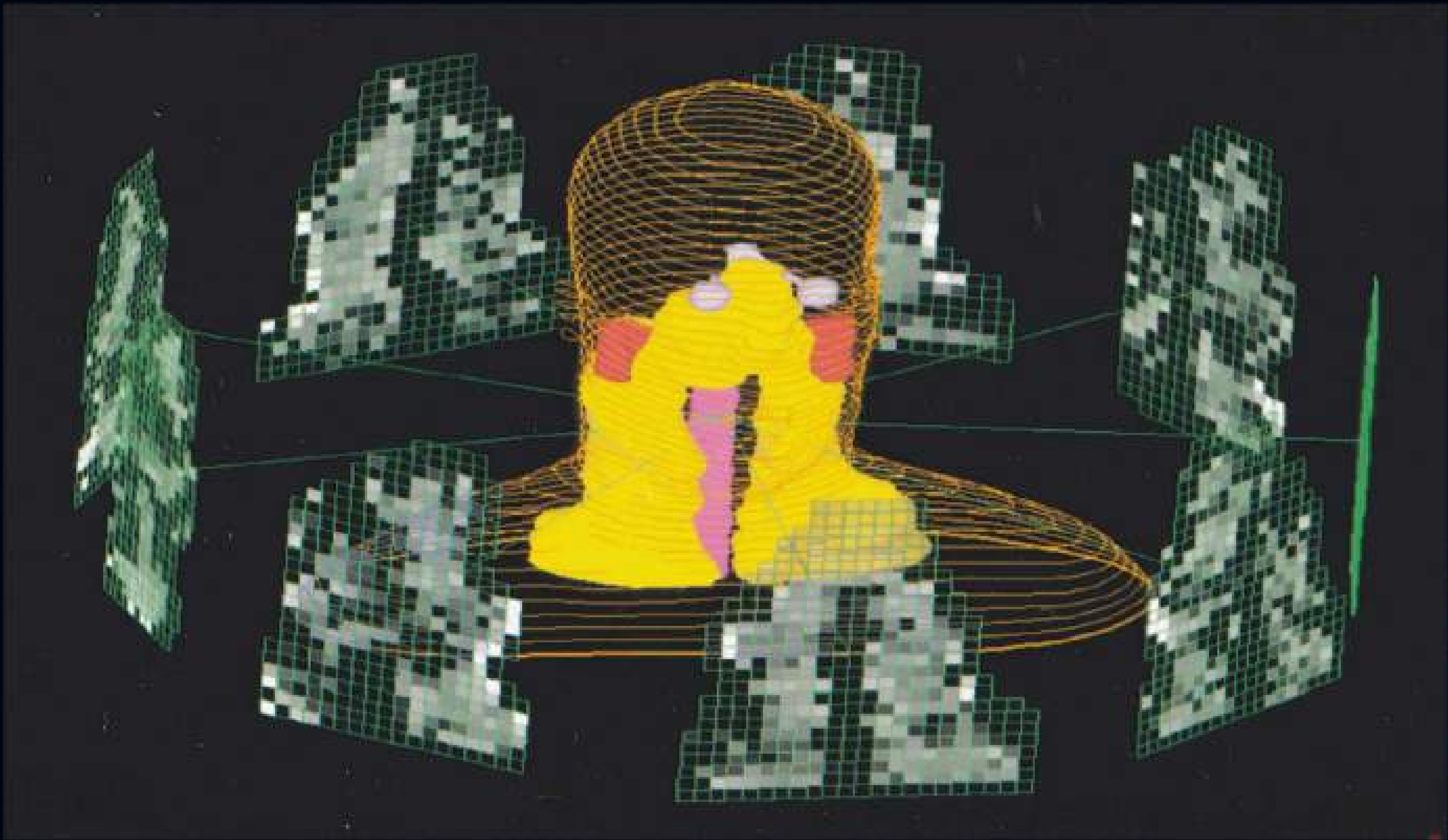
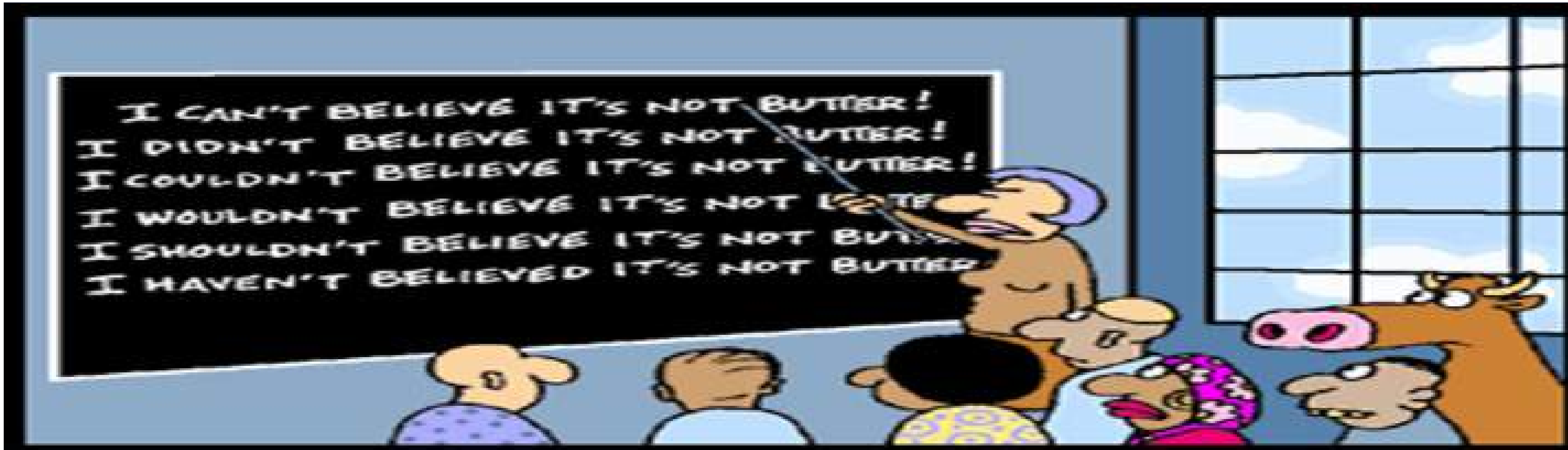
IMRT in Head & Neck Cancer



Dr Vijay Anand P. Reddy



- Introduction
- Delivery techniques
- Planning steps, Tumor vol delineation
- Clinical studies
- Advantages, Pit falls

3D-Conformal Radiation Therapy

3D-CRT

- Radiation intensity is uniform within each beam
- Modulation conferred only by wedges.

Intensity Modulated Radio Therapy

Conformal Radiation Therapy with Non-uniform intensity distributions generated via Inverse planning by a computer optimization process.

"Intensity of Radiation is modulated"

How does I M R T works

Each field is subdivided into numerous "beamlets"

whose intensities are <u>individually modulated</u>

to achieve a <u>nonuniform dose contribution</u> from each field.

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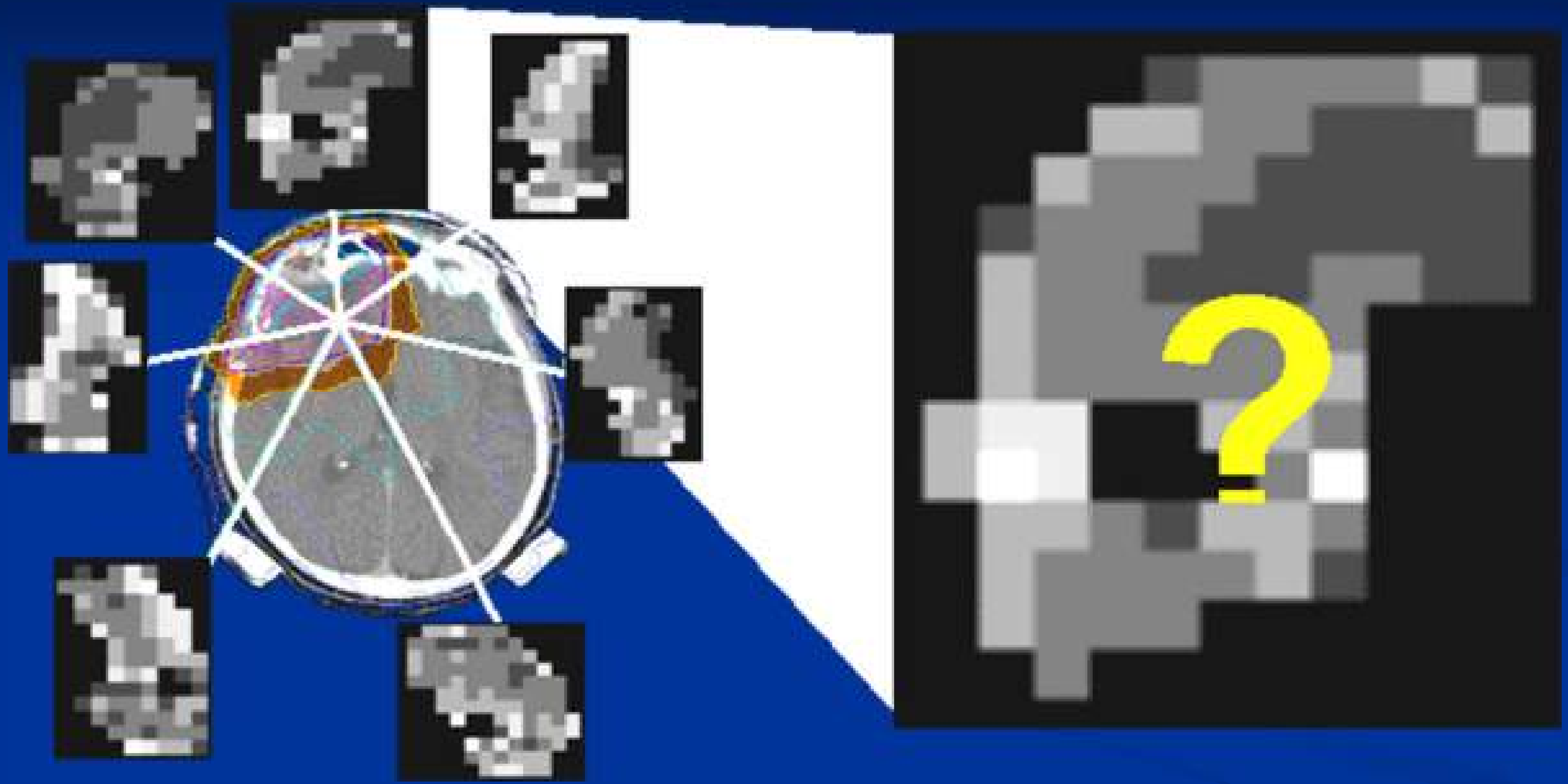
How to modulate RT fields?



Beamlet modulation is accomplished by actively moving multiple leaves during radiation treatment

thus achieving the desired dose distribution throughout the tissue volume.

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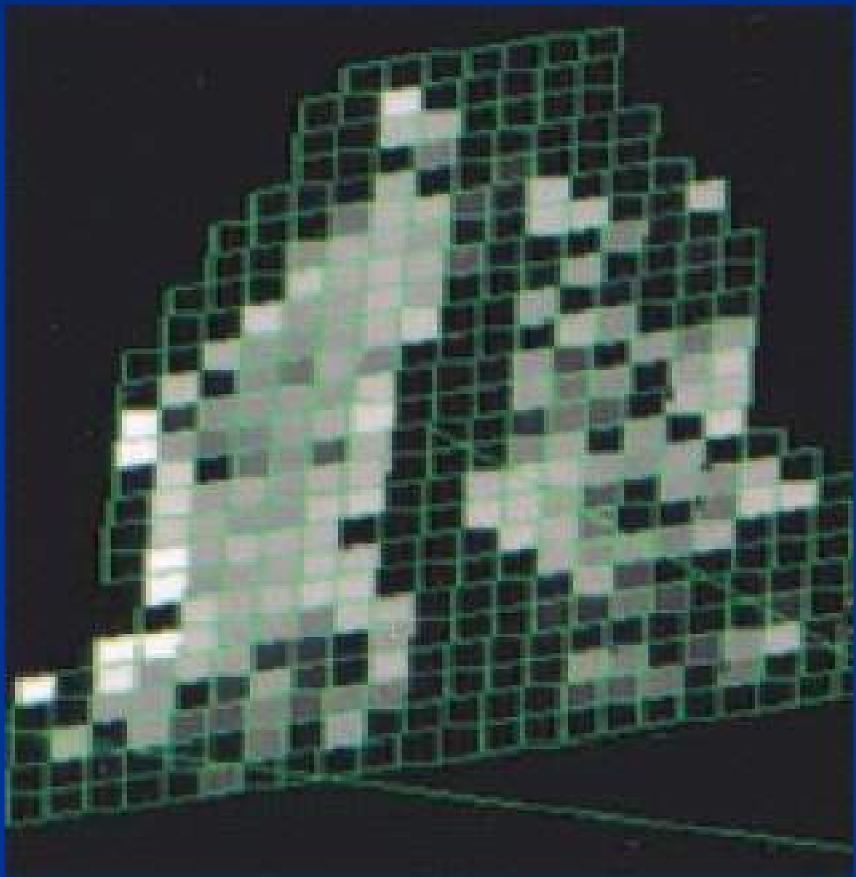
How does I M R T work

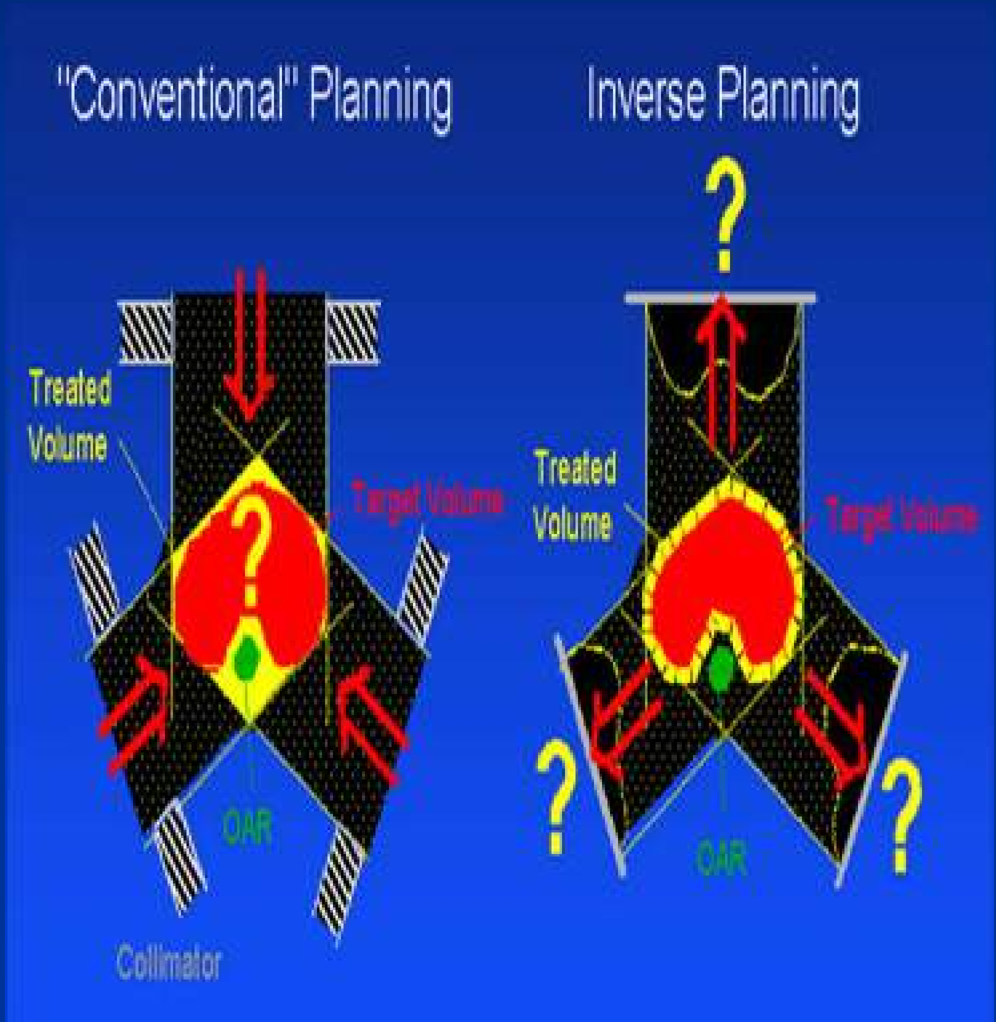


- 10 x 10 cm port is divided into 1 cm^2 beamlets
- There are now 10^{+2} beams in the port
- Each can have an intensity weight of 0 – 100%
- Then we have 10^{+200} possibilities
- If we use 5 ports we have 10^{+1000} possibilities

Inverse Planning

- We need to optimize Beam location, energy, modality
- High speed computer tests all the possibilities of a human decision for a best possible solution
- The mathematical process of defining a solution is known as "Inverse planning"

Computer Optimization



- **Forward Planning:**
  The beam geometry i.e beam angle, shape, modifier, weights etc. is first defined, followed by calculation of the 3D dose distribution.

