Nodal Volume Delineation For Head & Neck Cancer

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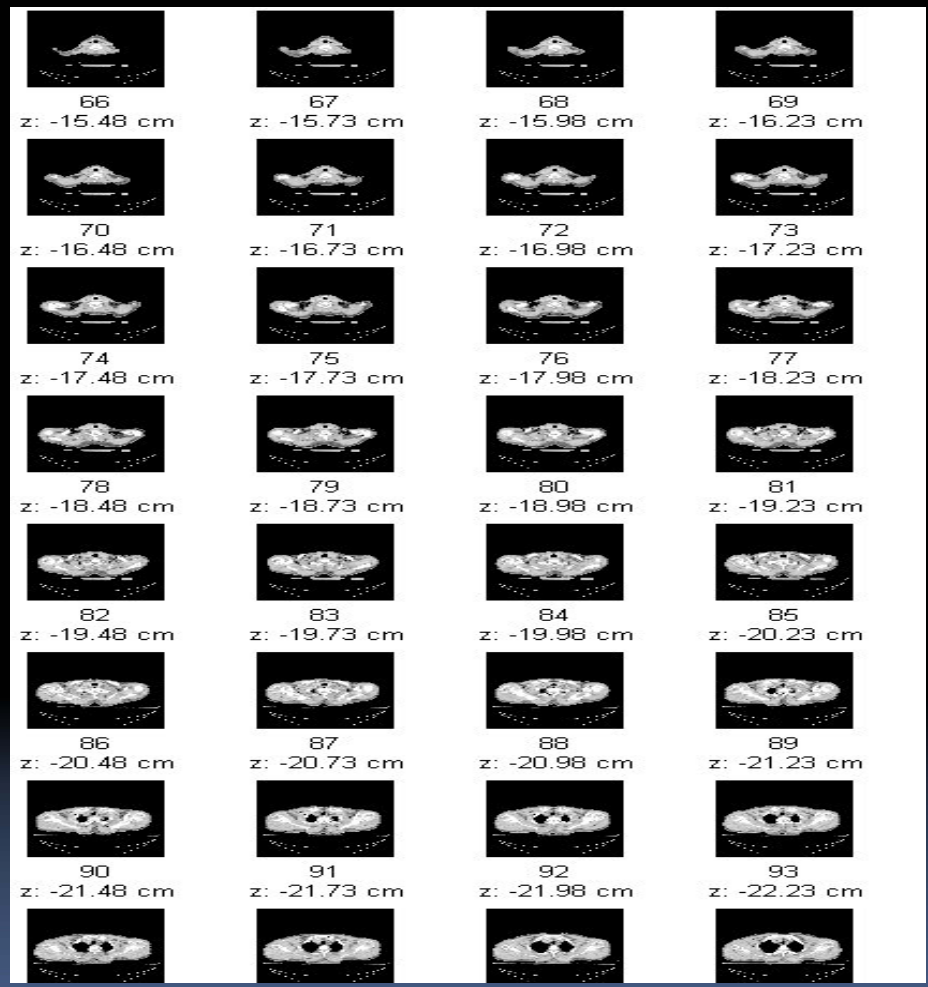
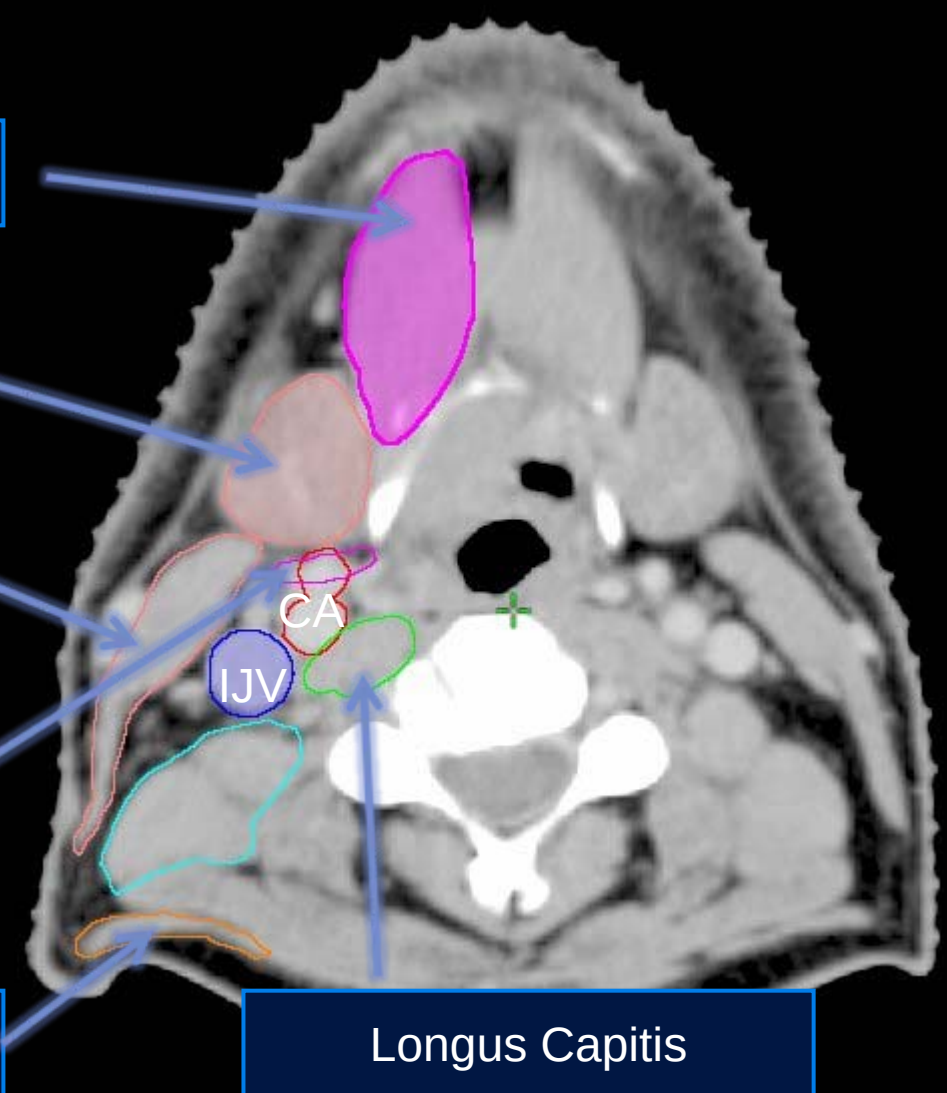
2D to 3D



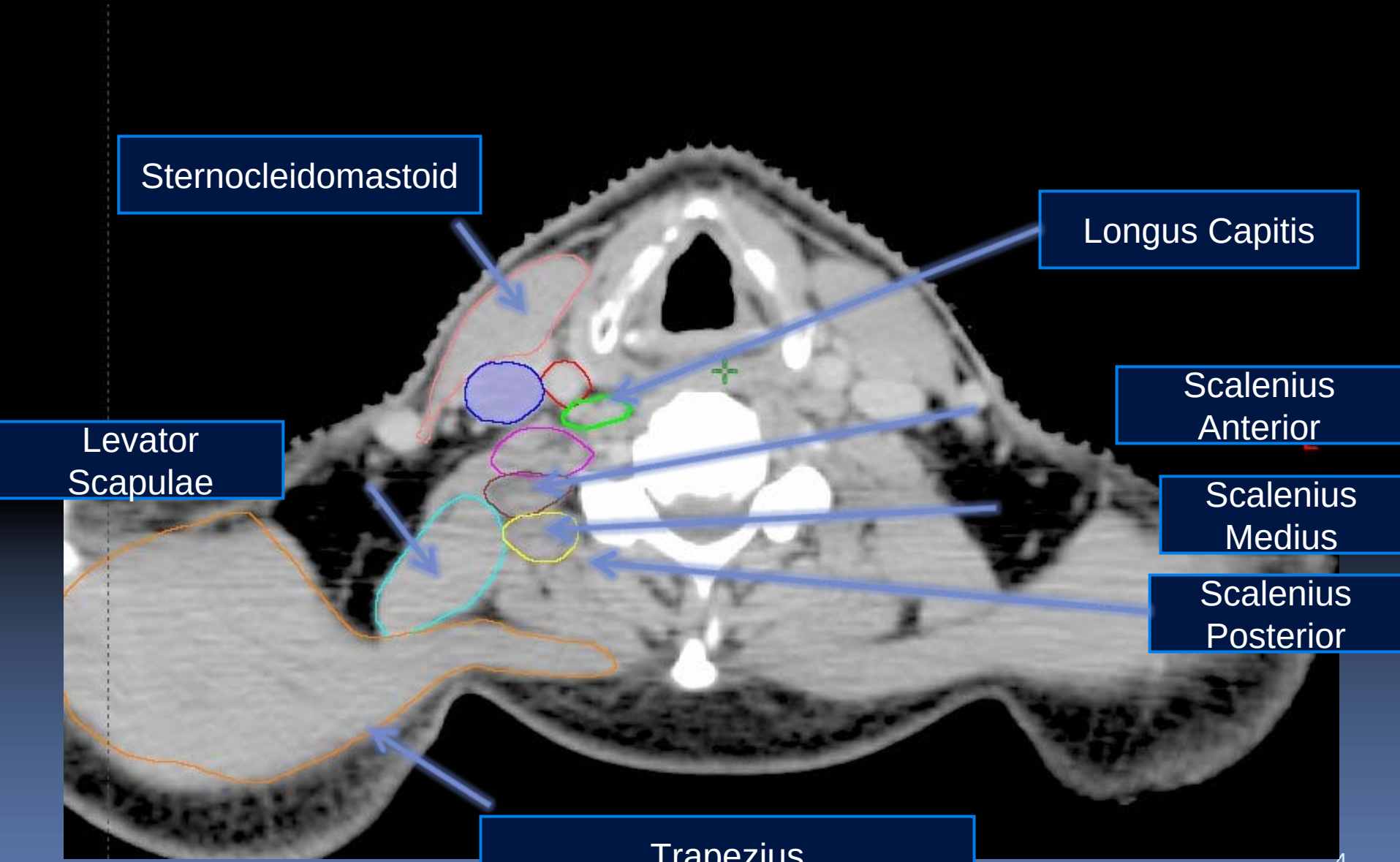
“In standard three field head & neck radiotherapy the first echelon nodes and retropharyngeal nodes are routinely treated when the primary tumour is targeted”

Eisbruch et al Semin in Rad Onco 12 (2002) 238-249

Axial Anatomy of the Neck



Axial Anatomy of the Neck



Neck Node Levels – The History

- Lymphatic system investigated by Sappey (d1896), Poirer & Chirpy (1909) & Trotter (1930)
- Rouviere (1938) identified various lymph node groups
- TNM Classification
- Robbins Classification
- MSKCC – Classification of lymph nodes in “Levels”

