-85	30-50	24-40
Surgery Alone (Memorial Hospital)	**85%**	**77%**	**50%**	NR
Floor of Mouth(RT alone) (MD Anderson)	75-85	60-80	30-50	5-30

Brachytherapy as sole treatment for oral cavity cancers

Author	Fx size	no.fr	Eq.dose	Pt.no	L.C
Dixit et al	3 Gy	20	65 Gy	3	-
Lau et al	6.5 Gy	7	63 Gy	27	53%
Inoue et al	6 Gy	10	80 Gy	14	100%
Donath et al	4.5-5	10	54-63	13	90%
Leung et al	5.5-6	10	71-80	13	100%

HDR Brachytherapy as boost to EBRT for oral cavity cancers

Author	EBRT dose	HDR dose/fr	No.Fr.	Eq.dose	No.Pt	L.C	survival
Yu et al	50 Gy	2.7 Gy	6	67 Gy	12	79%	45%
Dixit et al	40-48	3 Gy	7	63-71 Gy	18	80%	---

Conclusion

- Modern day implant more image guided
- Implants still follow the Paris system basically, but dosimetry more flexible
- Geometric and dose-point optimisations main advantages of modern day implant, but no amount of optimisations can make up for a bad implant
- Quality of an implant is now more defined and uniform
- More clinical experience and long term results will help to optimize the system further

Thank You