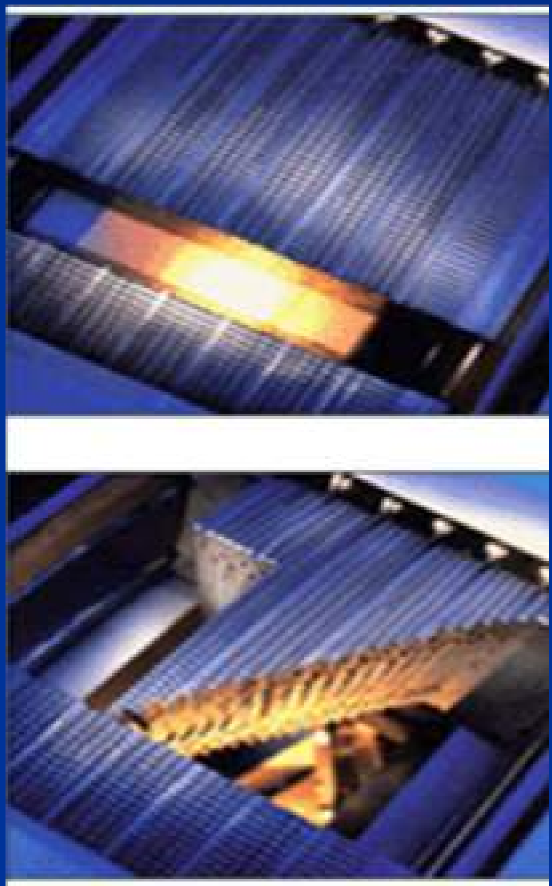
- **Inverse Planning:**
  The user specifies the goals, the computer then adjusts the beam parameters to achieve the desired outcome.

IMRT

Primary advantage of this technology

- Treating target volumes adjacent to critical or sensitive normal tissues
- Delivery of therapeutic radiation doses to target
- Minimizing normal tissue toxicity.

I M R T delivery techniques



1. Slit MLC:
- Narrow rectangular slit MLC
- Rotates in an arc around the patient
- Treats a target vol with multiple thin slices.

2. Tomotherapy:
- Actively modulated narrow slit beams
- as the treatment gantry and MLC rotate
- pt moves through gantry ring on a couch.

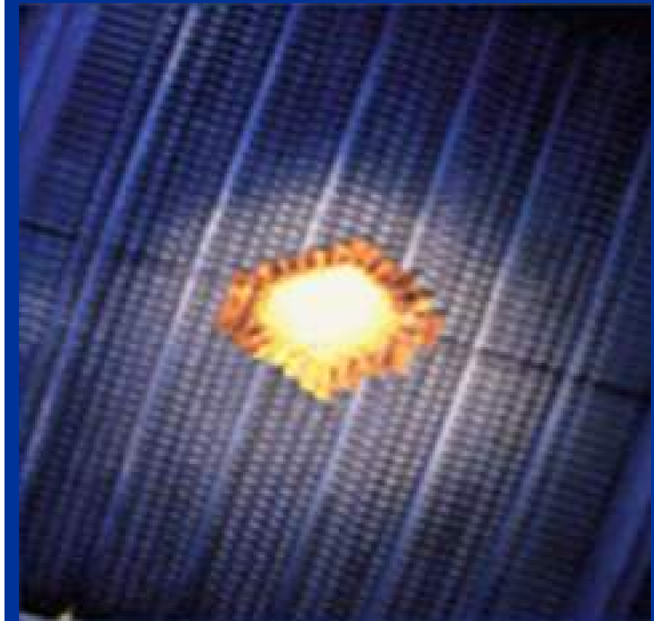
IGRT

Tomotherapy

I M R T delivery techniques

Standard MLC :

Beams can be delivered via multiple fixed gantry positions with a standard MLC



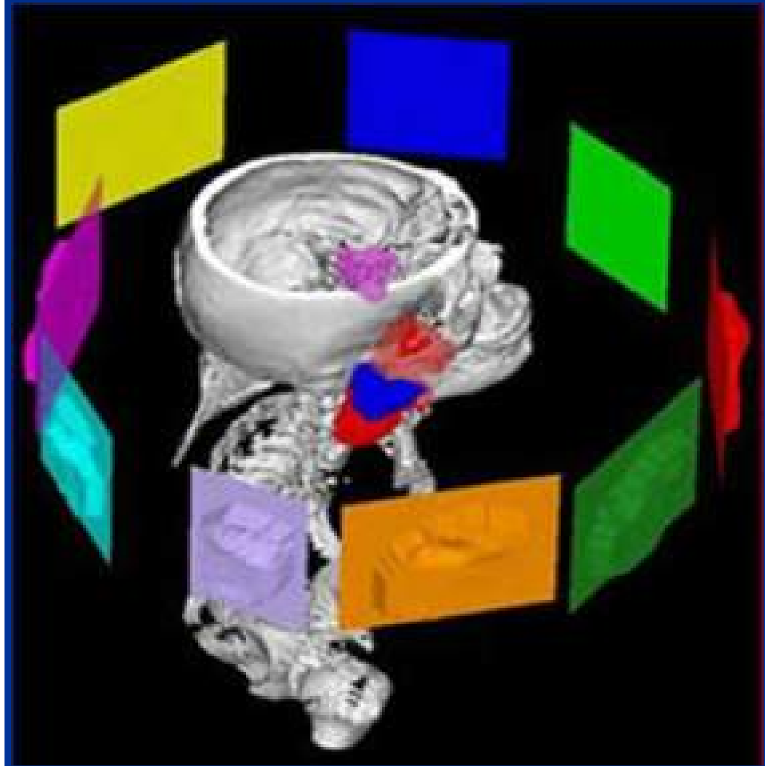
3. 'Step and shoot'

- Delivers Sequential subfields with
- Individualized intensity distributions from each gantry position,
- Radiation beam off between subfields.

4. Dynamic mode

- MLCs move while radiation beam is on VAR

I M R T delivery techniques



5. Intensity modulated Arc therapy (IMAT) combining rotational arcs with dynamic multileaf collimation.

6. Fully dynamic systems MLC, gantry, and treatment couch all move independently at some point during beam delivery

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Rationale of IMRT in H & N Cancer

1. Anatomically complex H&N region
   - *an ideal option - IMRT.*
2. Lack of organ motion in the H&N region
   - *an ideal region for IMRT*.
3. Allows for dose escalation
   - *concomitant boost – ideal for H&N*

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IMRT **Sites in H&N**

- Nasopharynx
- Sinonasal region
- Parotid gland
- Tonsil
- Buccal mucosa, Gingiva
- Thyroid
- Tumor tracking along the cranial nerves.

- Based on the studies comparing IMRT and other treatment approaches

Steps of IMRT

- Clinical evaluation & assessment
- Simulation
- Planning CT/MRI/PET-CT scan
- Target vol Delineation GTV,CTV,PTV
- IMRT Planning, Dose Vol Histogram
- QA
- Execution of IMRT

Steps of IMRT in H&N Cancer

Clinical Assessment

- Pt is seen by Surgeon, RO, MO
- Examination of the H&N region
  - Indirect laryngoscopy
  - Fiberoptic nasopharyngolaryngoscopy
- An illustration of the physical findings
  - Demonstrating the primary tumor extent
  - Lymph-adenopathy

Steps of IMRT in H&N Ca …

Clinical Assessment…

- Pretreatment dental consultation
  - Extraction of bad teeth
  - Initiation of prophylactic fluoride therapy.
- Pretreatment ophthalmology and audiology consults
- Thyroid function tests baseline.
- Review of imaging studies and further workup

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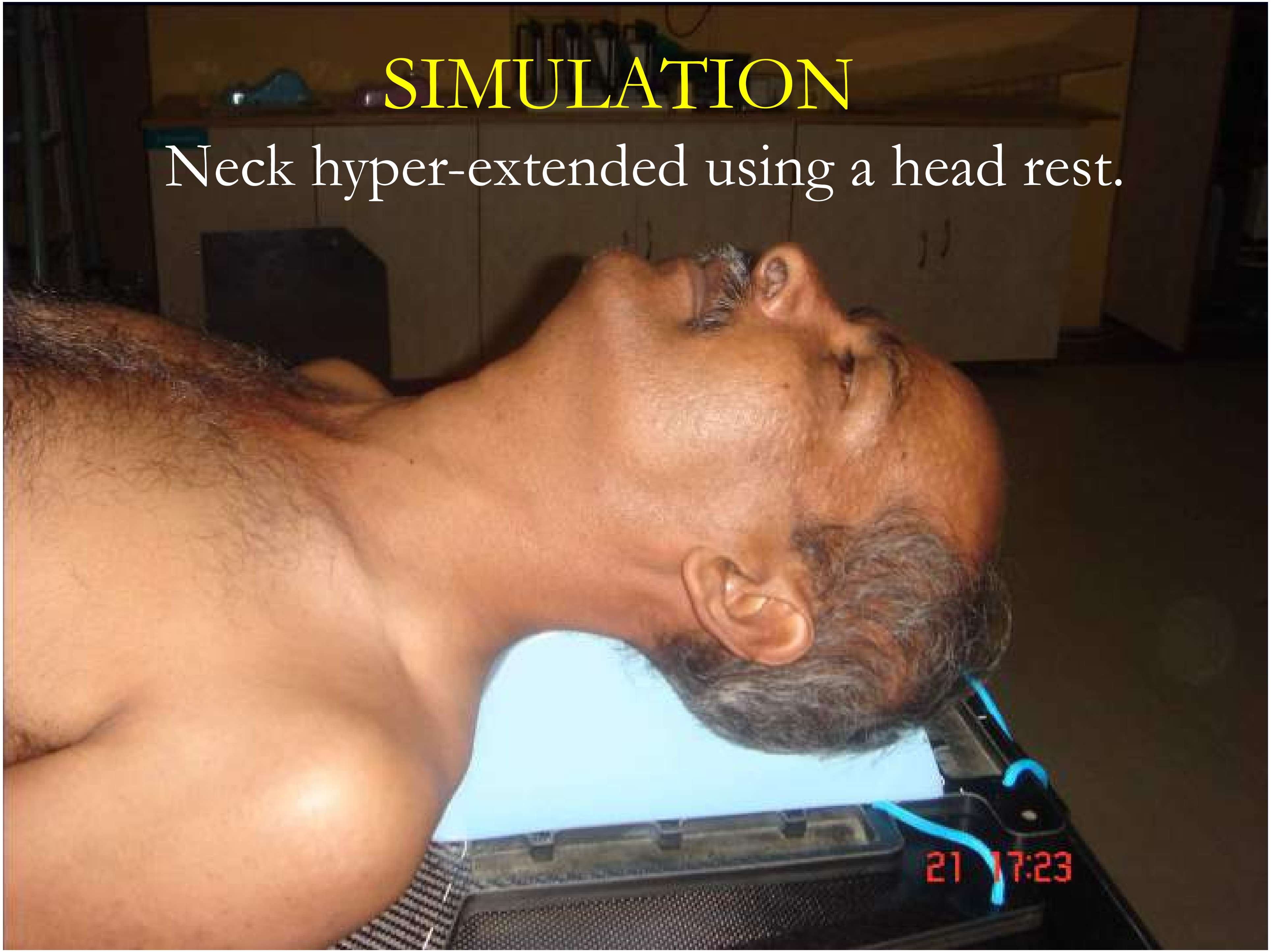
Simulation/CT simulation in the treatment position

- Conventional simulation followed by a CT or
- CT Simulation.

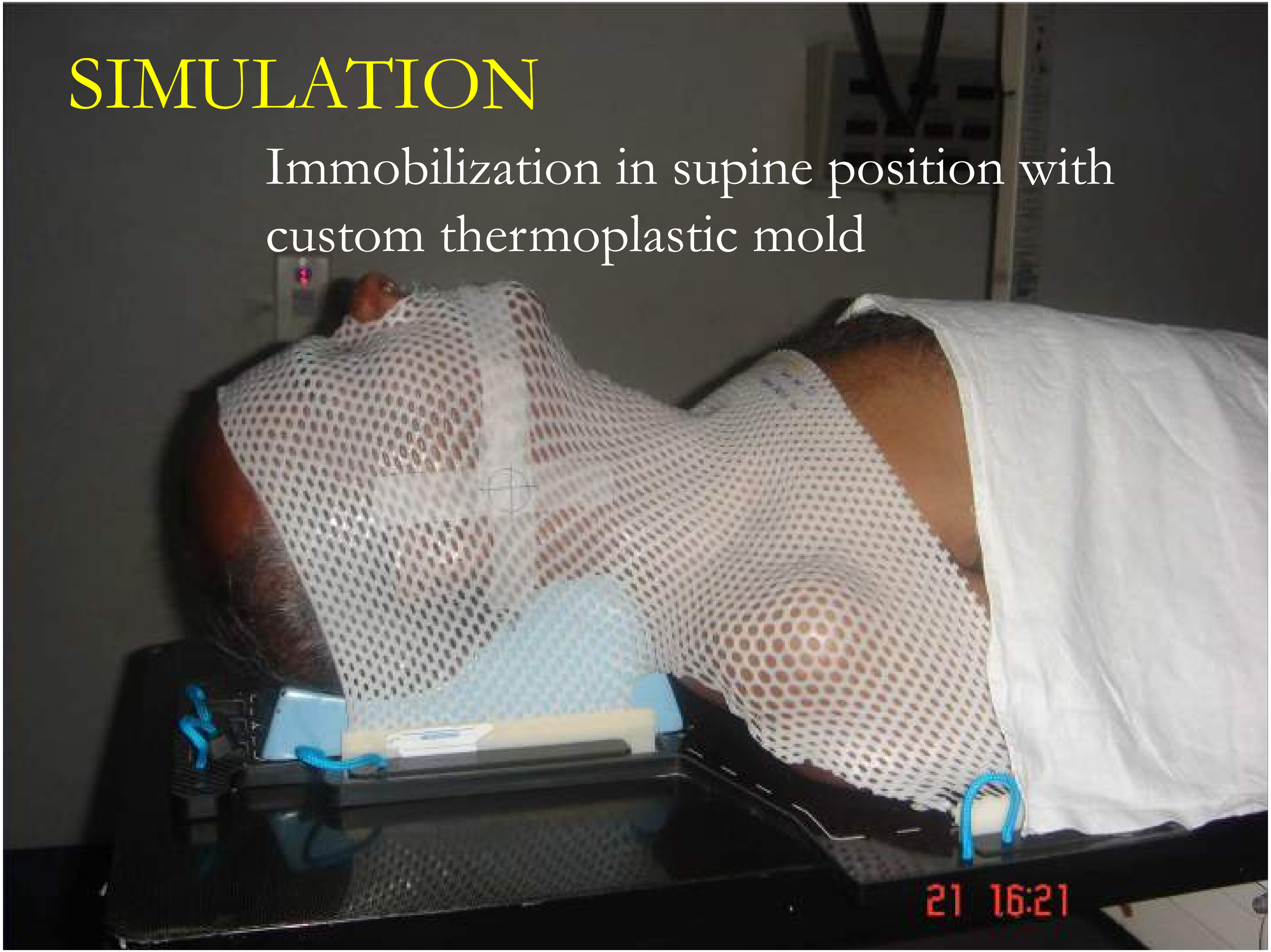
SIMULATION

Neck hyper-extended using a head rest.