Neck Node Levels – The History

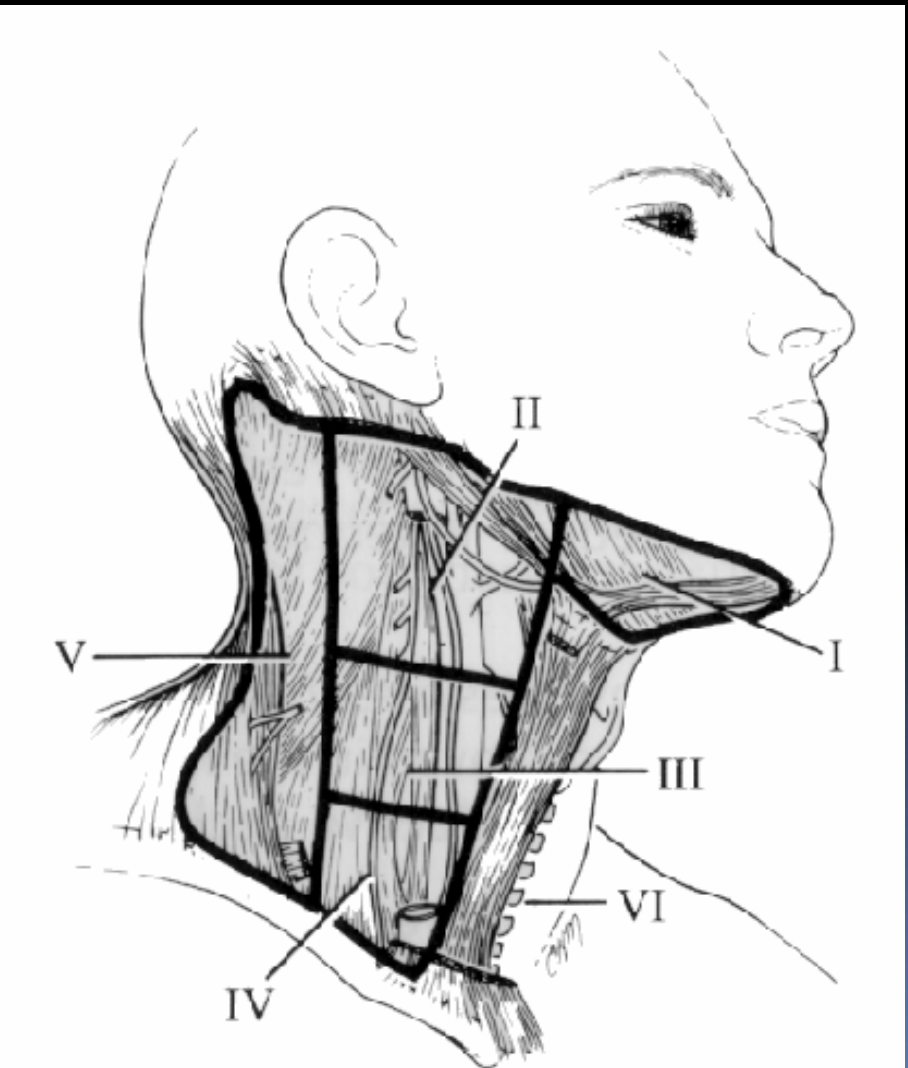
TNM Classifiation

Group	Terminology
1	Submental
2	Submandibular
3	Cranial Jugular
4	Middle Jugular
5	Caudal Jugular
6	Dorsal Cervical along SA
7	Supraclavicular
8	Pre laryngeal & retro
9	Retropharyngeal
10	Parotid
11	Buccal
12	Retroauricular & Occipital

Robbins Classification

Level	Terminology
IA	Submental
IB	Submandibular
II	Upper Jugular
III	Middle Jugular
IV	Lower Jugular
V	Posterior Triangle
V	Posterior Triangle
VI	Anterior Compartment
	-
	-
	-
	-

Neck Node Levels – Robbins Classification



- **Primarily for Surgeons**
- **Requires the identification of surgical landmarks viz stylohyoid m., ant belly of digastric m., spinal accessory nerve**
- **Does not include the levels which are not addressed in neck dissection i.e. retropharyngeal nodes .**
- **Classifies neck dissections (2001)**
  - **Radical Neck Dissection**
  - **Modefied Neck Dissection**
  - **Selective Neck Dissection**
  - **Extended Neck Dissection**

Robbins Arch Otolaryngol Head Neck Surg. 117 (1991) 601-605.

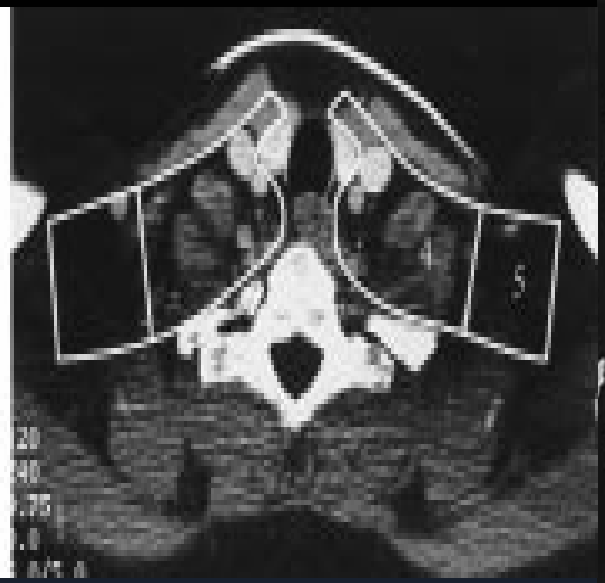
Neck Node Levels – The History

- " CT & MRI have offered progressively more refined anatomical precision, reproducibility & visualization of deep clinically inaccessible structures" Som et al 1999

- Provided Imaging Based Nodal Classification.
- Identified important landmarks for imaging based nodal levels
  - Back of submandibular gland
  - Back of sternocleidomastoid muscle
  - Anterior edge of the trapezius
  - Clavicle
  - Carotid arteries
- Laid the ground rules for deciding neck node level in case of an overlap.

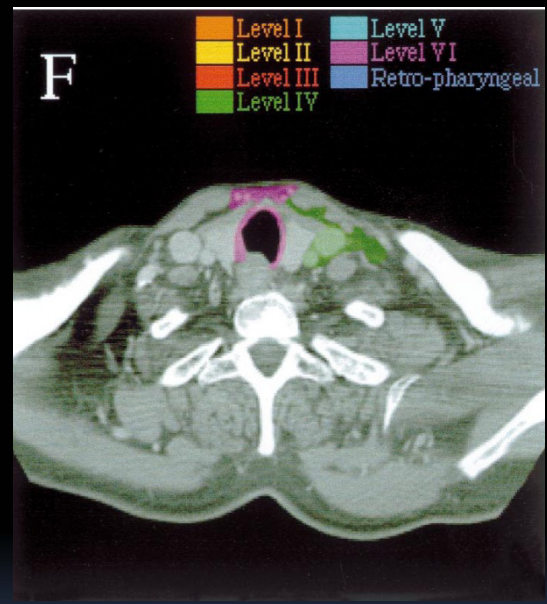
Som Arch Otolaryngol Head Neck Surg. 125 (1999) 388-398

Neck Node Levels – Guidelines for the Radiation Oncologist



Rotterdam - Wijers et al

Nowak et al



Brussels – Gregoire et al

Wijers et al R&O52 (1999) 35±42
Nowak et al IJROBP 45,(1999) 33–39
Gregoire et al, R&O56 (2000) 135±150

Current Guidelines – The GORTEC ESTRO RTOG Consensus Guidelines

ELSEVIER

Radiotherapy and Oncology 69 (2003) 227–236

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

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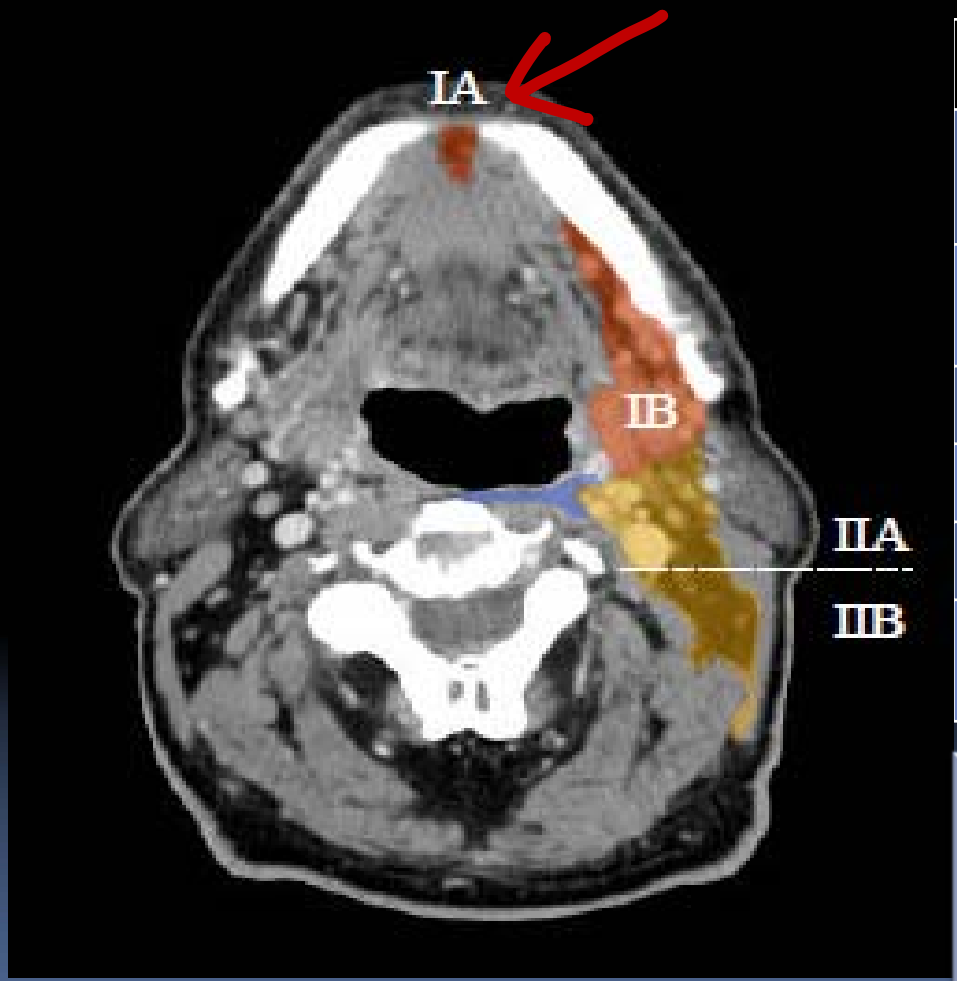
RTOG Guidelines – Level I A



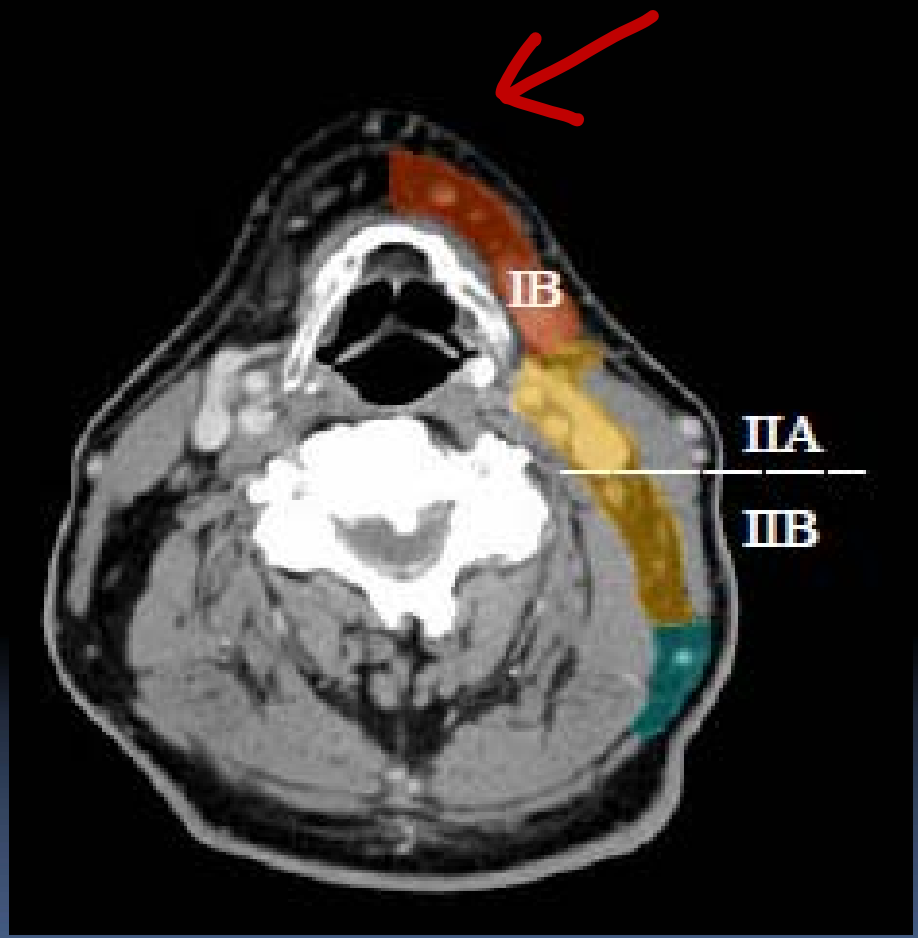
Cranial Boundary

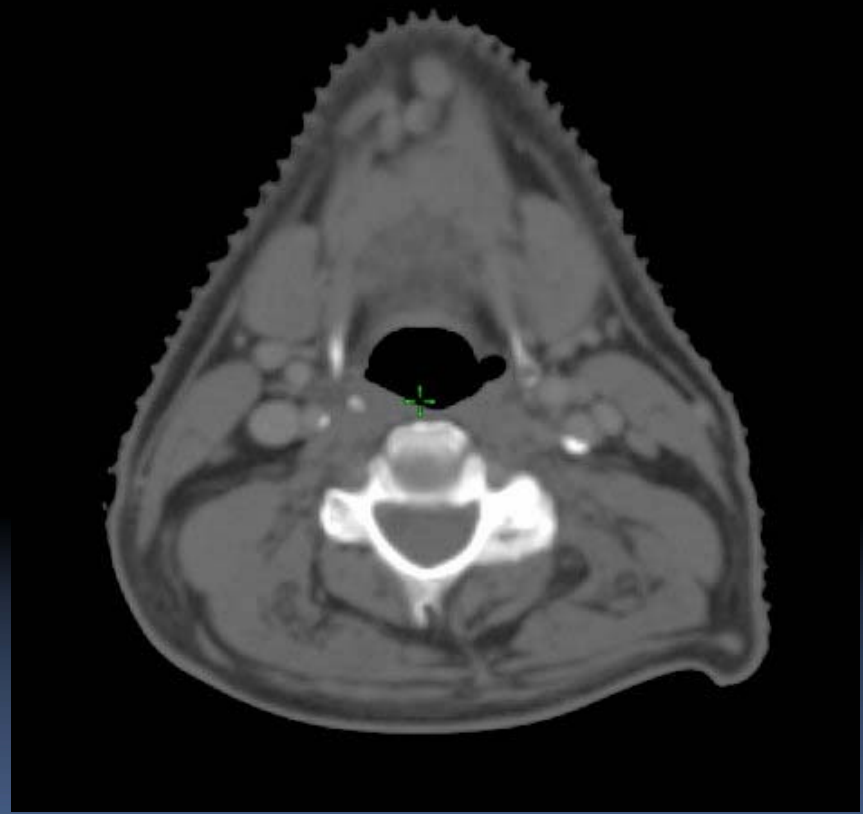
	Anatomical Boundary
Cranial	Genihyoid m. Plane tangent to basilar edge mandible
Caudal	Plane tangent to body of hyoid bone
Anterior	Symphysis menti, platysma
Posterio	Body of hyoid
Medial	NA
Lateral	Medial edge of anterior belly digastric m.

Involved in cancer of anterior tongue, floor of mouth, lower lip, anterior alveolar ridge