SIMULATION

Immobilization in supine position with custom thermoplastic mold



SIMULATION

Traction

- Shoulder traction to minimize shoulder in RT fields
- Palpable masses & incisional scars are outlined by ….
- For CT, use iv contrast to diff vessels from masses or LN

Image registration & Tumor volume delineation

- Planning CT scan
  - with i.v contrast in the treatment position
- MRI
  - better delineation of normal tissue & tumor
- FDG-PET-CT
  - Improve tumor delineation better than CT alone

It is imperative that the radiation oncologist be trained in the interpretation of all images used for structure localization

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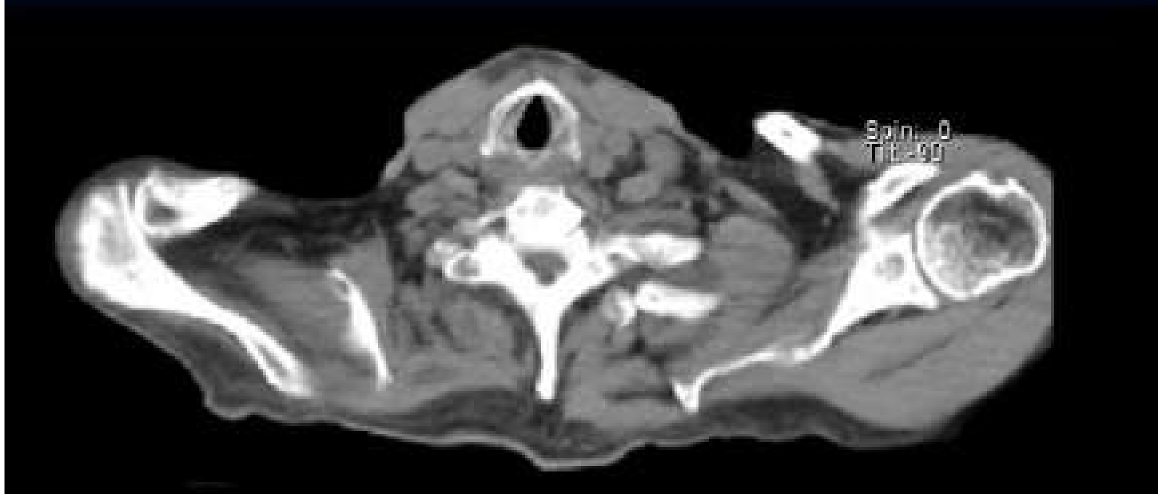
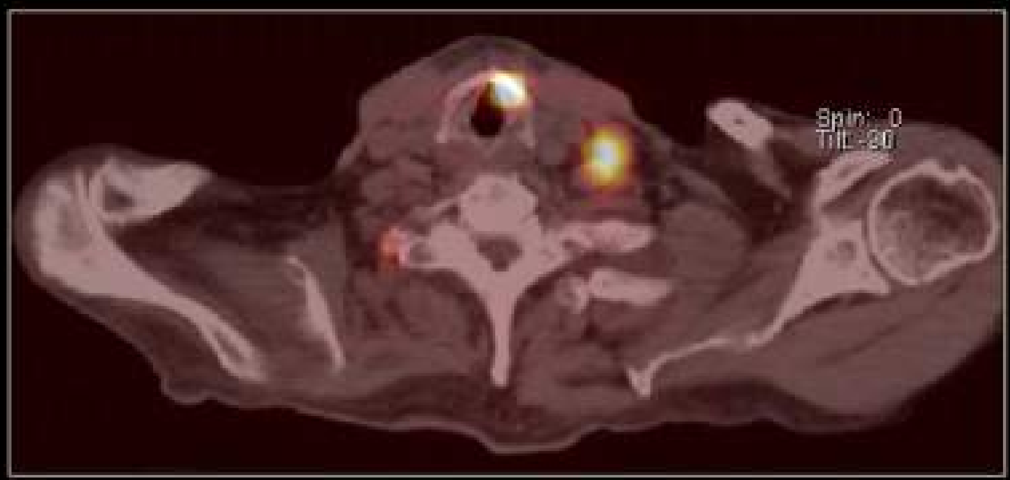
PET Scores over others!





CT, MRI

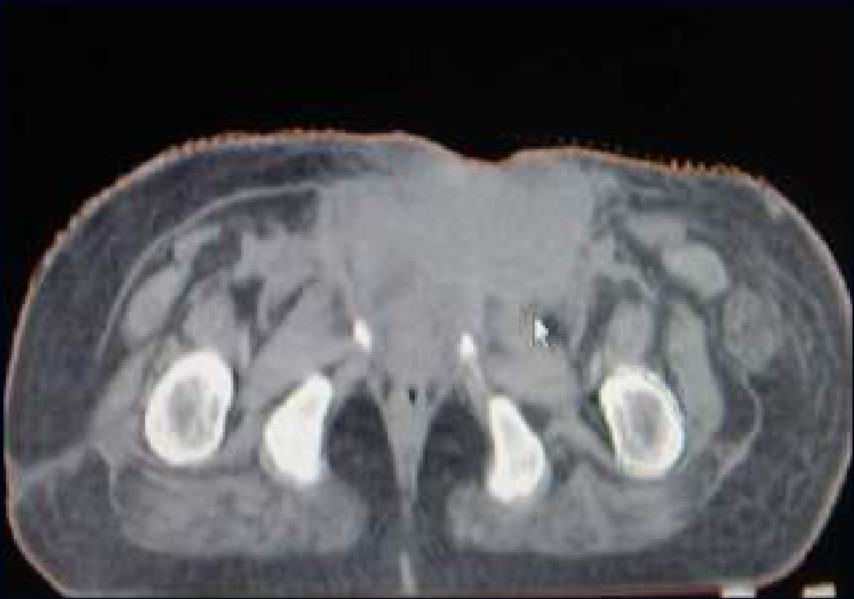
Anatomical imaging

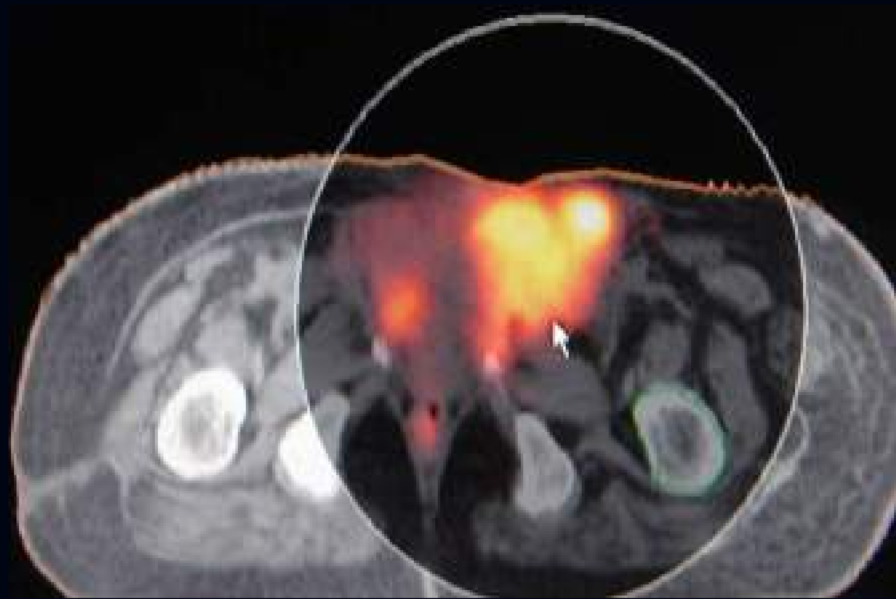
PET

is functional imaging

Active viable tumor

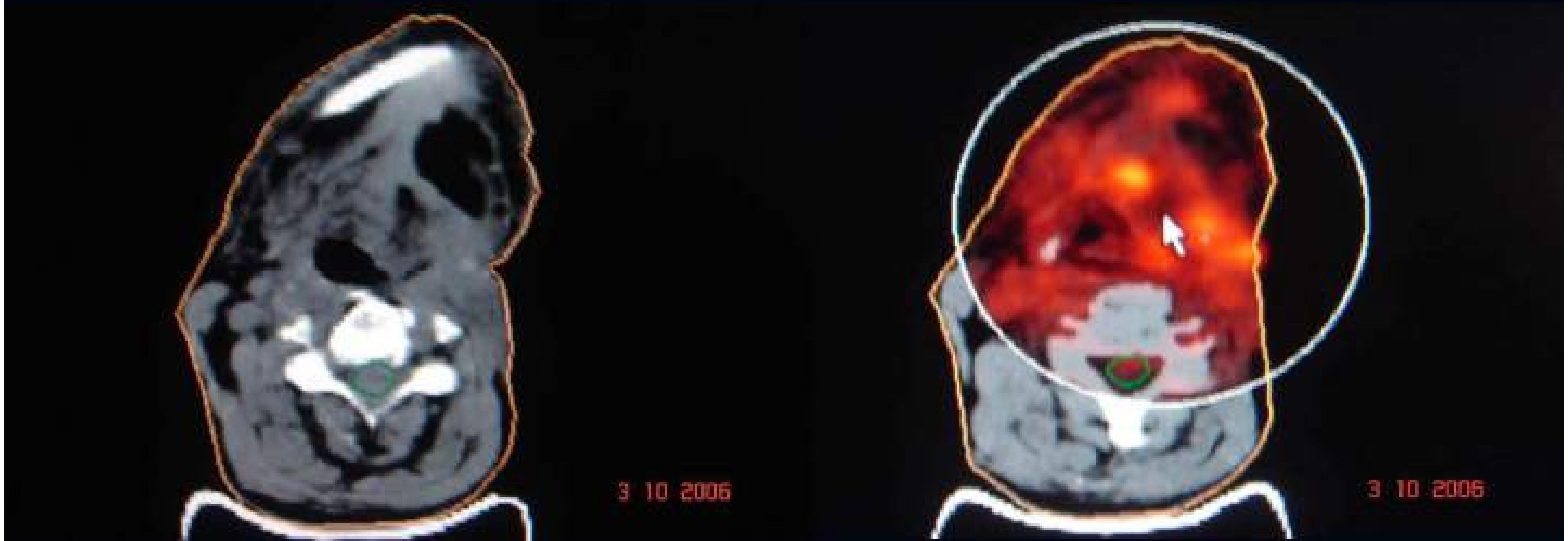
Limitations of Anatomical Imaging





- Tumor and normal tissue have similar density or intensity
- Tumor and normal tissue have similar properties of contrast enhancement

Advantages of Biological Imaging..



Will not be affected with post op anatomical disturbances!

Clinical applications of FDG-PET in Target volume delineation…

- Lung Cancer
- Head and Neck Cancer
- Gynecological Cancers
- GI tract Cancers
- Brain tumors
- Lymphomas

Impact of PET-CT in H & N Cancer

Author	Patients	Change of GTV using PET	Increase in GTV	Decrease in GTV	Remarks
Rahn, 1998	22(prim)	41%	41%	0%	No image fusion
	12(recur)	58%	58%	0%	
Nishioka, 2002	21	71%	0%	71%	PET/CT/MRI fusion
Ciernik, 2003	12	50%	17%	33%	Integrated PET-CT
Daisne, 2004	29	93%	18%	75%	CT-PET image fusion
Paulino, 2005	40	100%	-	-	PET/CT/MRI and surgical specimen image fusion