Gregoire et al R & O 69 (2003) 227–236
www.rtog.org

RTOG Guidelines – Level I A

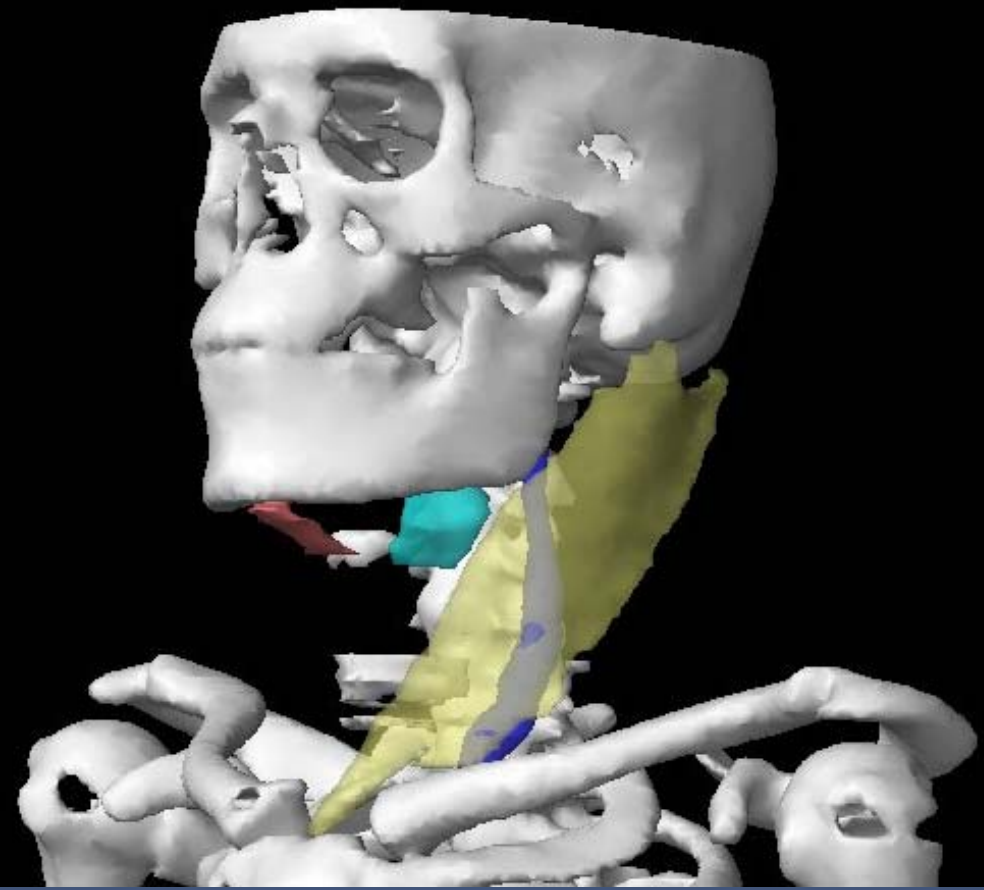


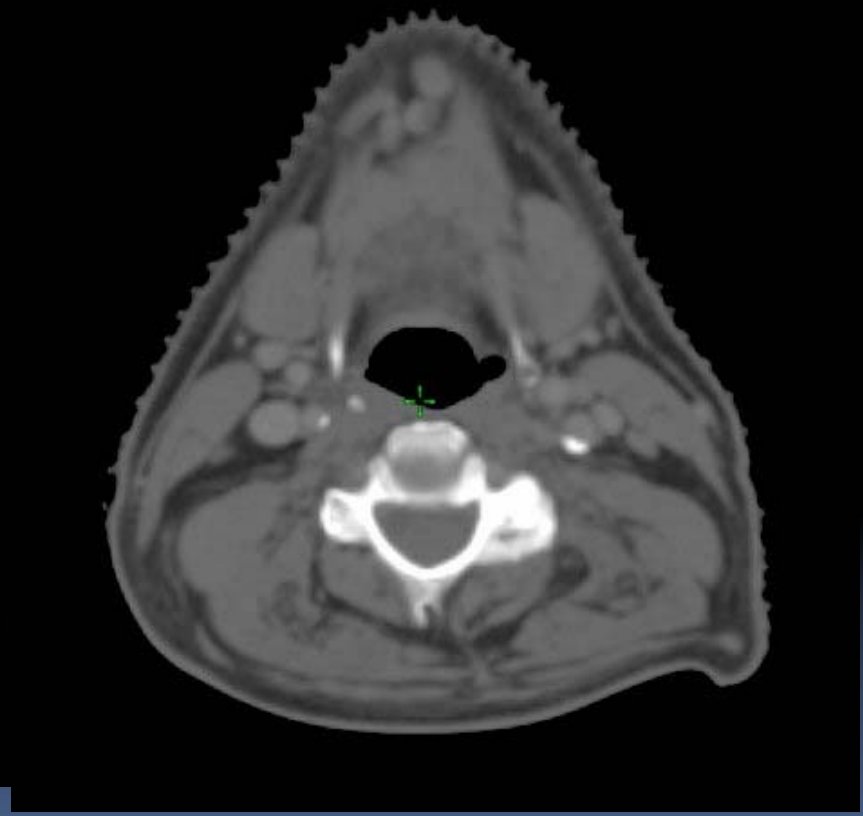


Caudal Boundary

Gregoire et al R & O 69 (2003) 227–236

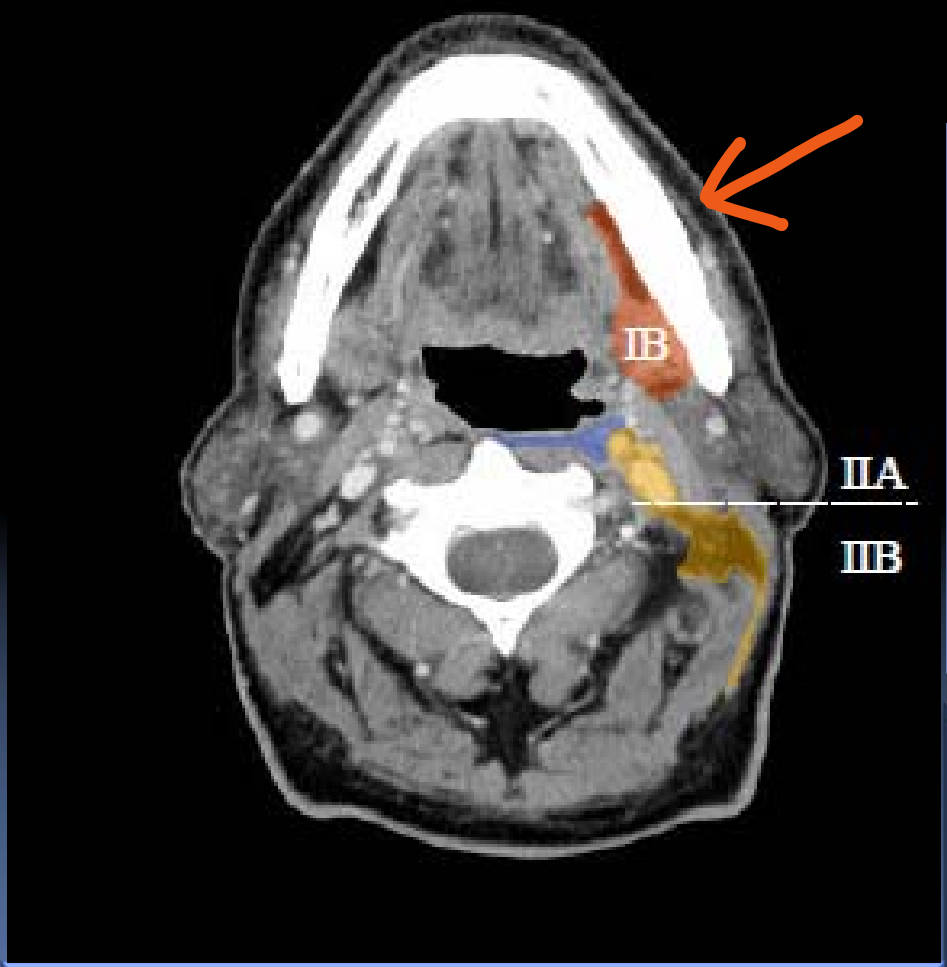
RTOG Guidelines – Level I A





Gregoire et al R & O 69 (2003) 227–236

RTOG Guidelines – Level I B

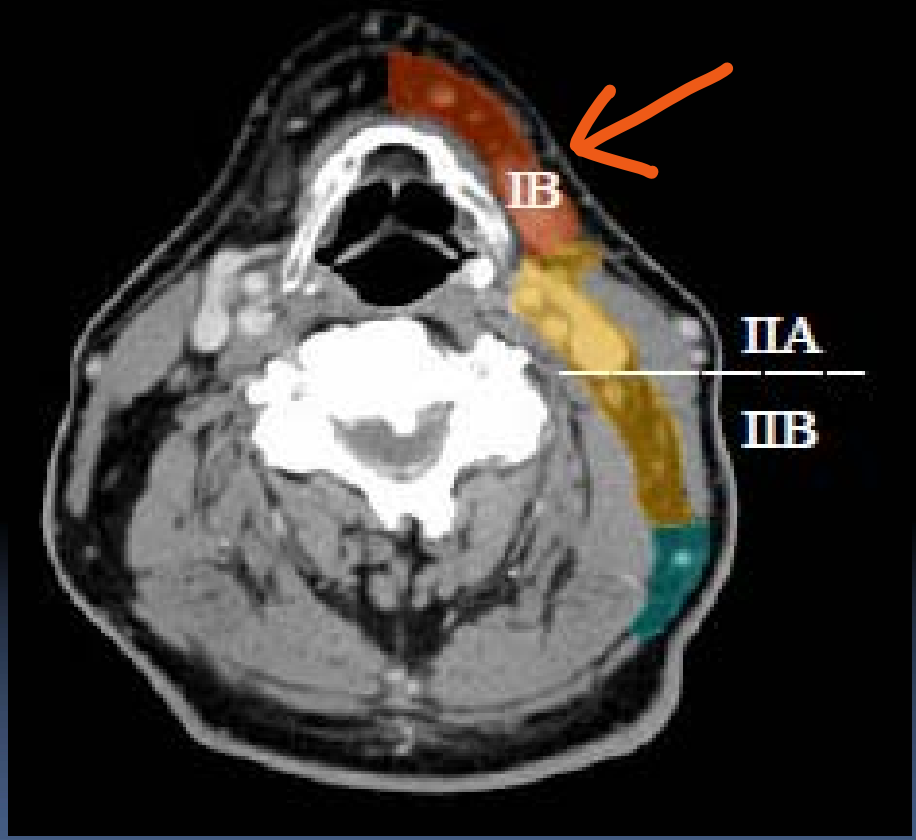


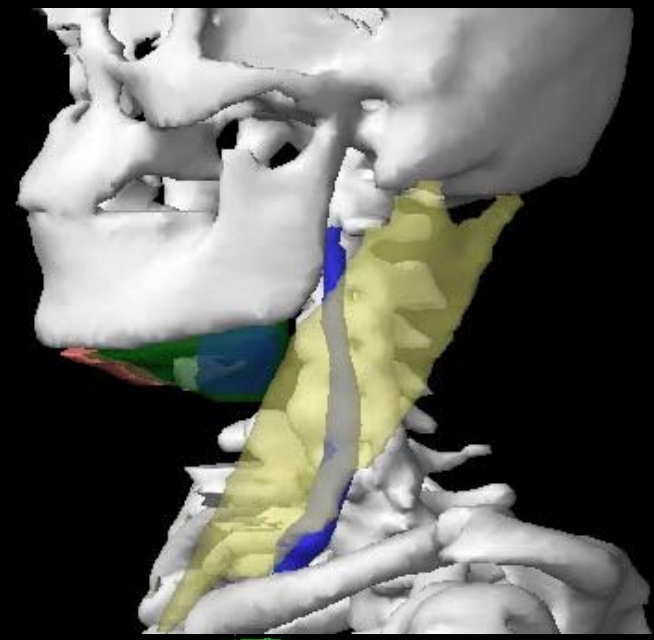
Cranial Boundary

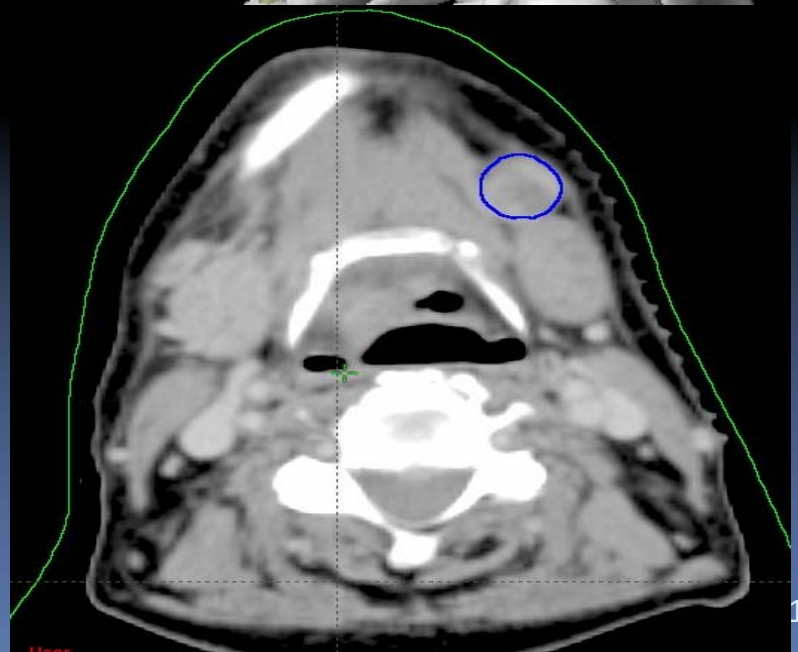
	Anatomical Boundary
Cranial	Mylohyoid m. Cranial edge of submandibular gland
Caudal	Plane through central part of body of hyoid bone
Anterior	Symphysis menti, platysma
Posterior	Posterior edge of sub mandibular gland
Medial	Lat edge of ant belly digastric muscle
Lateral	Basilar edge/inner side of mandible, platysma skin

Receives lymphatics from sub mental lymph nodes , medial canthus, palate, alveolus, buccal mucosa, upper & lower lip and anterior tongue.

RTOG Guidelines – Level I B

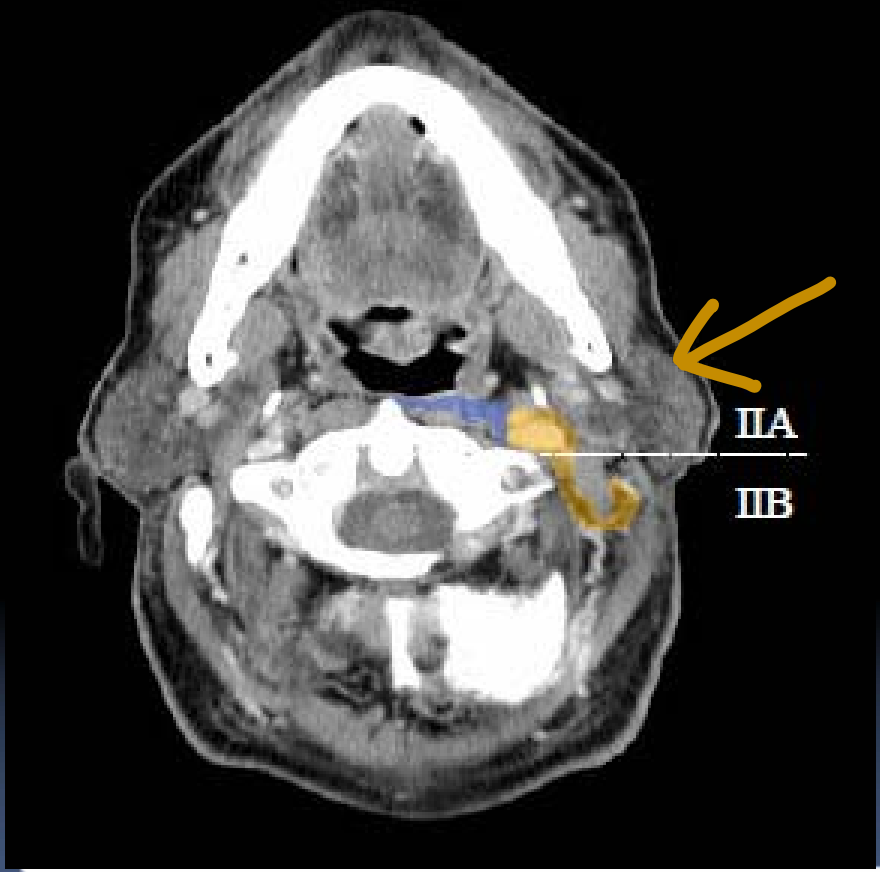






Caudal Boundary

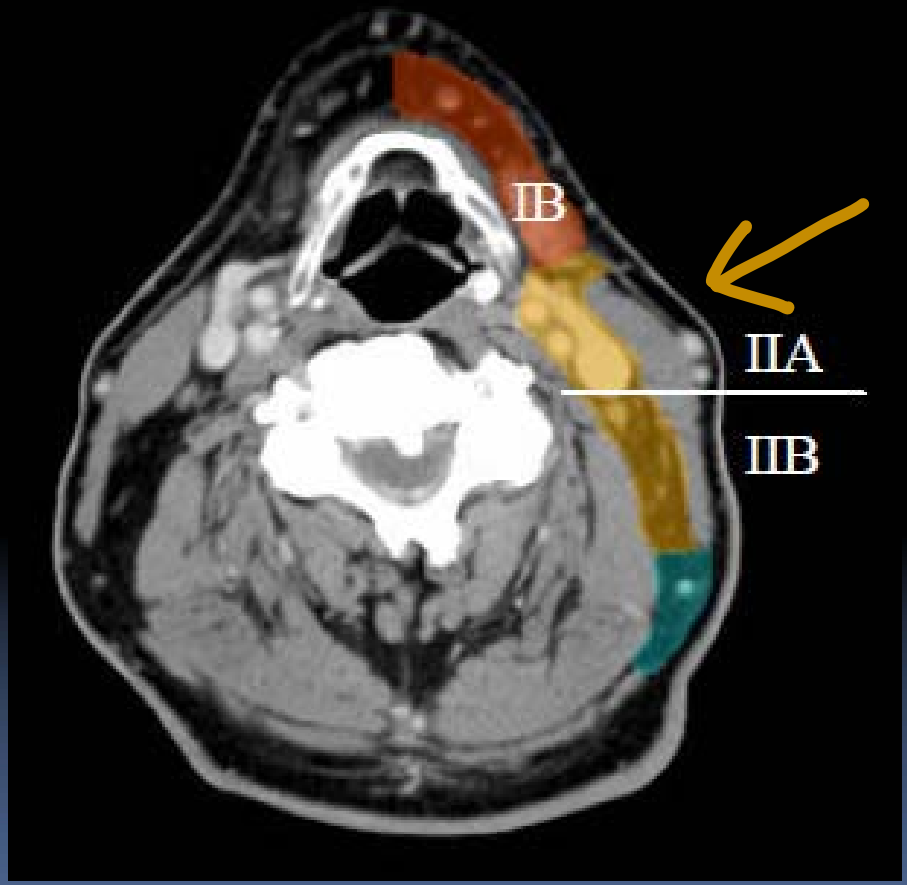
RTOG Guidelines – Level II A & B



Cranial Boundary

	Anatomical Boundary
Cranial	Caudal edge of lateral process of C1
Caudal	Caudal edge of the body of hyoid bone
Anterior	Post. edge of sub-mandibular gland, ant. edge of int. carotid artery, post. edge of post. belly of digastric m.
Posterior	Post. border of the sternocleidomastoid m
Medial	Medial edge of int. carotid artery, paraspinal (levator scapulae) m.
Lateral	Medial edge of sternocleidomastoid

RTOG Guidelines – Level II A & B

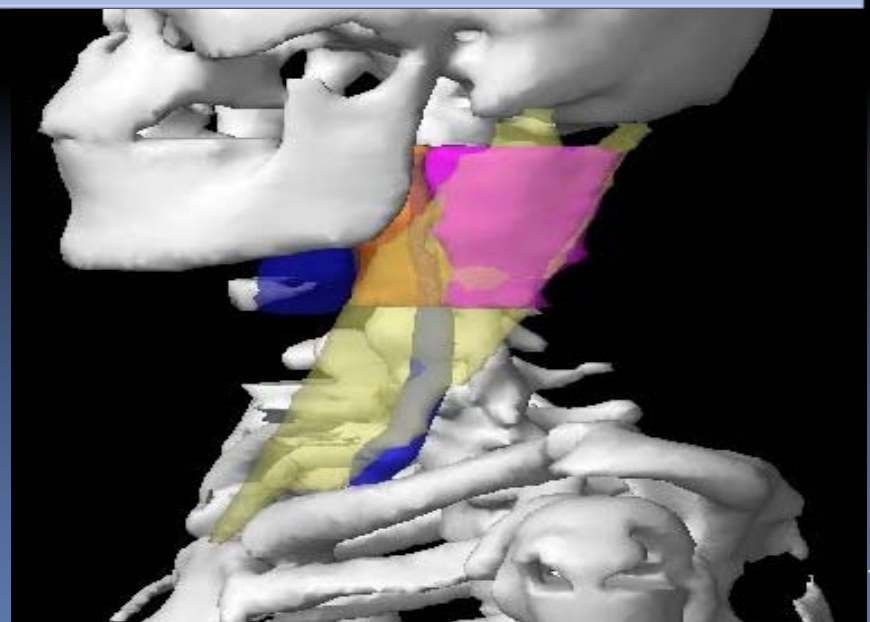


Caudal Boundary

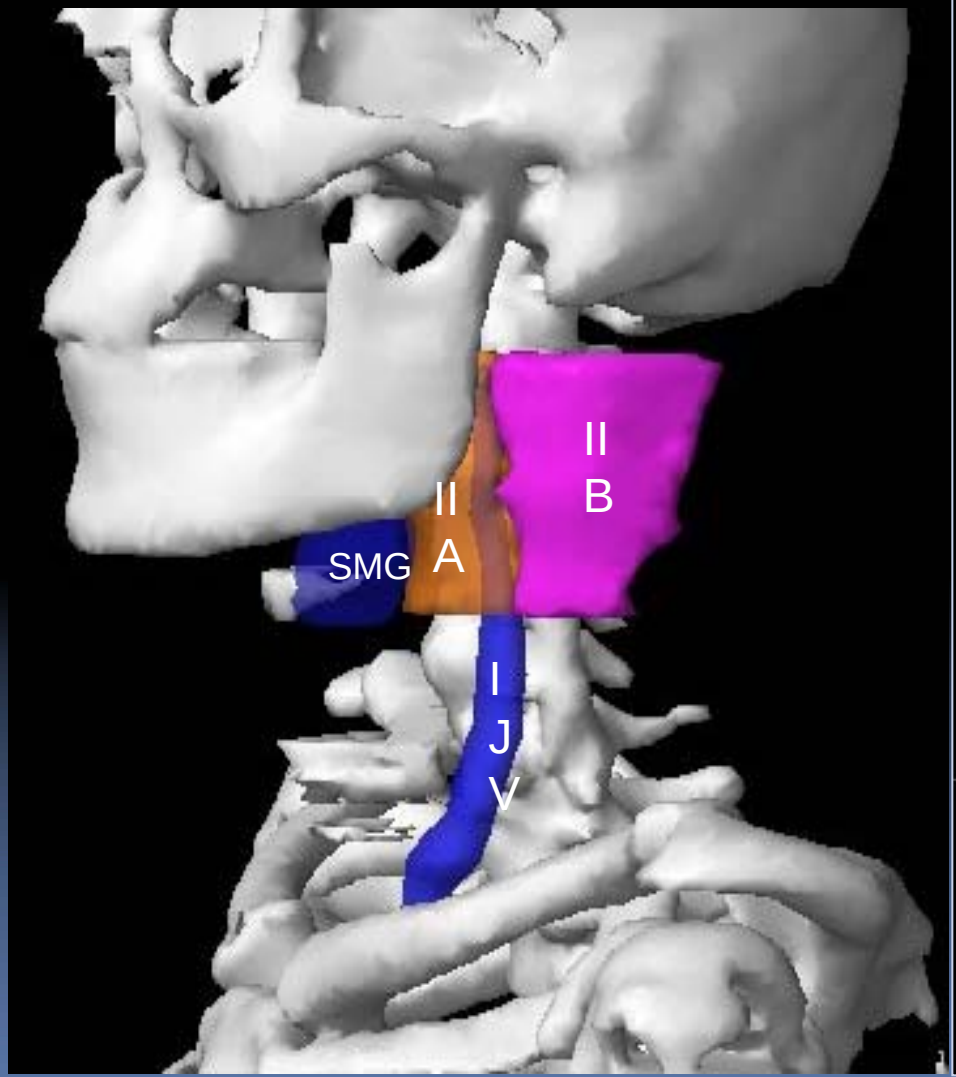
First echelon nodes for many sites.

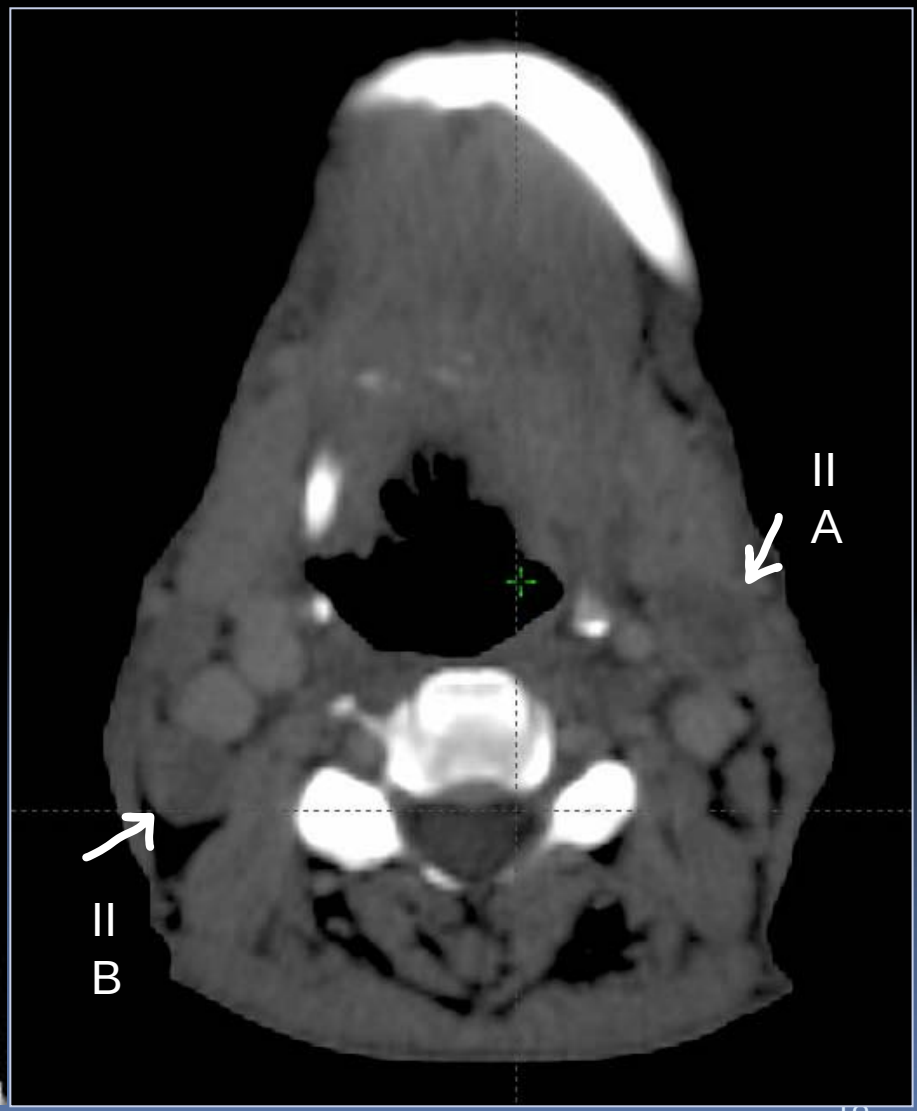
May be involved in cancers of nasopharynx, oral cavity, oropharynx, hypopharynx, larynx salivary glands, nasal cavity & middle ear.