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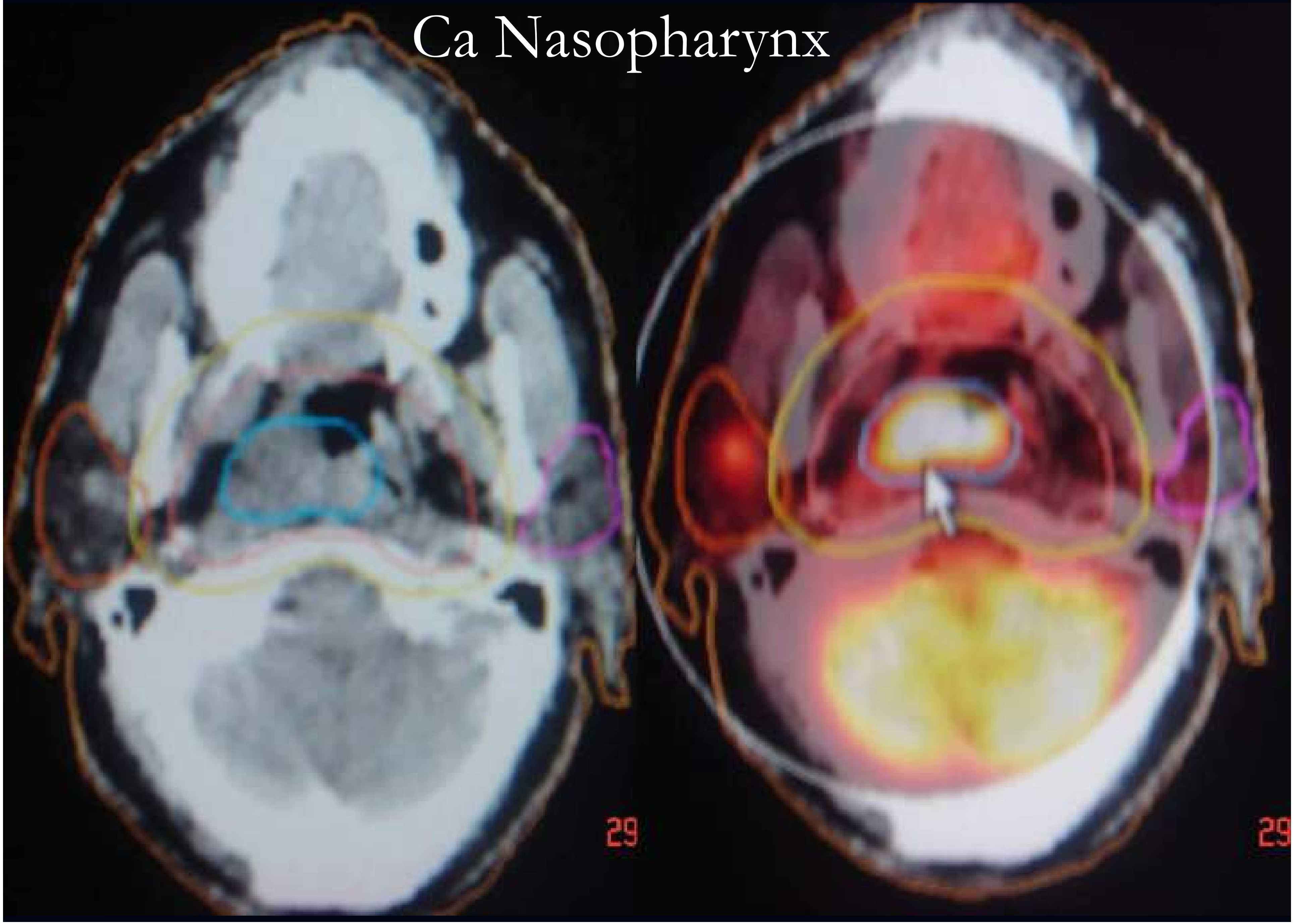
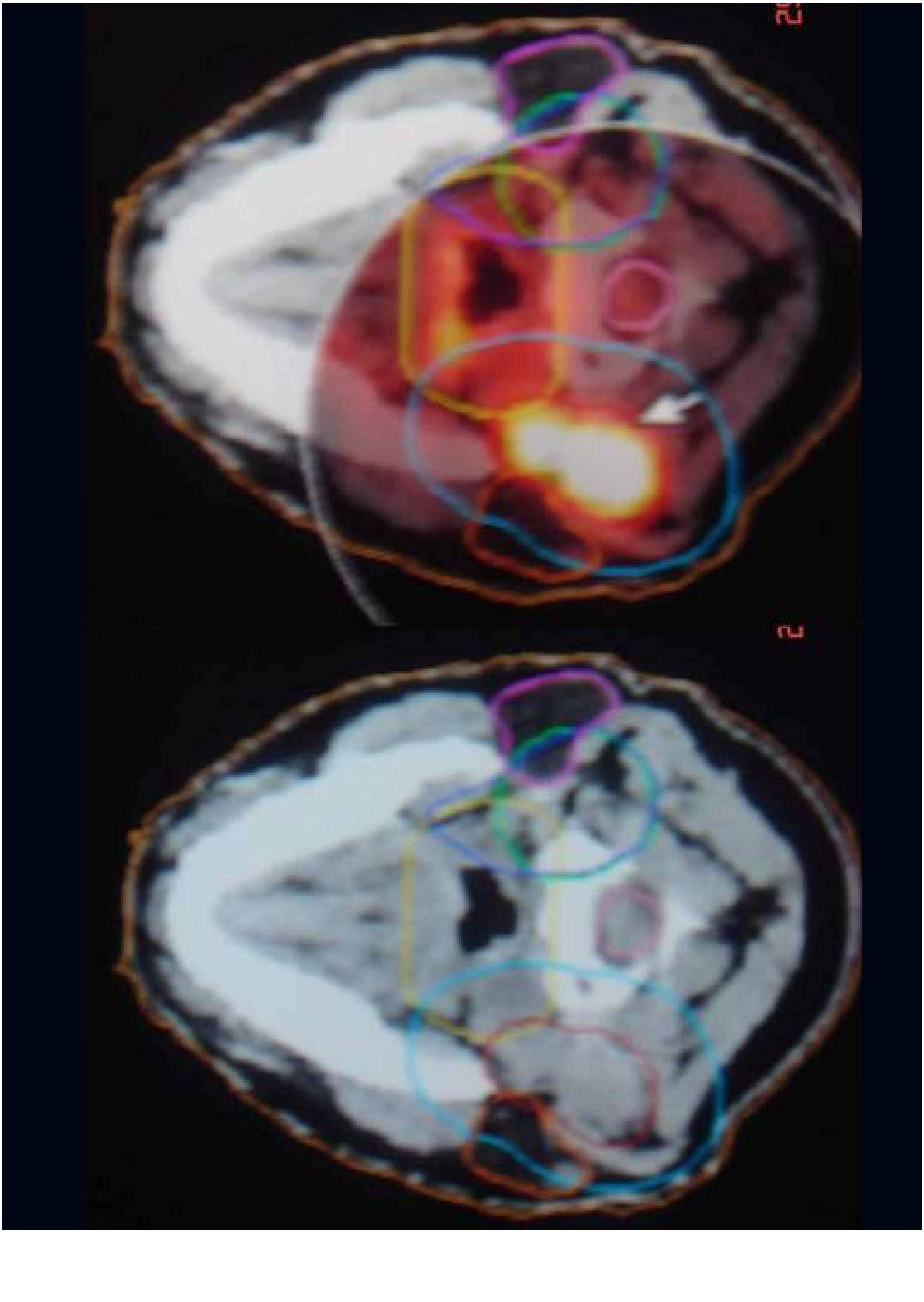
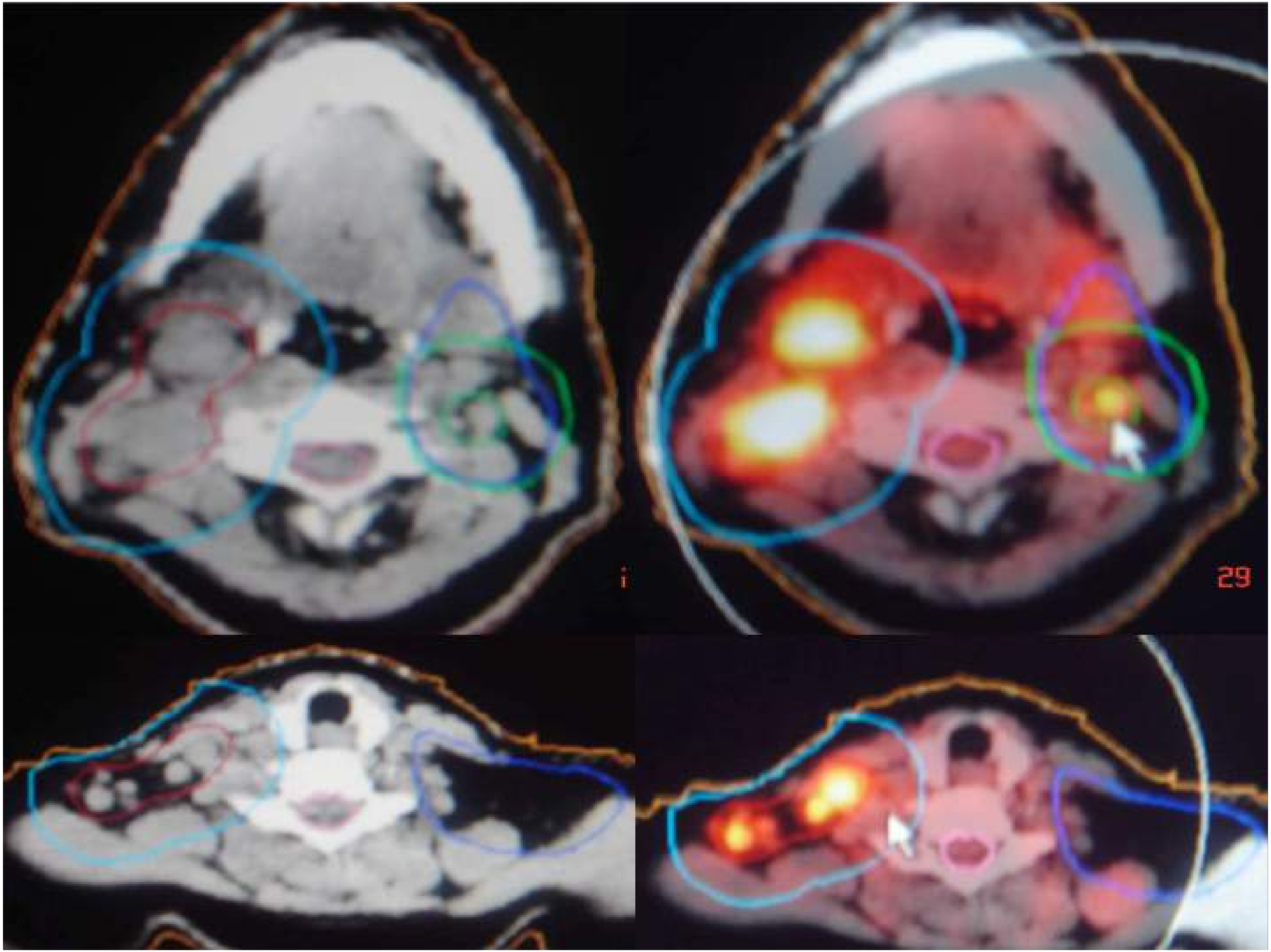
Ca Nasopharynx



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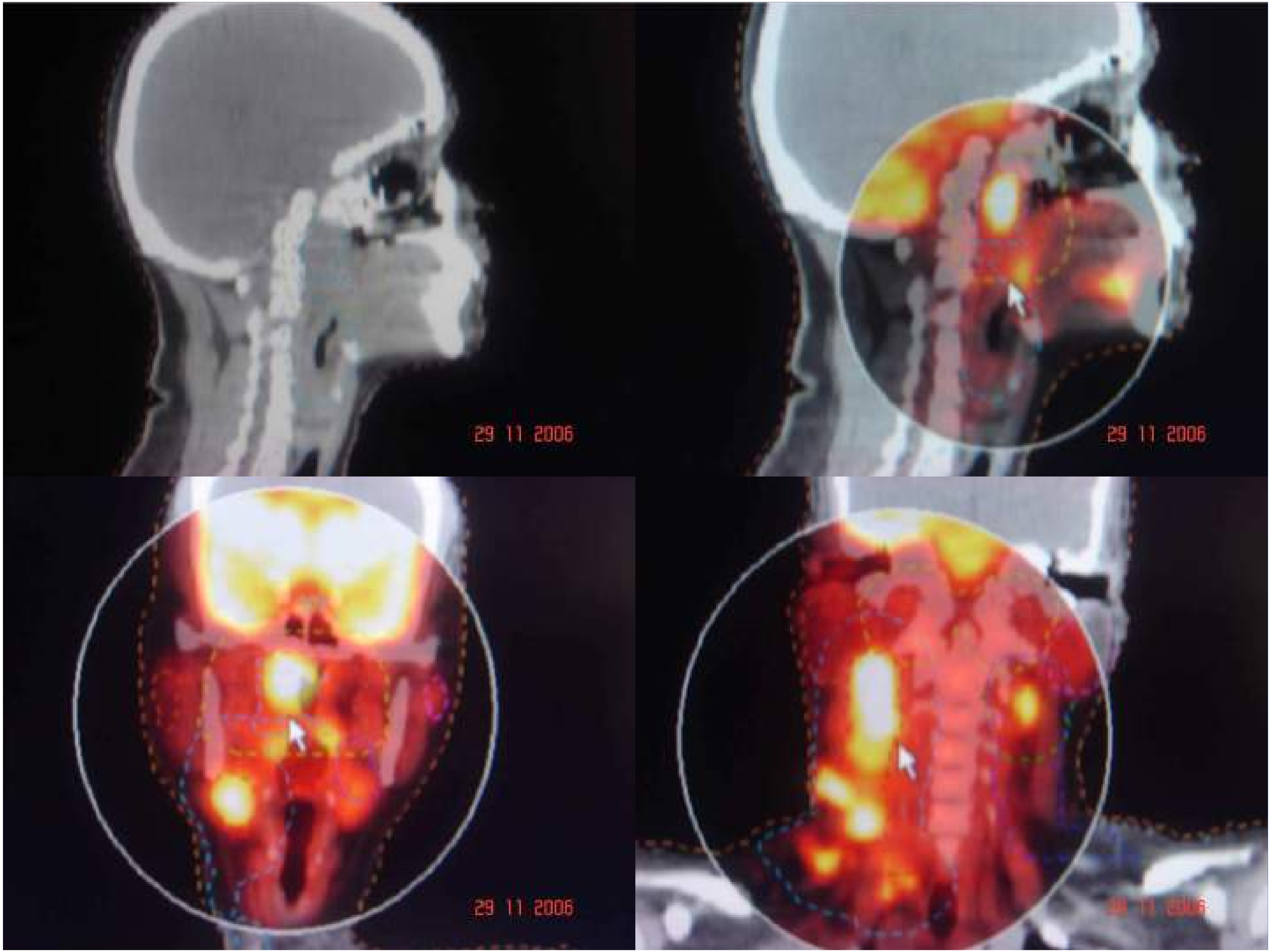
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I M R T - Target volume

- IMRT requires a thorough understanding of target delineation in the complex H&N
- Areas to be delineated on the planning CT
  - Gross tumor volume (GTV)
  - Subclinical disease (CTV)

Target volumes

- Gross tumor volume GTV (Primary & LN)
- Clinical Target volume CTV
  - Primary incl subclinical + elective nodal regions
- Planning Target volume (gross)
  - 1 cm margin everywhere
  - except post along the skull (0.5 cm margin)
- Planning Target volume PTV (elective)
  - Uniform .5 cm margin all round

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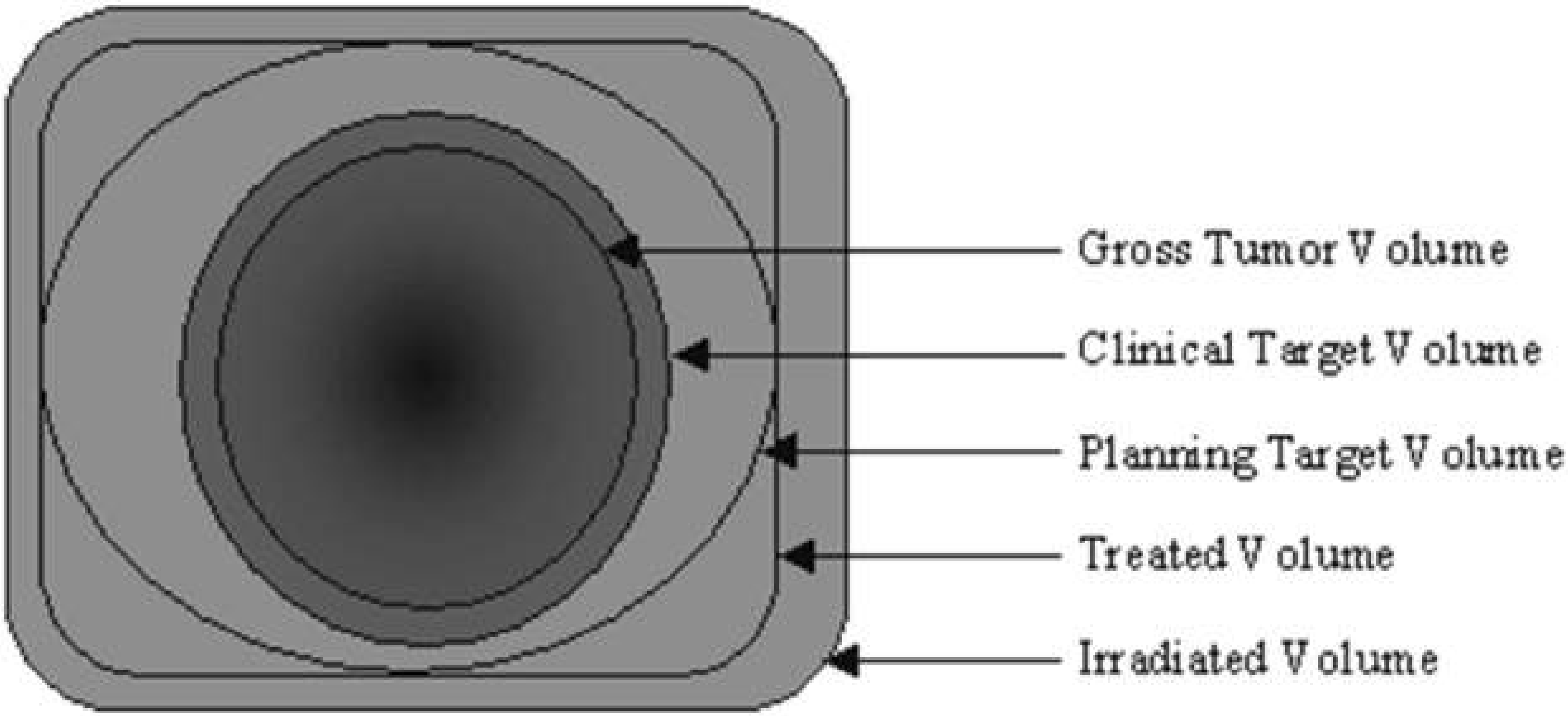
IMRT Target Volume Specification (CWG recommendation)

Target volume(s) should follow the recommendations of ICRU Reports 50 and 62.



Clinical Target Volume (CTV)

- *targeting the sub-clinical disease*

- Every primary in H&N region there are associated LN regions or levels, that are at risk & must be contoured.
- Knowledge of these levels and their anatomic boundaries is essential.
- The RTOG, EORTC and DAHANCA groups have all established CTV guidelines for the clinically and radiographically negative, surgically nonviolated neck
  - imaging based nodal atlases