Cancers of larynx, hypopharynx and oral cavity mainly involve Level II A



RTOG Guidelines – Level II A & B





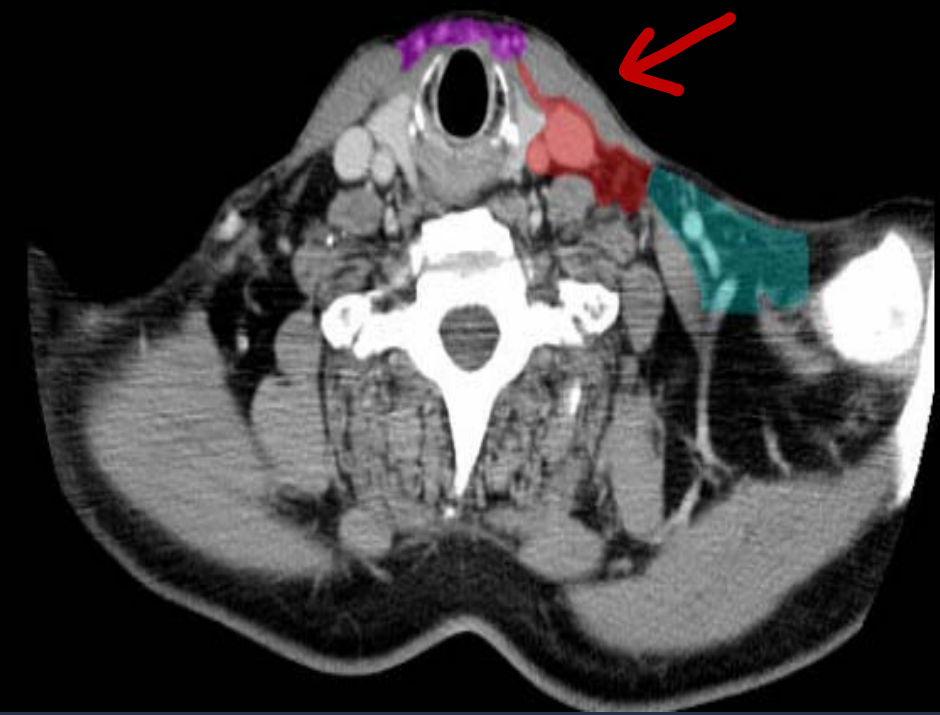
RTOG Guidelines – Level III

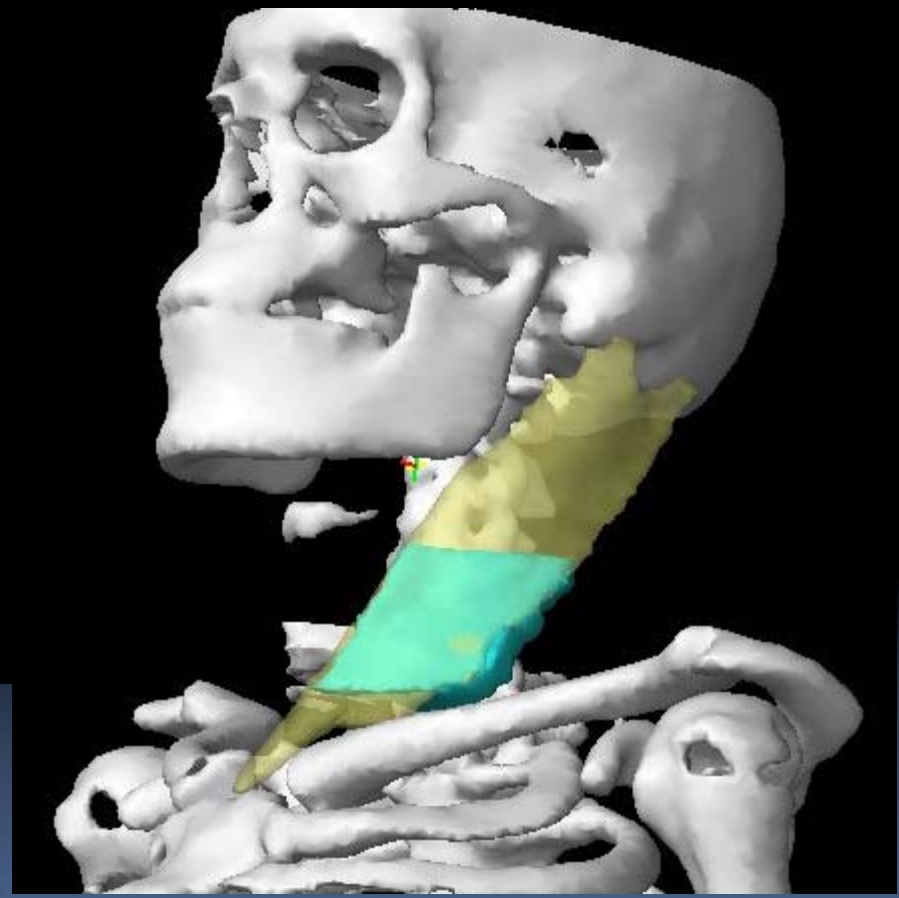
Cranial Boundary

	Anatomical Boundary
Cranial	Caudal edge of the body of hyoid bone
Caudal	Caudal edge of cricoid cartilage
Anterior	Postero-lateral edge of the sternohyoid m.; ant. edge of sternocleidomastoid m.
Posterior	Post. border of the sternocleidomastoid m
Medial	Edge of internal carotid artery, Paraspinal (scalenius) m.
Lateral	Medial edge of sternocleidomastoid

Efferent lymphatics from levels II, V, VI, RP Nodes
At risk in cancer of the oral cavity, oropharynx, hypopharynx, larynx and thyroid. .

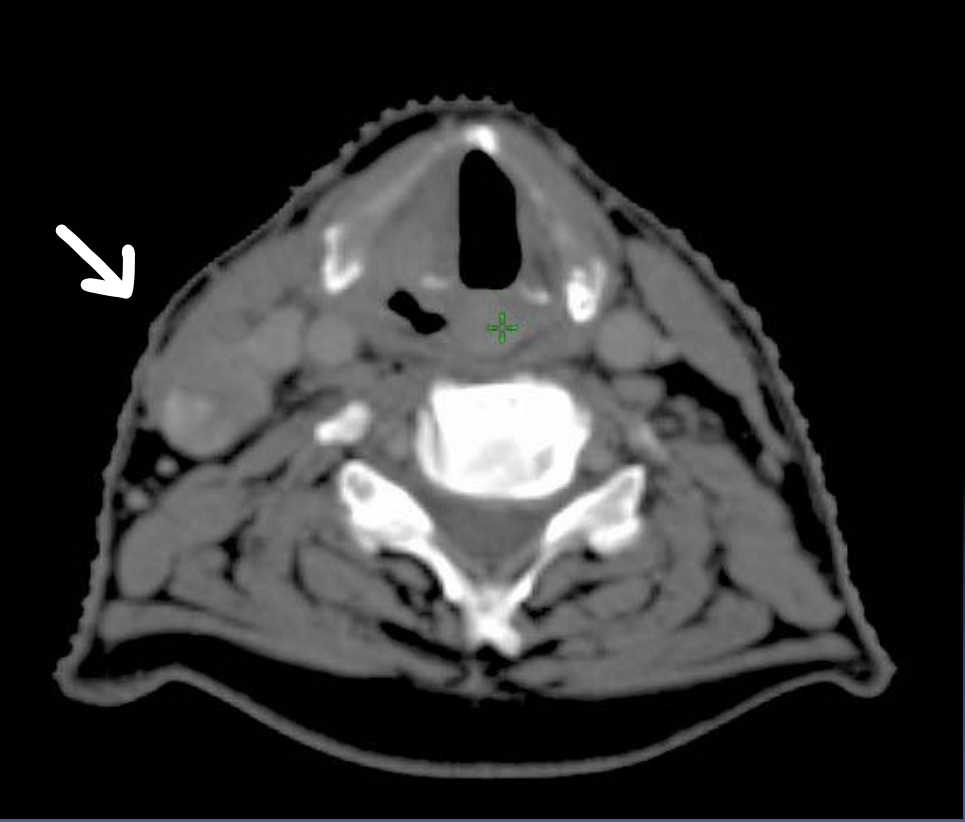
RTOG Guidelines – Level III



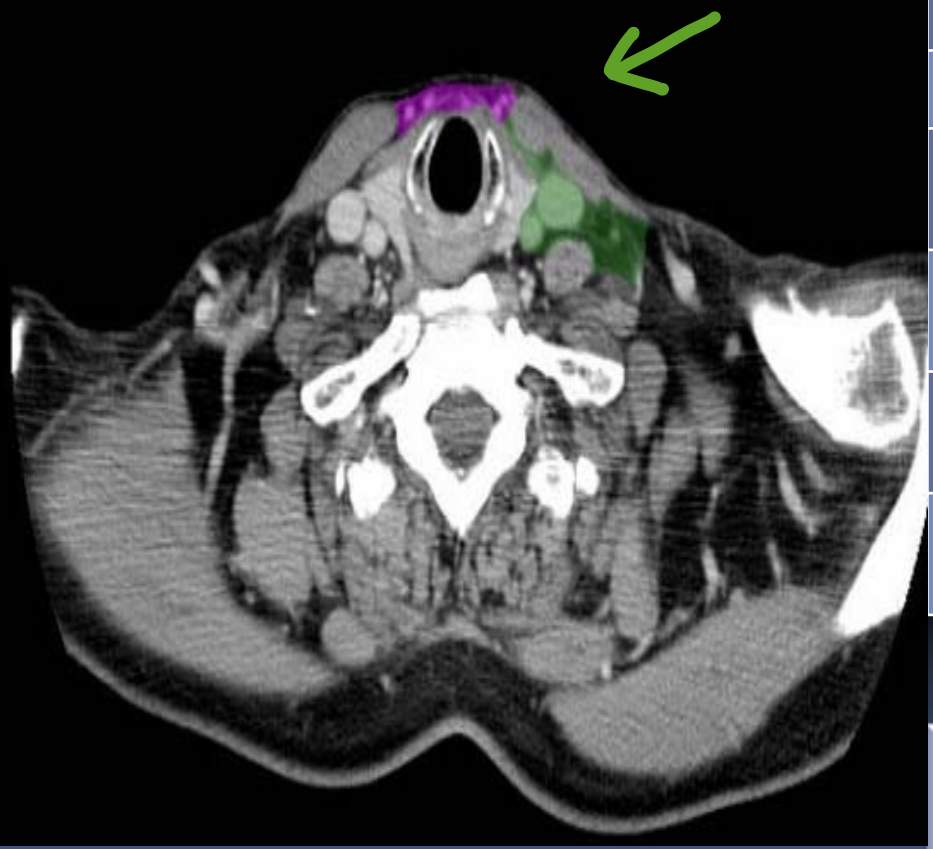


Caudal Boundary

RTOG Guidelines – Level III



RTOG Guidelines – Level IV



	Anatomical Boundary
Cranial	Caudal edge of cricoid cartilage
Caudal	2 cm cranial to sternoclavicular
Anterior	Anteromedial edge of sternocleidomastoid m.
Posterior	Post. border of the sternocleidomastoid m
Medial	Edge of internal carotid artery, paraspinal(scalenius) m.
Lateral	Medial edge of sternocleidomastoid

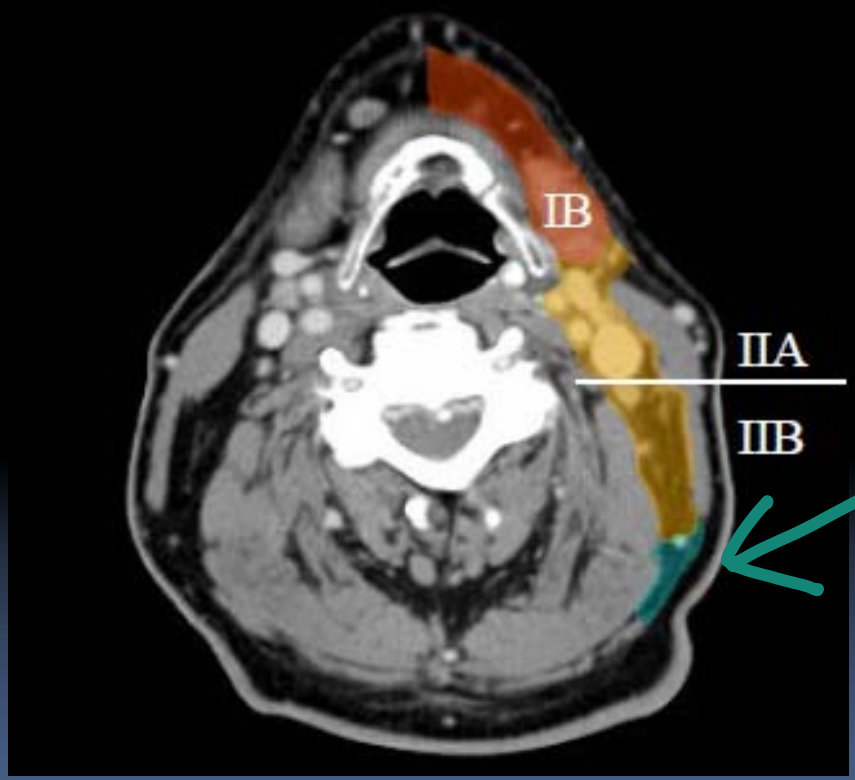
Cranial Boundary

Can harbour metastases from laryngeal, hypopharyngeal, cervical oesophageal and thyroid cancers. Receives lymph from Level III, V , VI & RP

RTOG Guidelines – Level IV

Caudal Boundary

RTOG Guidelines – Level V

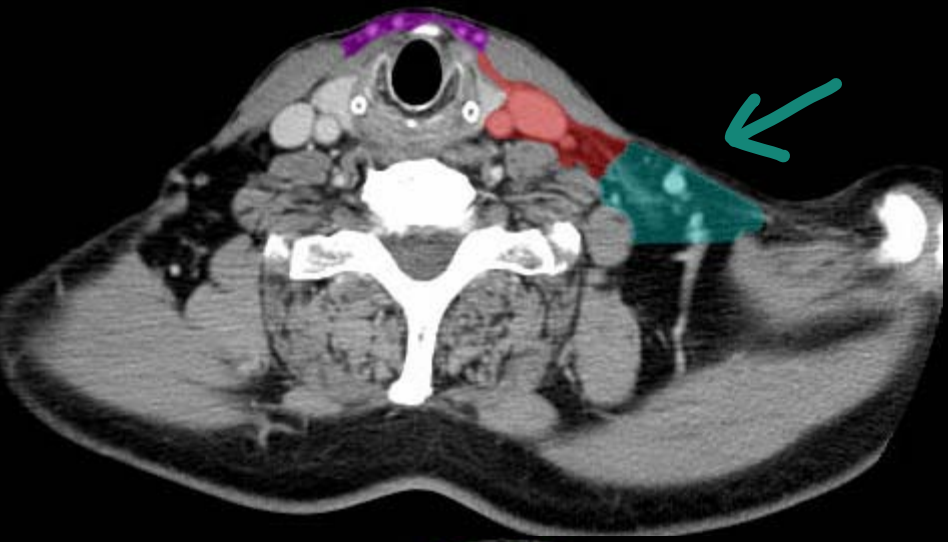


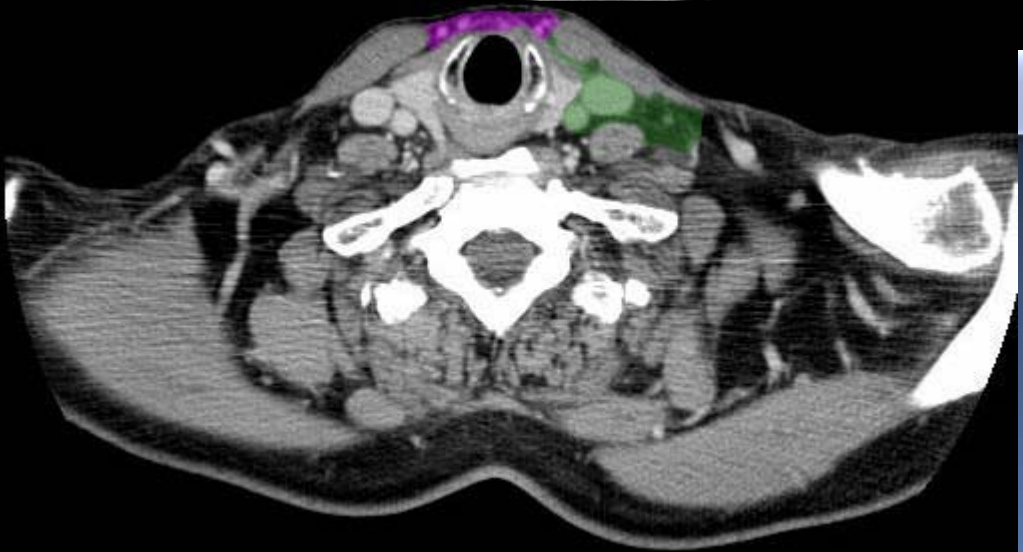
	Anatomical Boundary
Cranial	Cranial edge of body of hyoid bone
Caudal	CT slice encompassing the transverse cervical vessels
Anterior	Post. edge of the sternocleidomastoid m.
Posterior	Ant-lateral border of the trapezius m.
Medial	Paraspinal (levator scapulae, splenius capitis) m.
Lateral	Platysma m., skin

Cranial Boundary

At risk in cancers of the nasopharynx, oropharynx, subglottic larynx, pyriform sinus, cervical oesophagus, thyroid

RTOG Guidelines – Level V

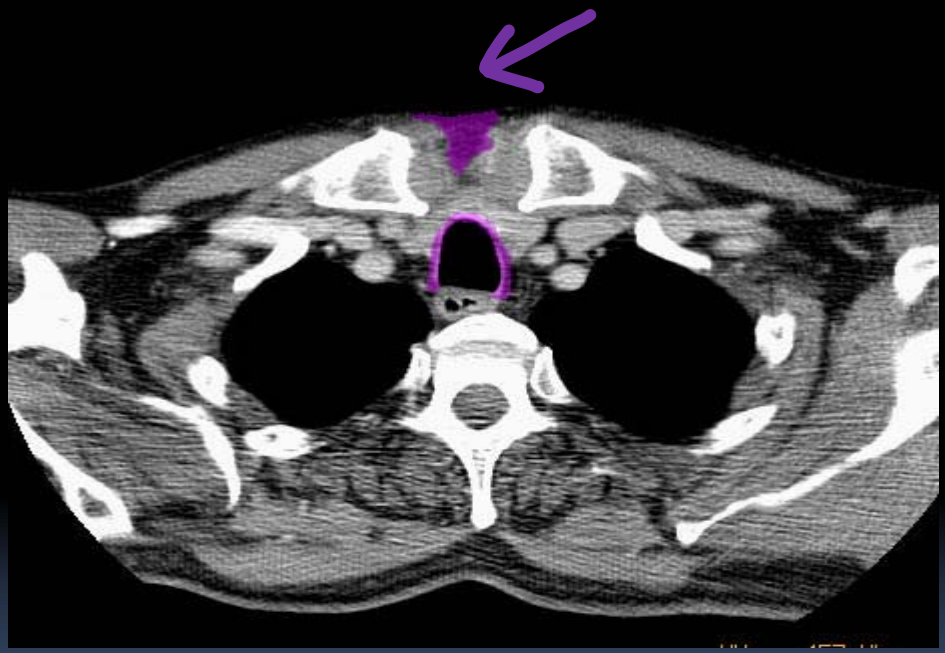




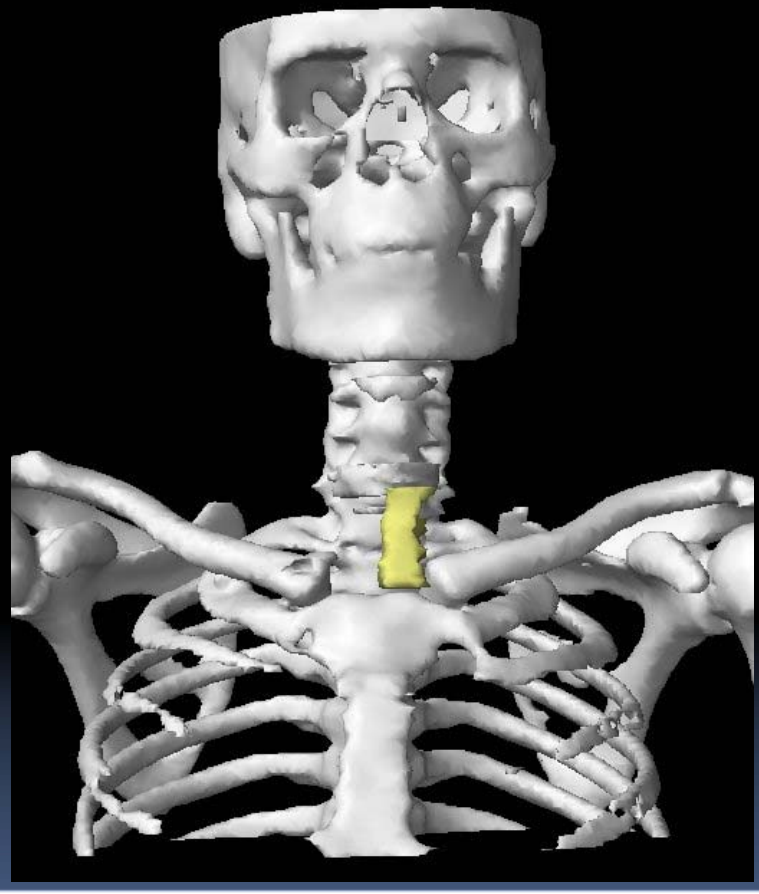
Caudal Boundary

For Nasopharyngeal cancer, the entire fossa from clavicle to the trapezius i.e.,the Ho's triangle is treated