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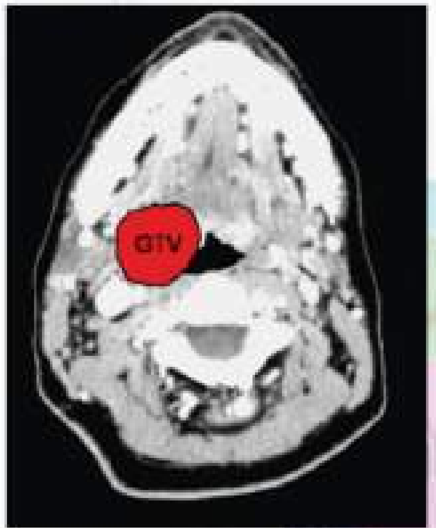
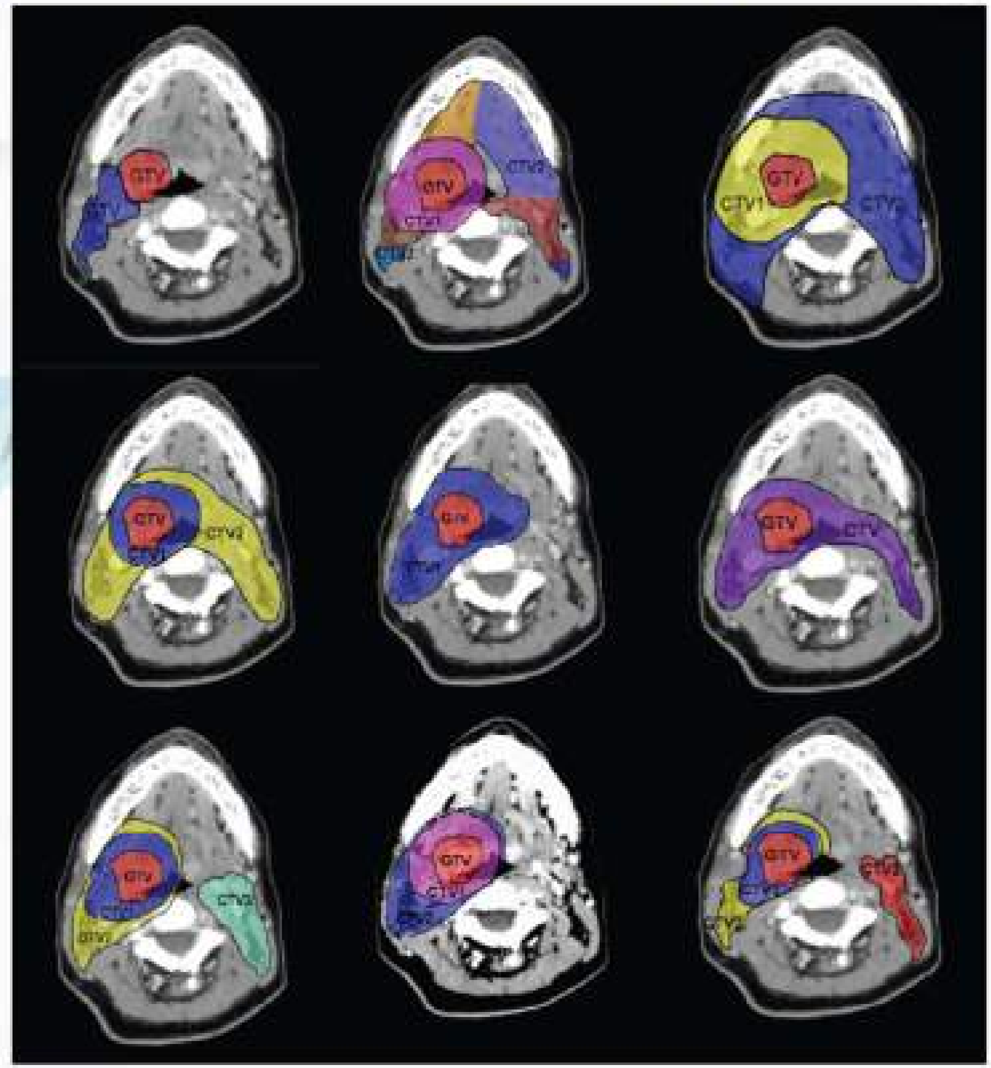
H&N IMRT practice heterogeneity



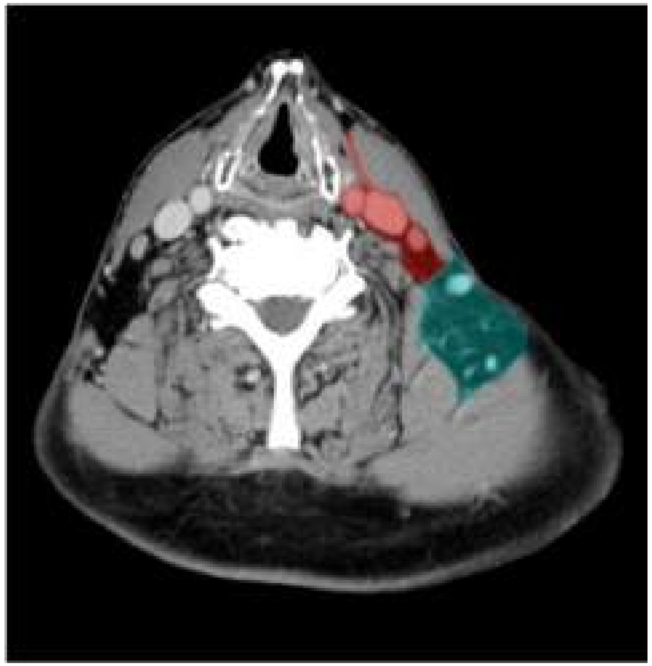


Atlases?

MAESTRO
Jan. 2007

Harari et al., 2005

Radiotherapy & Oncology 69: 227, 2003
http://www.rtog.org/hnatlas/main.html



Level I	Level II	Level III	Level IV	Level V	Level VI	RP

CT-based delineation of lymph node levels and related CTVs in the node-negative neck: DAHANCA, EORTC, GORTEC, NCIC, RTOG consensus guidelines

Vincent Grégoire[a,*,1], Peter Levendag[b,1], Kian K. Ang[c], Jacques Bernier[d], Marijel Braaksma[b], Volker Budach[e], Cliff Chao[c], Emmanuel Coche[f], Jay S. Cooper[c], Guy Cosnard[f], Avraham Eisbruch[c], Samy El-Sayed[g], Bahman Emami[c], Cai Grau[h], Marc Hamoir[i], Nancy Lee[c], Philippe Maingon[j], Karin Muller[b], Hervé Reychler[k]

Steps…

Dose volume histograms (DVHs)

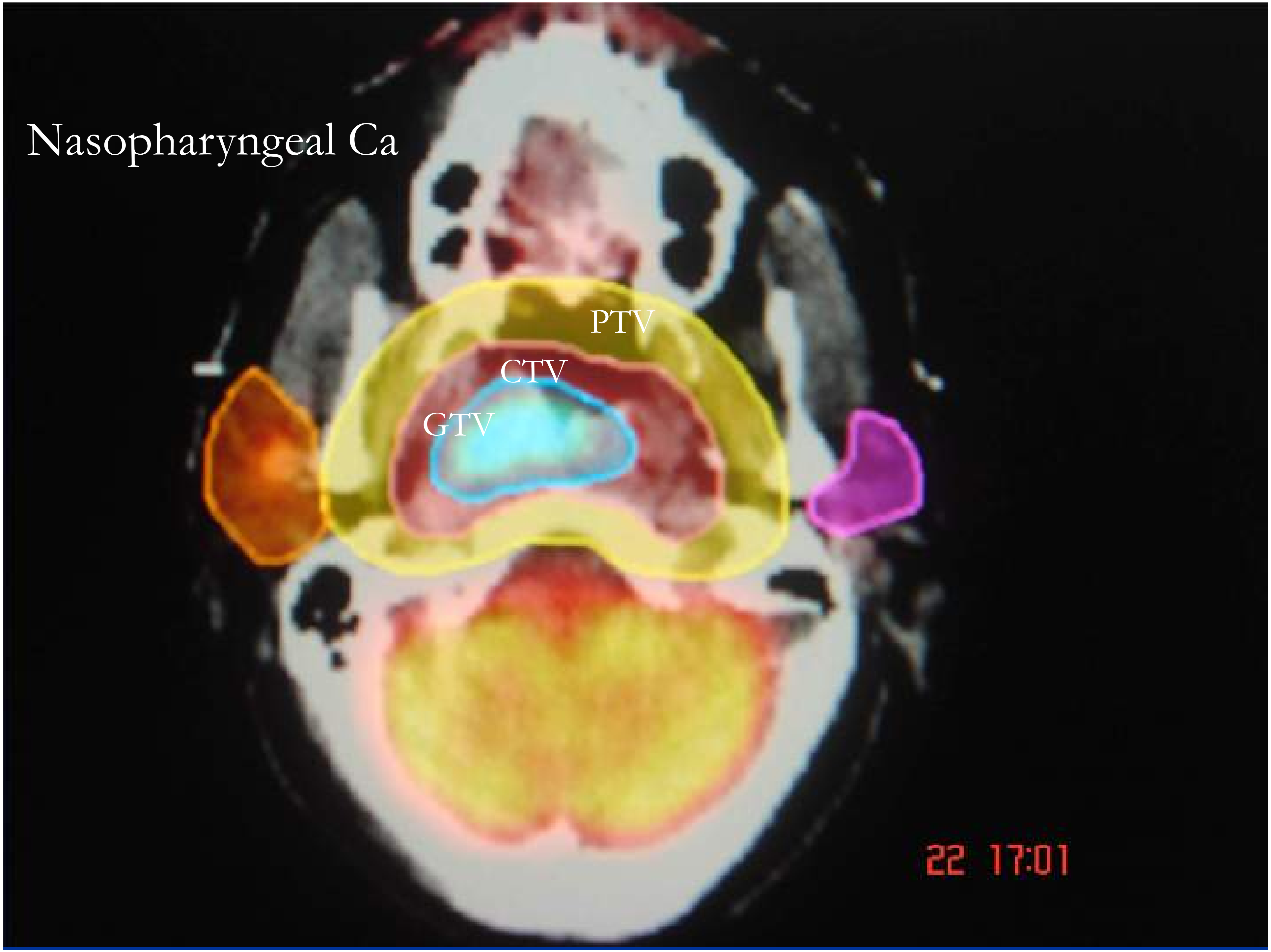
Accurate calculation of DVHs

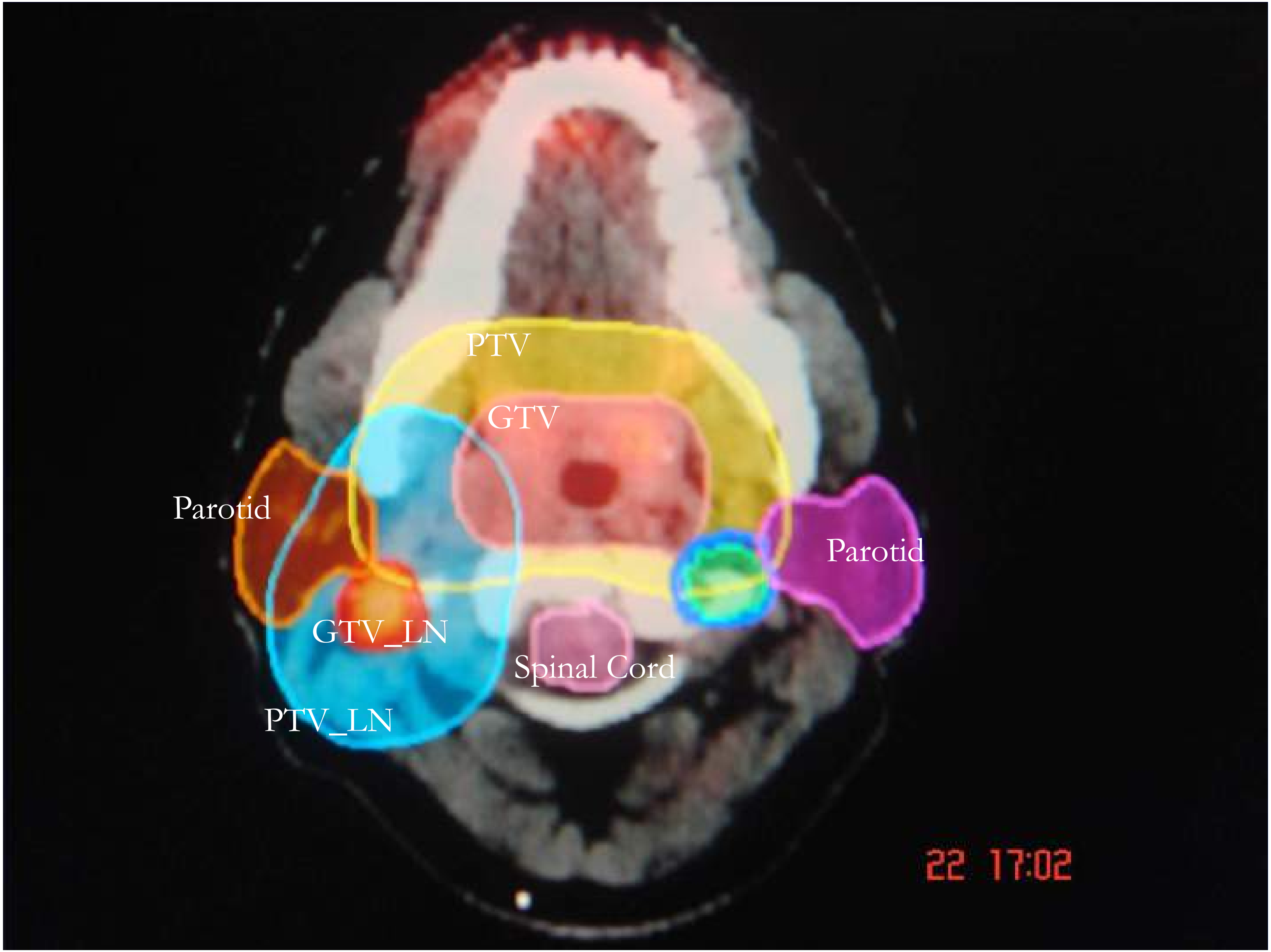
Biological indices (e.g., normal tissue complication probability)

Mandate the inclusion of the entire extent of the relevant structures

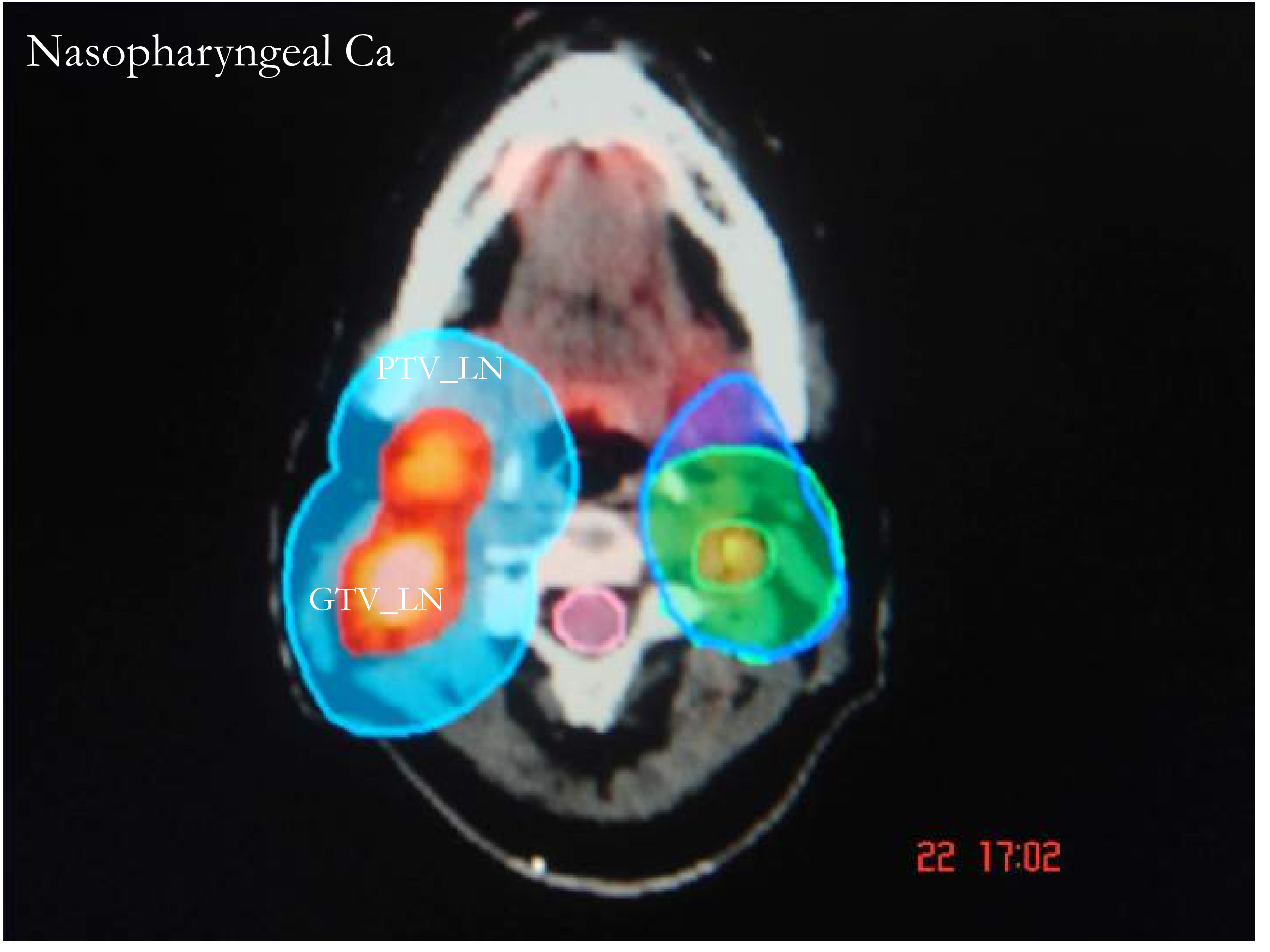
Normal tissues Contouring…

- Parotid glands
- Spinal cord
- Brainstem
- Cochlea
- Optical structures
- Pituitary gland

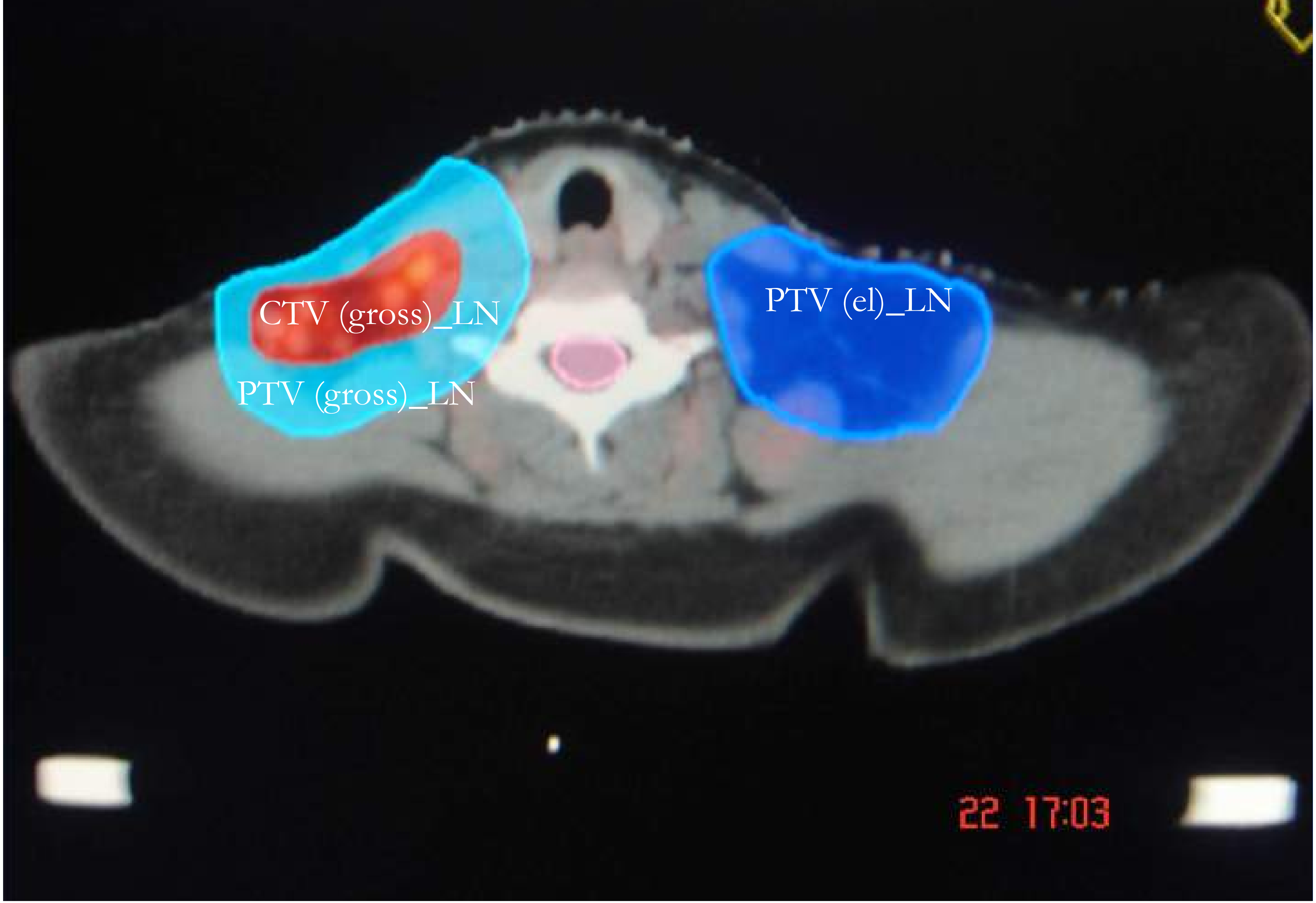

Nasopharyngeal Ca
PTV
CTV
GTV
22 17:01

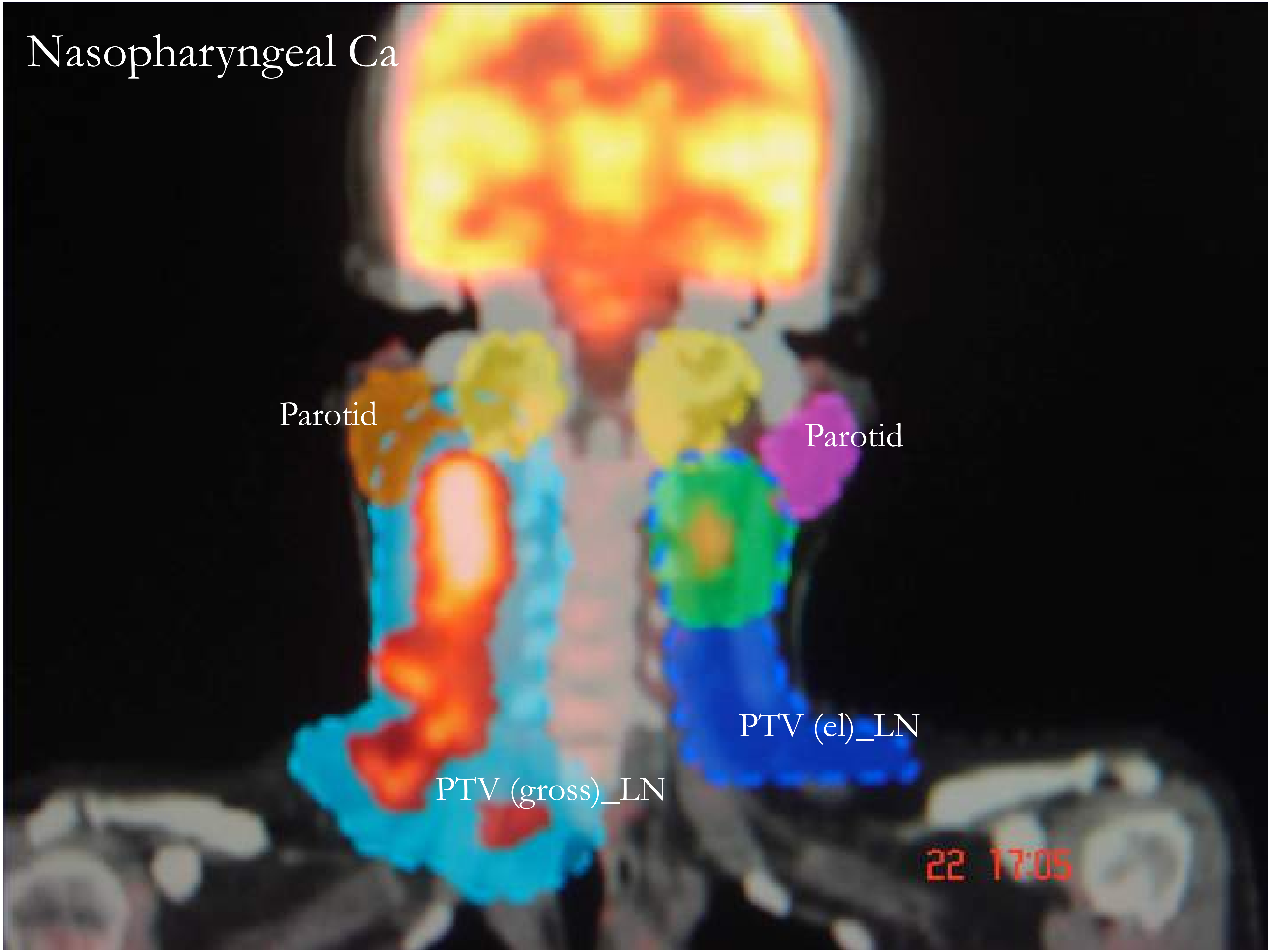

PTV
GTV
Parotid
Parotid
GTV_LN
Spinal Cord
PTV_LN
22 17:02

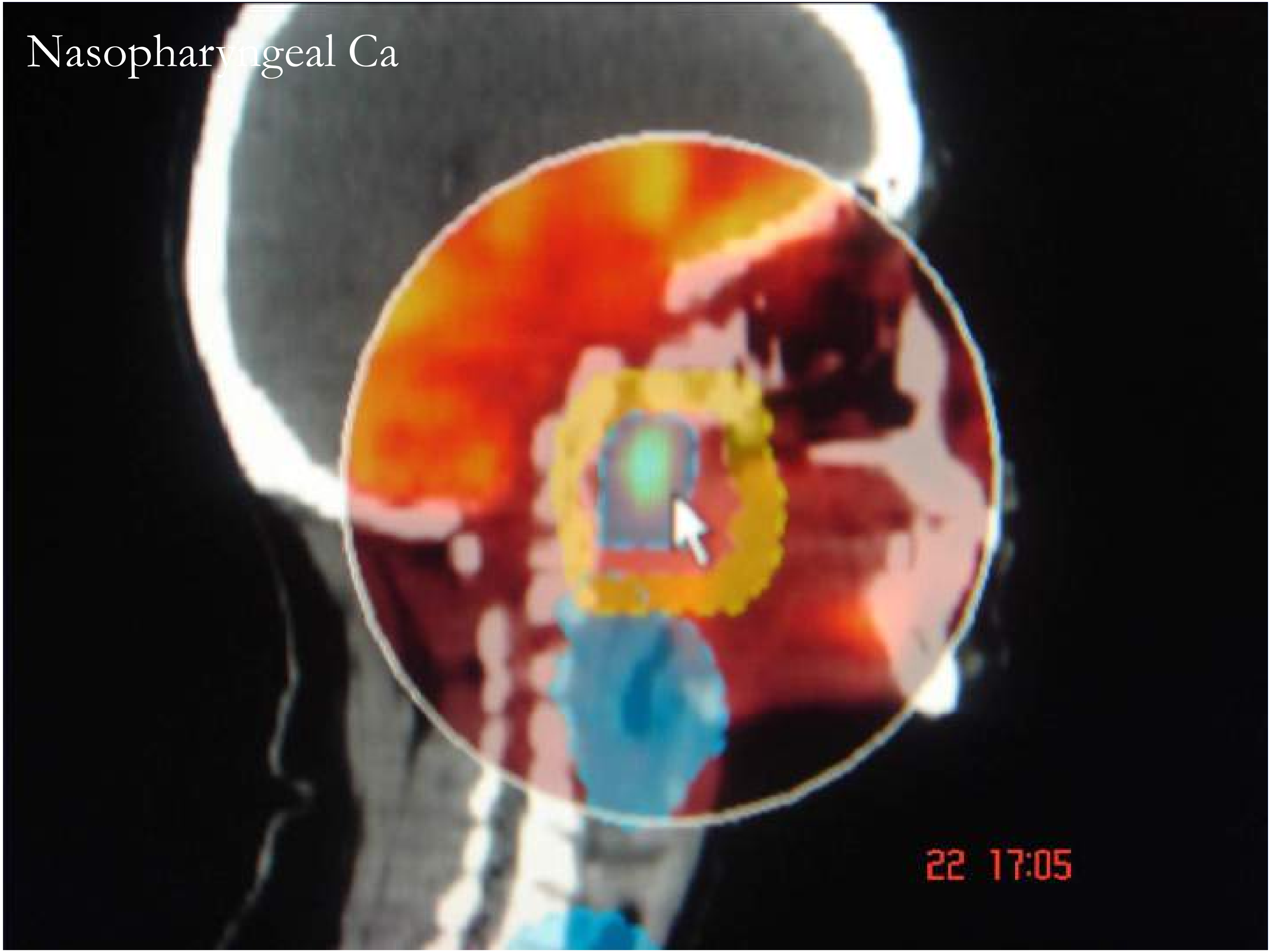
Nasopharyngeal Ca



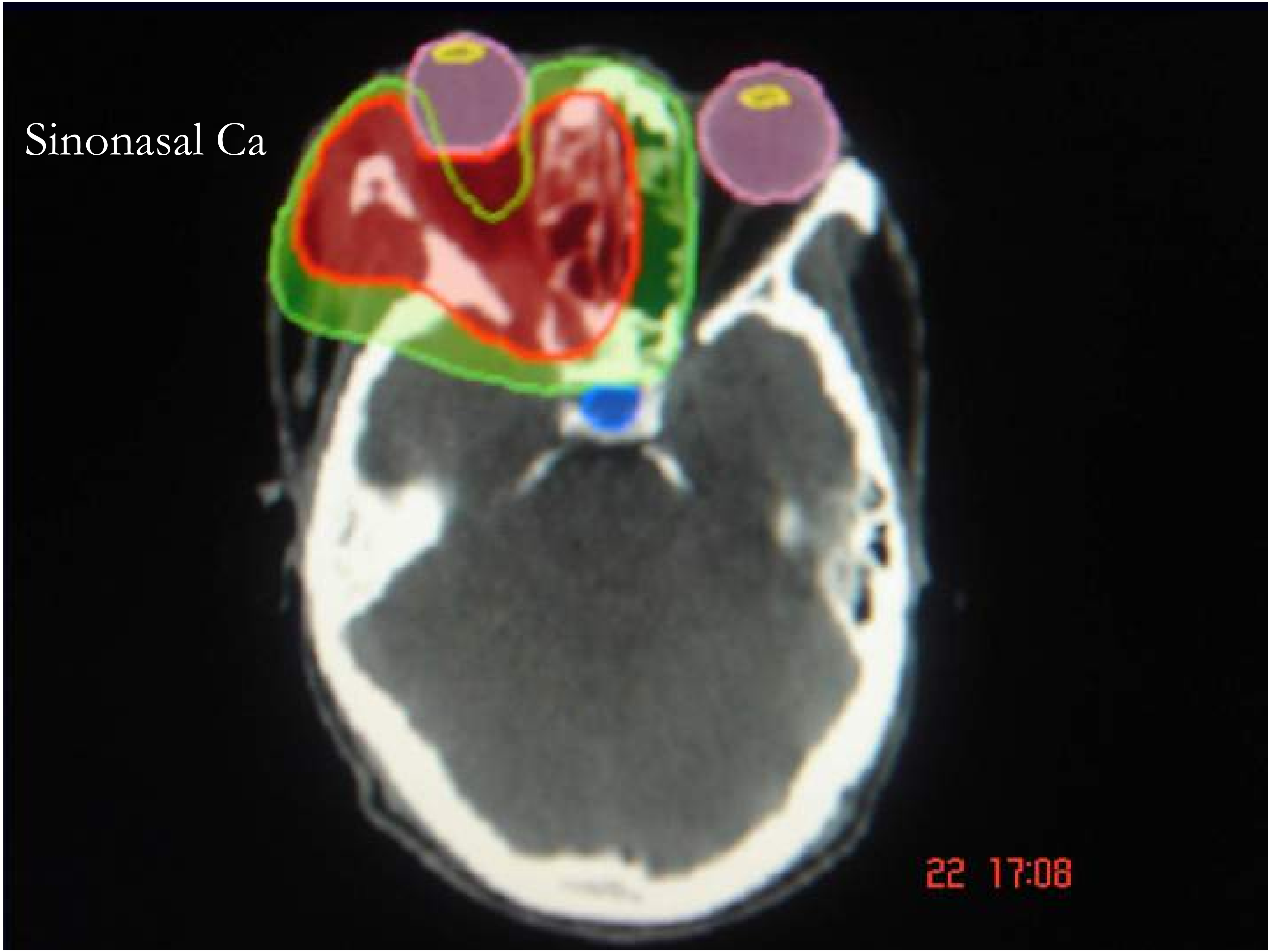
Nasopharyngeal Ca




Nasopharyngeal Ca
Parotid
Parotid
PTV (el)_LN
PTV (gross)_LN
22 17:05


Nasopharyngeal Ca
22 17:05

Sinonasal Ca



Ca Oral Tongue

Post-op/RT

Recurrence

Ca Oral Tongue

Post-op/RT

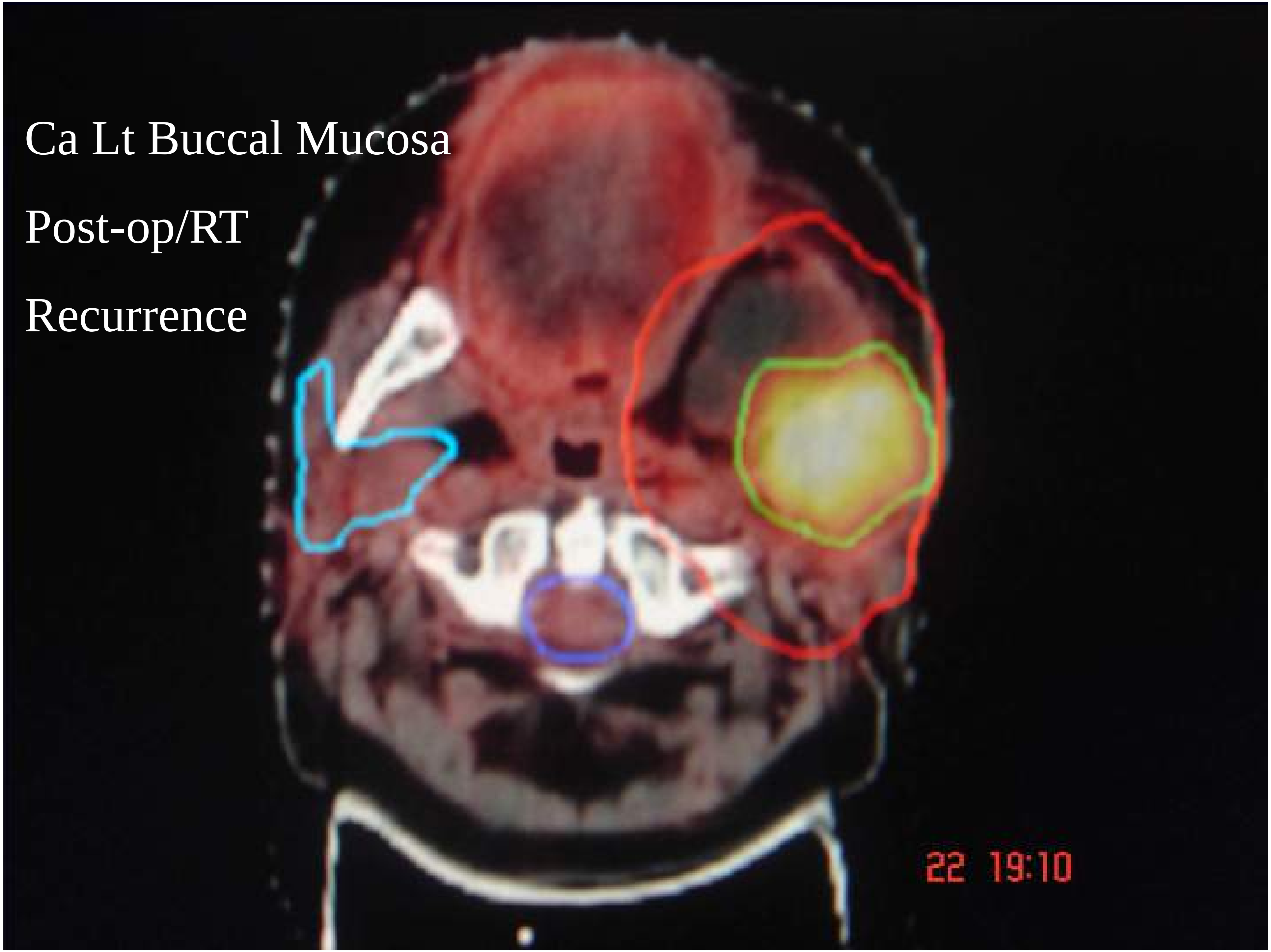
Recurrence

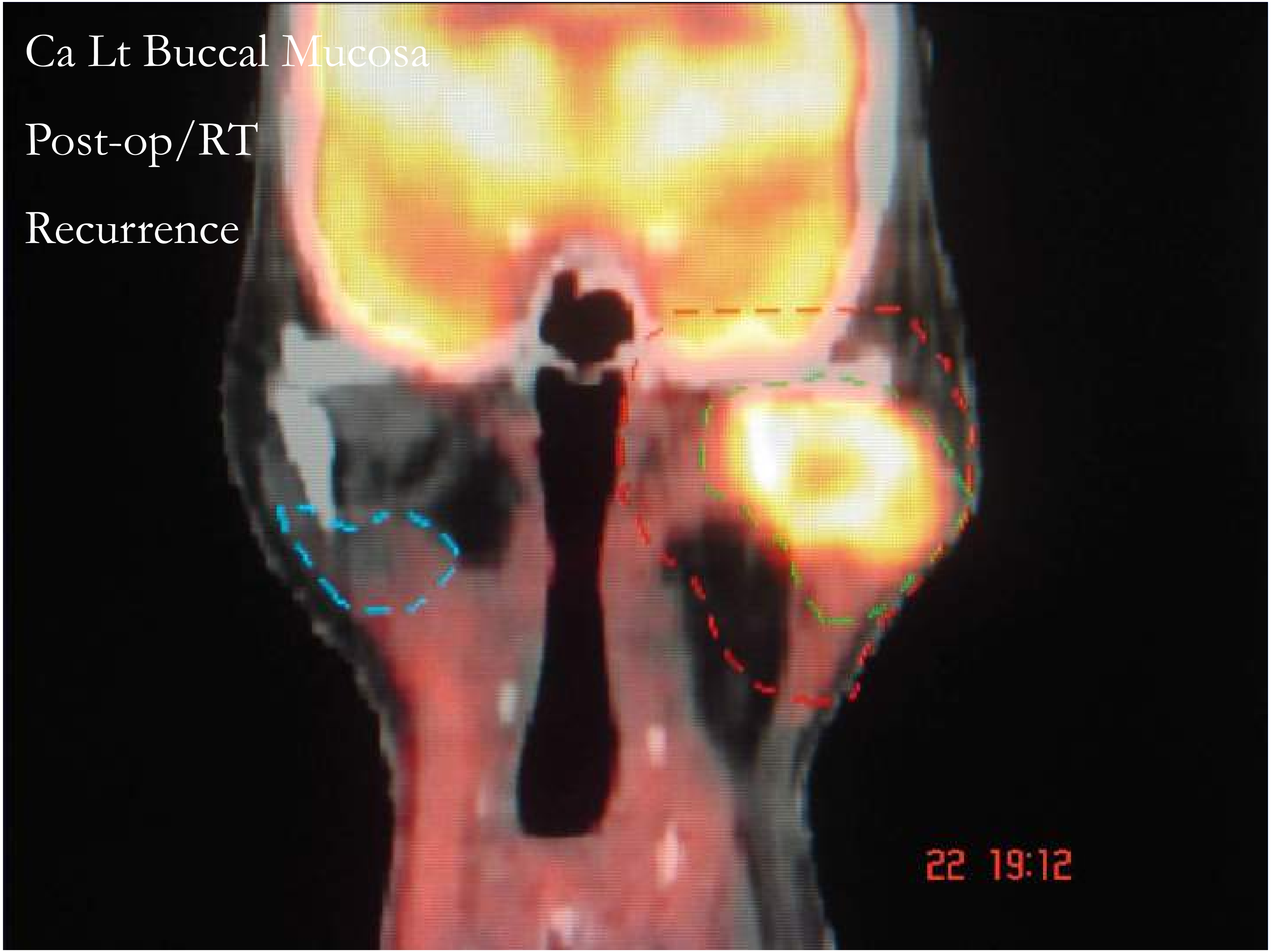
Ca Rt Tonsil

Ca Lt Buccal Mucosa

Post-op/RT

Recurrence

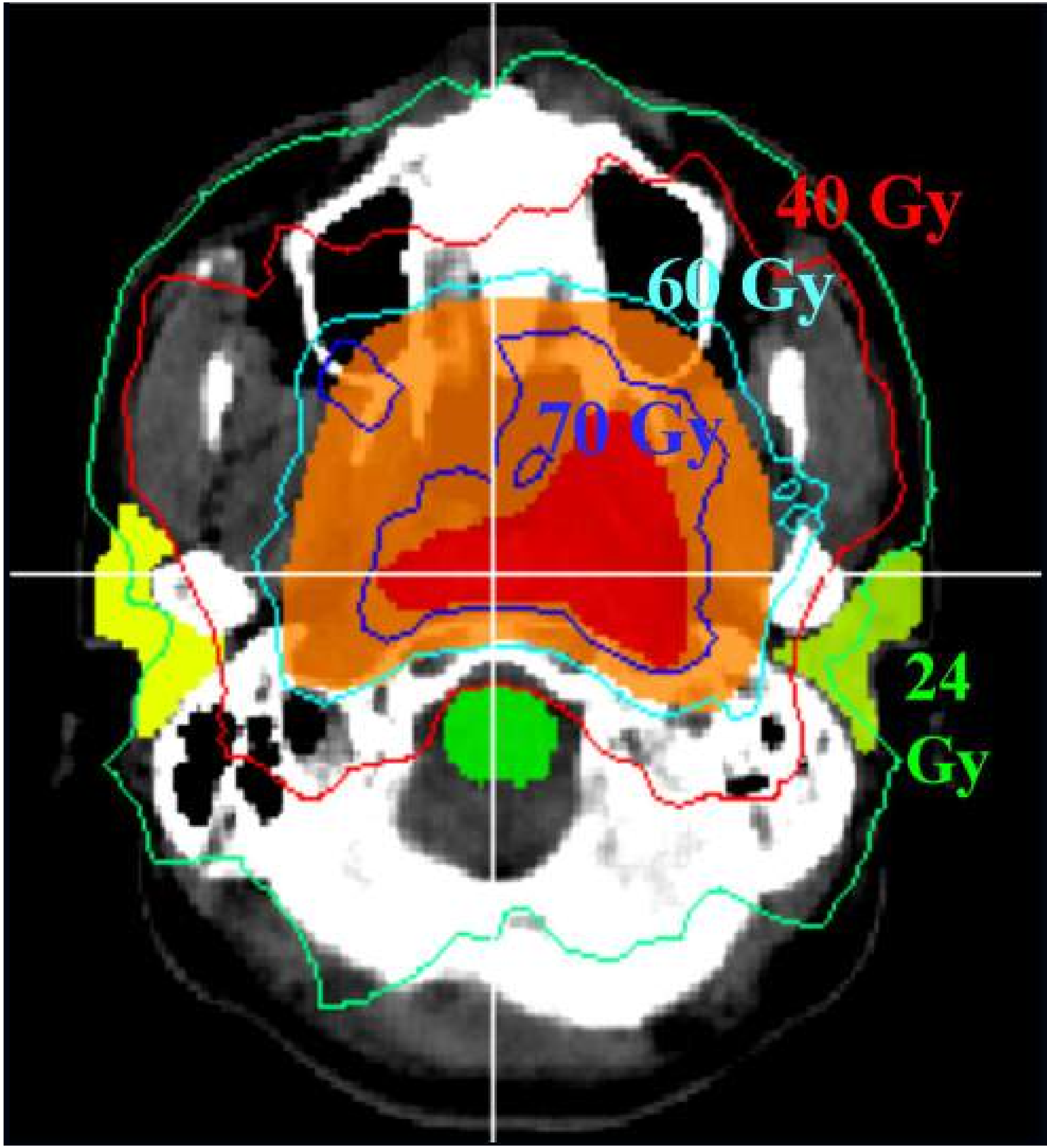



Ca Lt Buccal Mucosa
Post-op/RT
Recurrence
22 19:12

Discussion with Physicist..

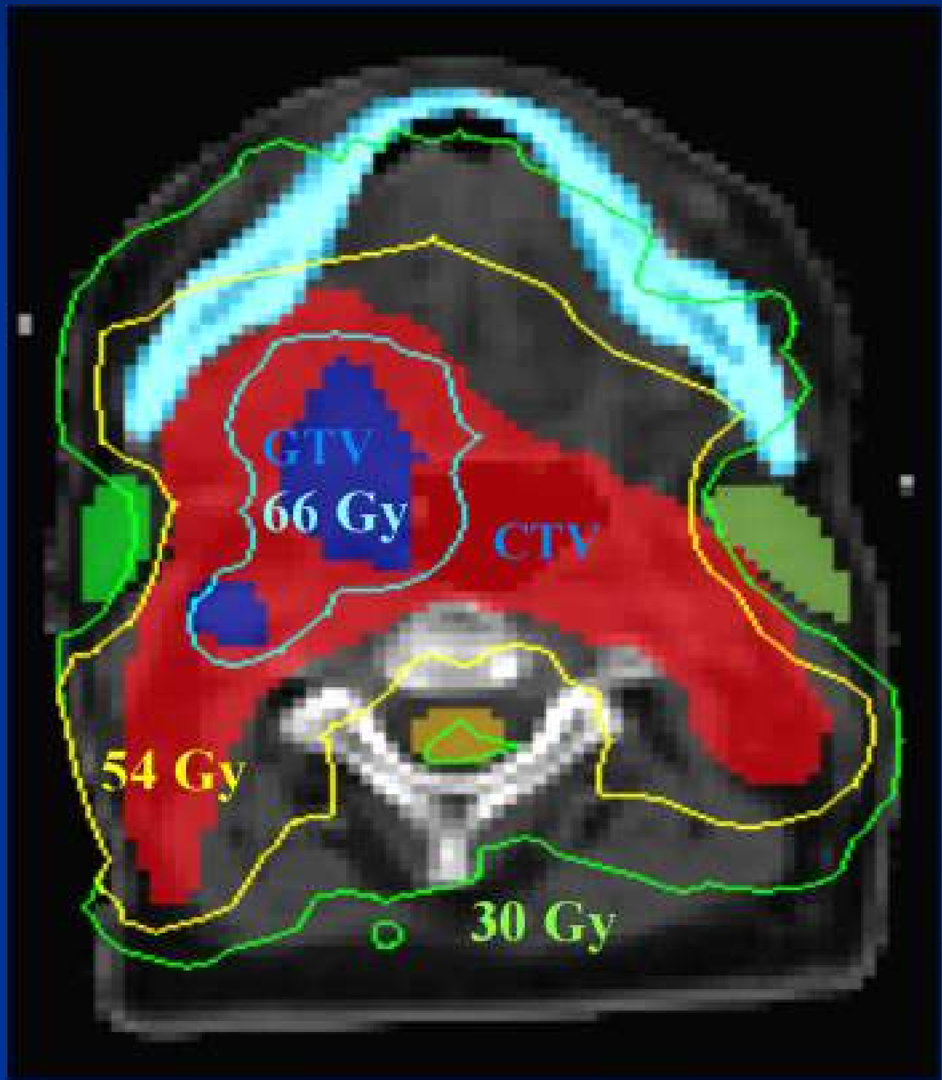
Communicating pertinent information

- Brief clinical findings
- Location of the primary
- Adenopathy
- High risk regions
- Adjacent critical structures



IMRT
Ca NP

IMRT - Ca Oropharynx



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IMRT
Head & Neck studies

Table 1. Locoregional Control After IMRT for Head and Neck Cancer

			RT		Follow-Up (months)		Control		
Study	No. of Patients	Primary Site	Definitive	Postoperative	Median	Range	Local (%)	Regional (%)	Interval (years)
Chao et al[19]	126	Various	52	74	26	12-55	85		2
Lee et al[5]	67	NPX	67	0	31	7-72	98		4
Chao et al[20]	74	OPX	31	43	33	9-60	87		4
Eisbruch et al*[21]	133	Various, non-NPX	60	73	32	6-107	82		3
Kam et al[33]	63	NPX	63	0	29	8-45	92	98	3
Kwong et al[34]	33	NPX	33	0	29	11-42	100	92	3

Abbreviations: IMRT, intensity-modulated radiotherapy; RT, radiotherapy; NPX, nasopharynx; OPX, oropharynx.
*Patients treated from 1994 to 2002; three-dimensional conformal radiotherapy was used before 1996, and IMRT thereafter.

JCO, 2006

IMRT ± Chemo for NPC
(Single Institutions)

Center	N	Stage	FU (mo)	LC DM-Free
Bucci IJROBP, 2004(abs)	118	50% T3-4	30	96% 72% (4-year data)
Kam IJROBP, 2004	63	51% T3-4	29	92% 79% (3-year data)
Wolden IJROBP, 2006	74	51% T3-4	35	91% 78% (3-year data)

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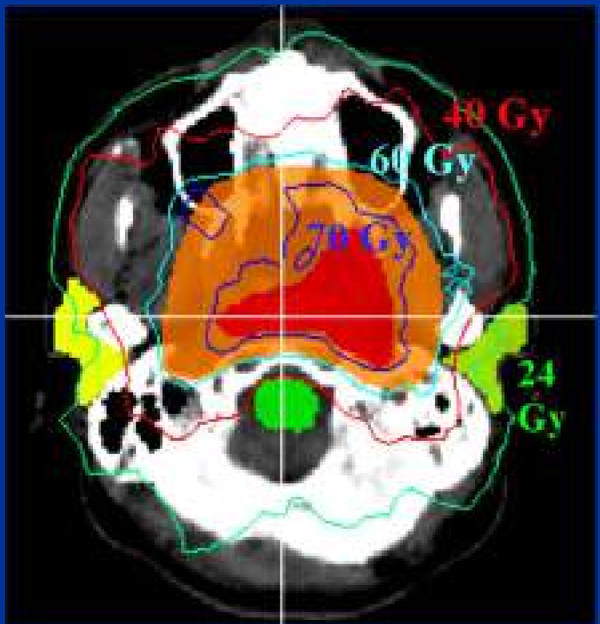
IMRT for NPC
RTOG Protocol H-0225 (Lee & Garden)

Stage: I-IVb

Histology:

WHO I-III



R E G I S T E R

IMRT:

2.12 Gy/F/d X 33 F to ≥ 95% of GTV

1.8 Gy/F/d X 33 F to ≥ 95% of CTV

Chemotherapy (≥T2b or N+)

Concurrent: Cisplatin x 3

Adjuvant: Cisplatin + 5-FU

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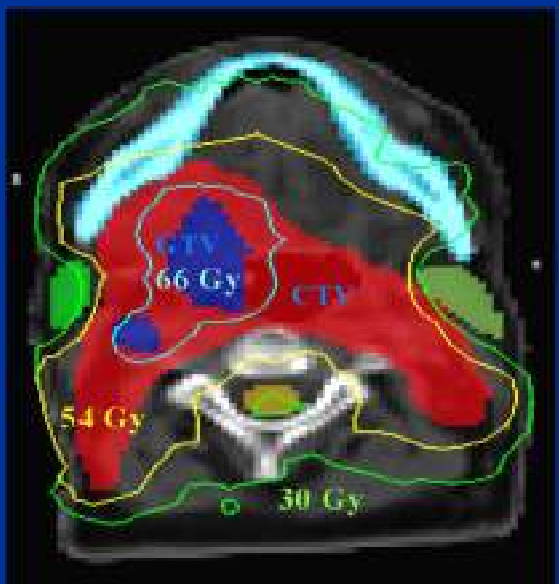
IMRT for Oropharyngeal SCC

RTOG Protocol H-0022 (Eisbruch & Chao)

Stage: T1-2 N-1

Site:
Tonsil, BOT, Soft Palate



R E G I S T E R

Gross disease PTV:

66 Gy/30 FX

Subclinical disease PTV:

54-60 Gy/30 FX

Boost of 4-6 Gy/2-3 FX to the tumor PTV allowed

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RTOG 0022 – ASTRO 2006

- Study population: 67 patients (14 centers)
- Tumor: tongue base-20 (39%),
  tonsil-33 (49%), soft palate 8 (12%)
- Stage: T1-25%, T2-75%; N0-57%, N1-43%
- Median follow-up: 1.6 (0.2-3.8) years
- LR progression: 3 patients (4.9%)
- No metastatic disease observed

A Eisbruch, J Harris, A Garden, C Chao, W Straube,
C Schultz, G Sanguineti, C Jones, W Bosch, K Ang YAAR

IMRT for Oropharynx Cancer

- 2000-June 2003: 133 patients
- Age: 30-75 (53) years; 85% male
- Site: tonsil-52%; tongue base-40%
- T1-2(x): 114; T3-4: 19
- Chemotherapy: 28 (T3-4 or N2-3)
- 3-Y local control: 95%
- 3-Y overall survival: 93%

Garden et al., 2005

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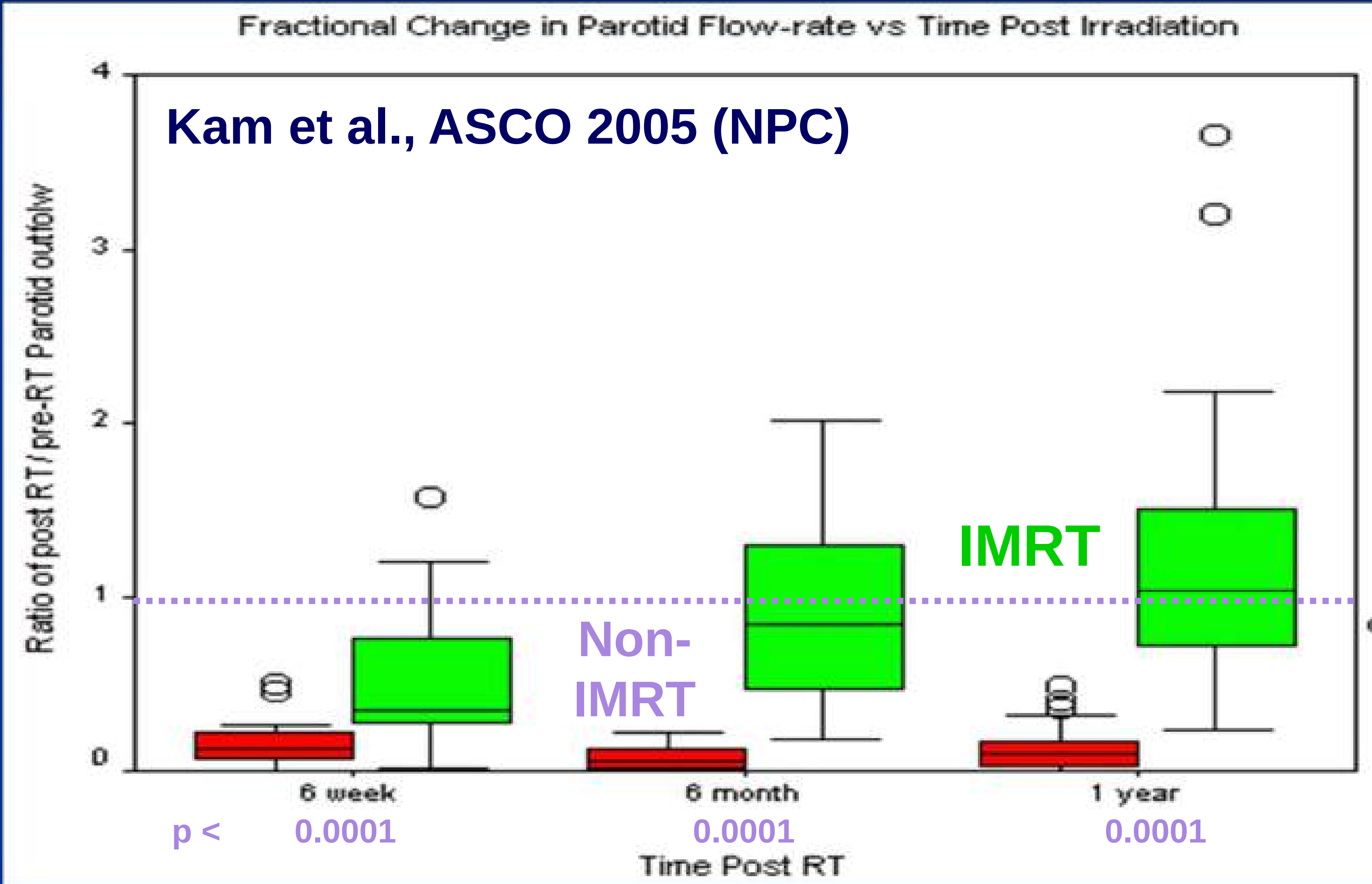
Recovery of Saliva Flow (A vs C)



Advantages – Variable doses

- Boosting doses within targets

  Diff doses per fraction to multiple target vol within a treatment field.

- Simultaneous Integrated Boost

  Concomitantly with standard doses to the remainder of targets

- 70Gy vs 45-55Gy within the target vol

Advantages of I M R T…

Eliminate the need for standard fields

- Low anterior neck field.
- Electron boost

Advantages of I M R T…

Re-treatment

Re-treatment of radiated H&N ca Possible due to its ability to spare adjacent normal tissues with acceptable target dose uniformity.

Sparing of normal tissues

Uninvolved tissue sparing of multiple sites to reduce short and long term side effects

- Major and minor salivary glands, most notably parotids, mandible, oral cavity, larynx and pharynx.
- Critical structures - Cochlea, temporal lobes, optic pathways, spinal cord, brainstem & brain

Pit falls ….

- Smaller PTV margins, Sharper dose fall-off can allow for geographic misses if target localization and immobilization are not accurate
- More complex, more beams/arc increase the overall treatment time - decrease dose rate!
- Lack of uniformity – no IMRT planning standards for every anatomical site.
- Diff to compare data between institutions

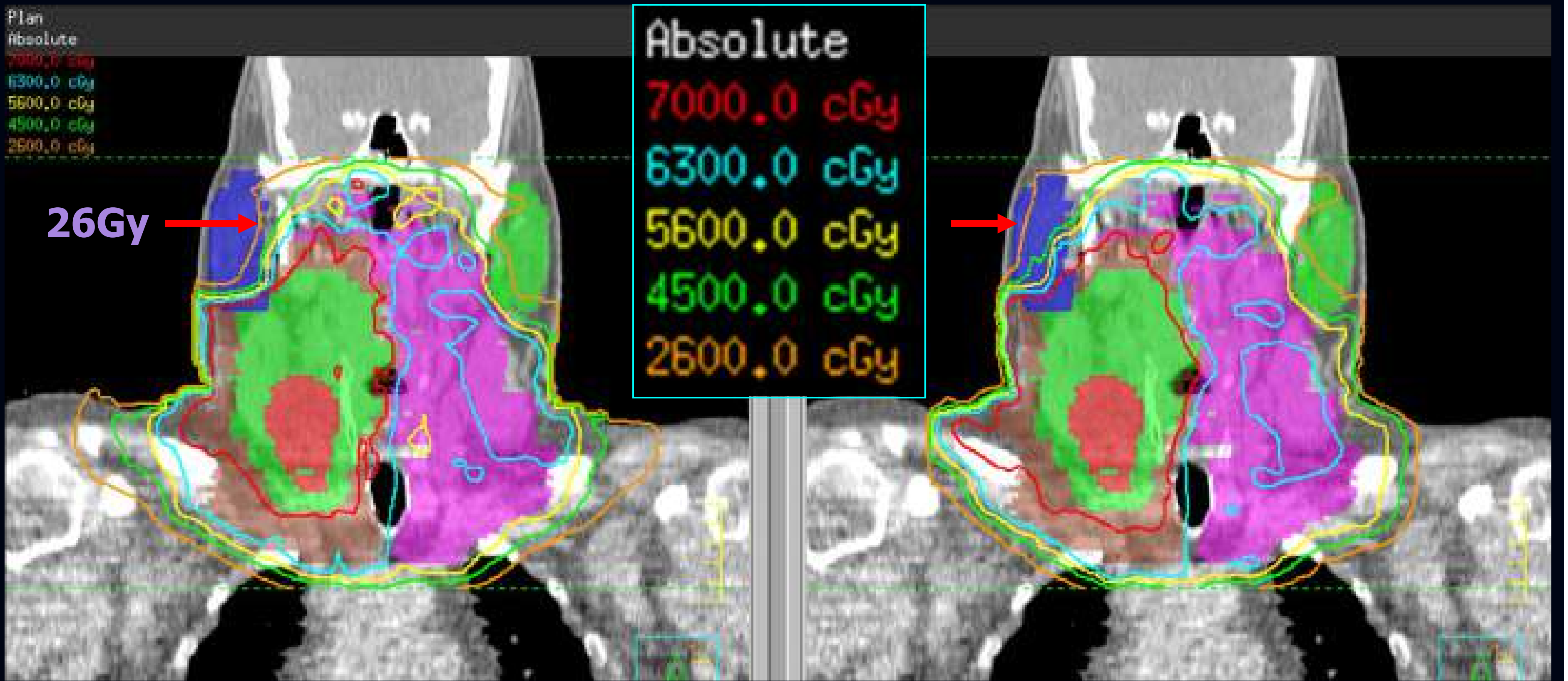
Changes in Anatomy during course of Rx

Planning CT

Three Weeks into RT

Barker et al. *IJROBP* 59:960, 2004 & Lei Dong et al. (MDACC)

Dosimetric Impact of Anatomic Changes



Original Plan

Four Weeks Later (Mapped back to the original planning CT using deformable registration)

Barker et al. IJROBP 59:960, 2004 & Lei Dong et al. (MDACC)

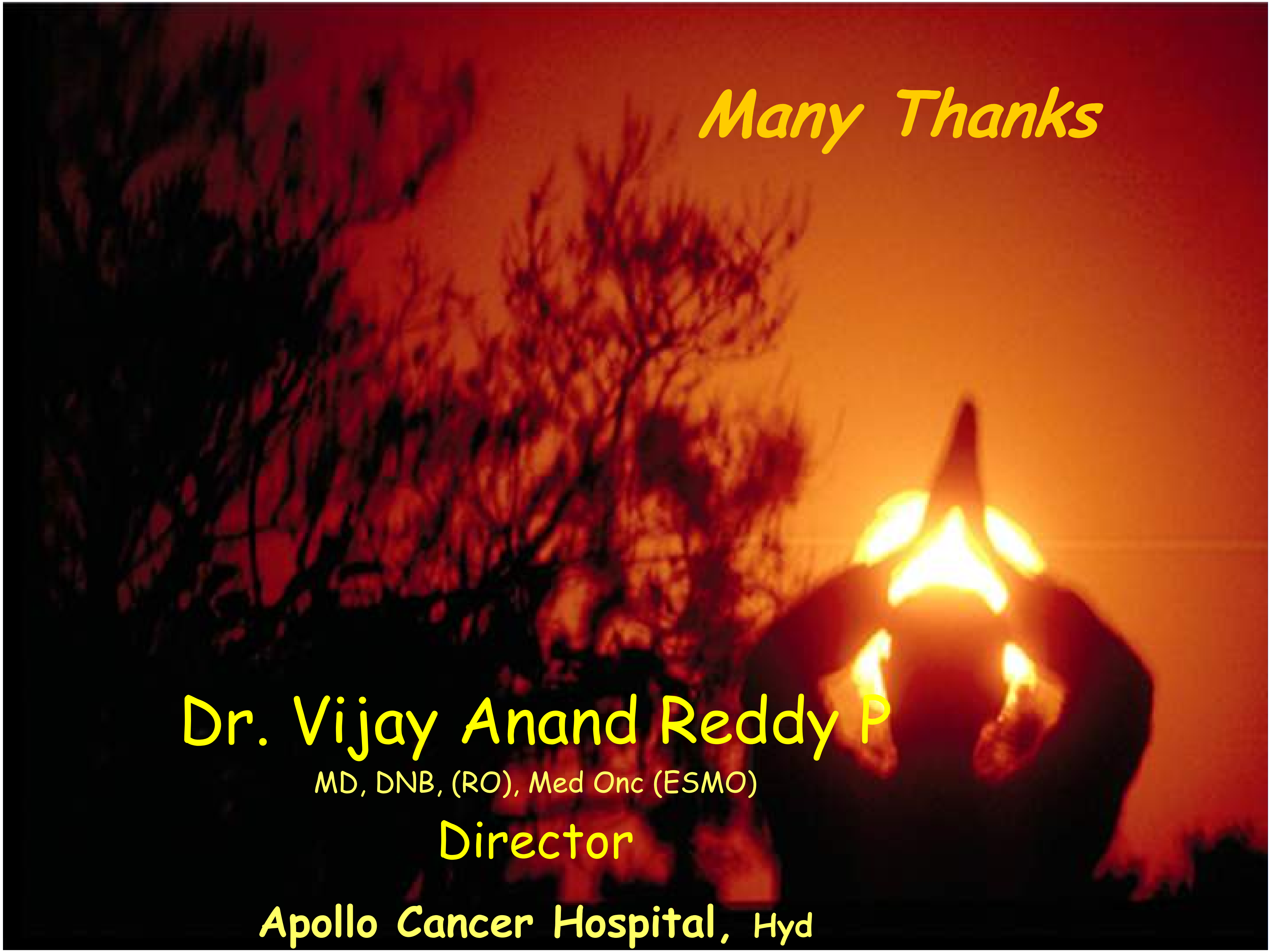
Conclusion

- IMRT is an obvious choice for H&N Ca (NP,OP,PNS etc)
- Obtains tight dose gradients around gross & sub-clinical disease when desirable
- Tumor in close vicinity of the cord, parotids & brain stem
- Re-irradiation possible
- ***Requires expertise***
- Newer tech-needs longer f u to testify its advantage

Lecture, lecture, lecture …

Audience

VAR


Many Thanks
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