RTOG Guidelines – Level VI



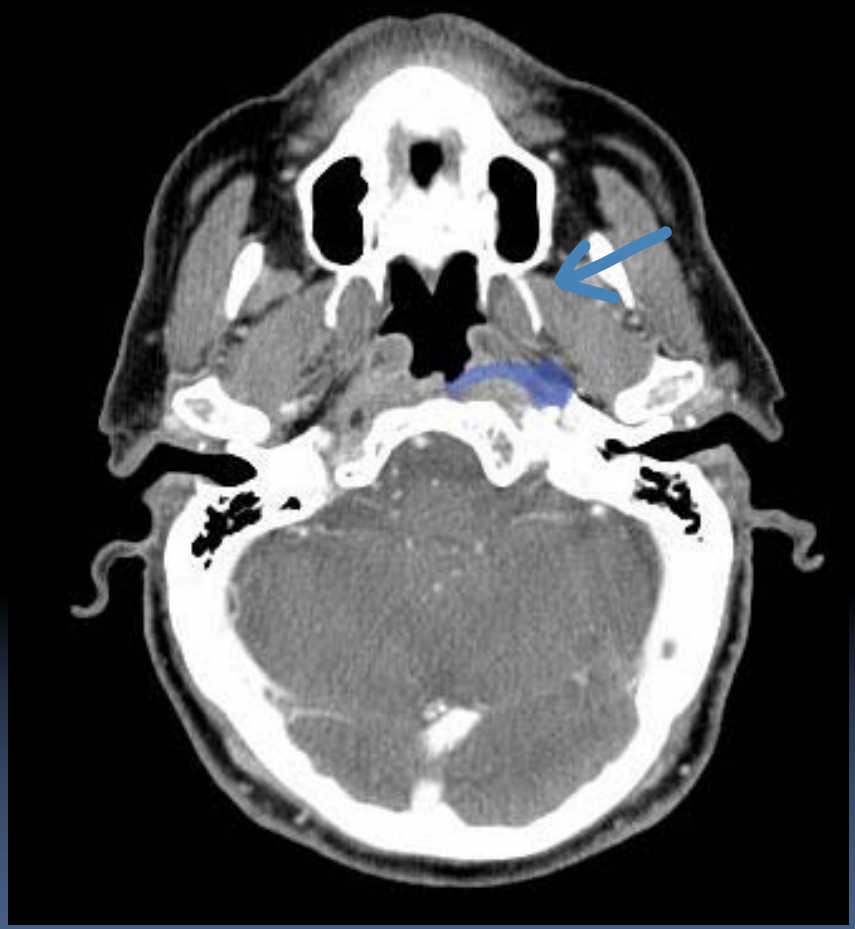
Caudal Boundary



Extends from caudal edge of thyroid cartilage to manubrium sterni, limited anteriorly by skin & platysma and posteriorly by separation b/w trachea & oesophagus.

Laterally, limited by the medial edge of the thyroid gland and the anteromedial edge of the sternocleidomastoid.

RTOG Guidelines-Retropharyngeal Nodes



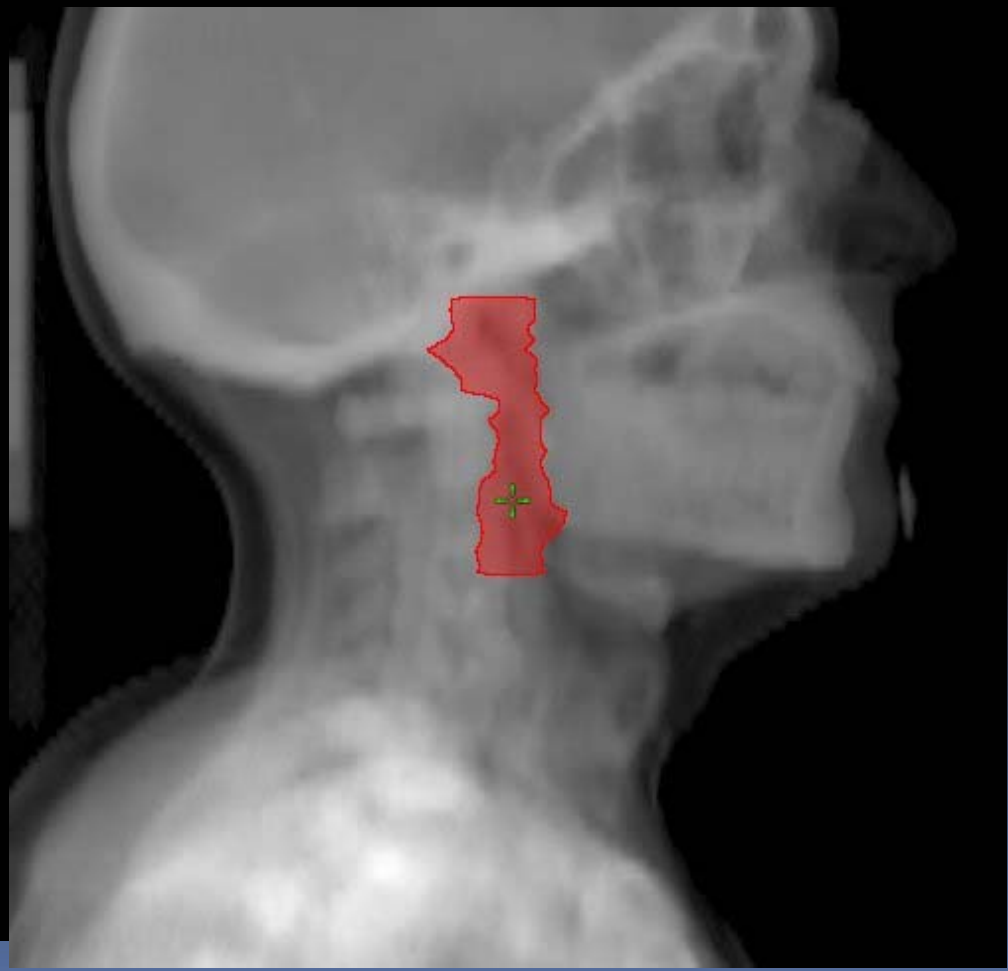
Cranial Boundary

	Anatomical Boundary
Cranial	Base of skull
Caudal	Cranial edge of the body of hyoid bone
Anterior	Fascia under the pharyngeal mucosa
Posterior	Prevertebral m. (longus colli, longus capitis)
Medial	Midline
Lateral	Medial edge of the internal carotid artery

At risk in cancers of the nasopharynx, posterior pharyngeal wall, palate and when nodal involvement present in other cancers.

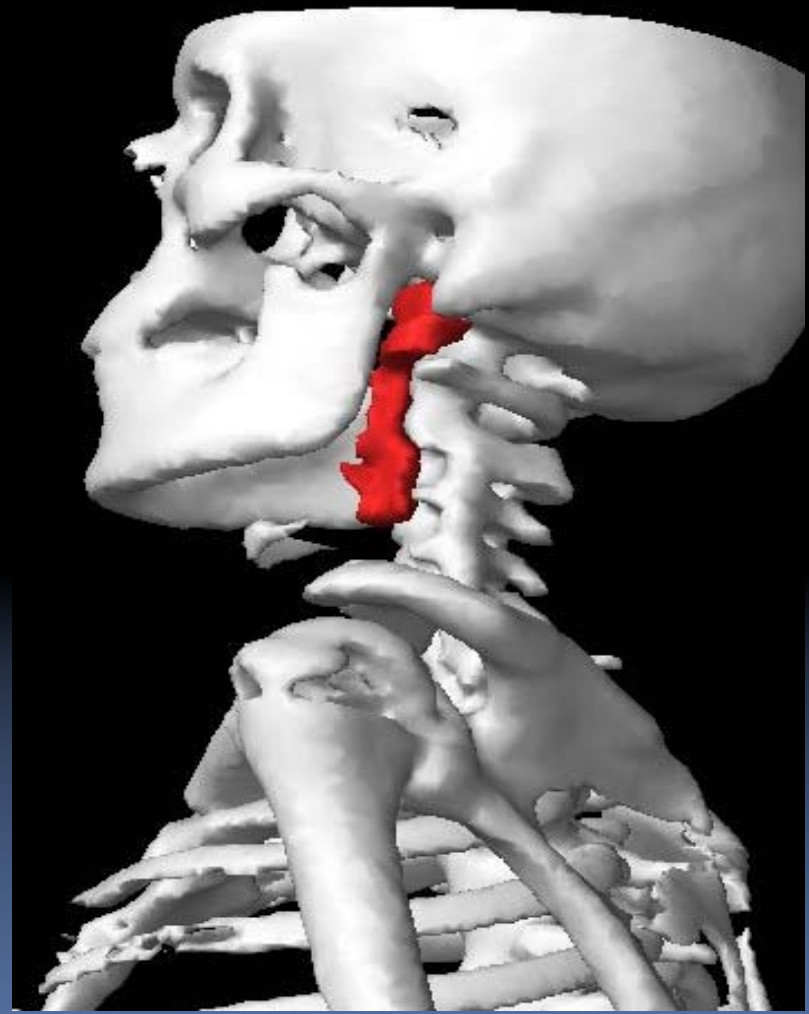
In future possibly only lateral RPNodes will be treated

RTOG Guidelines – Retropharyngeal Nodes



Caudal Boundary

RTOG Guidelines – Retropharyngeal Nodes



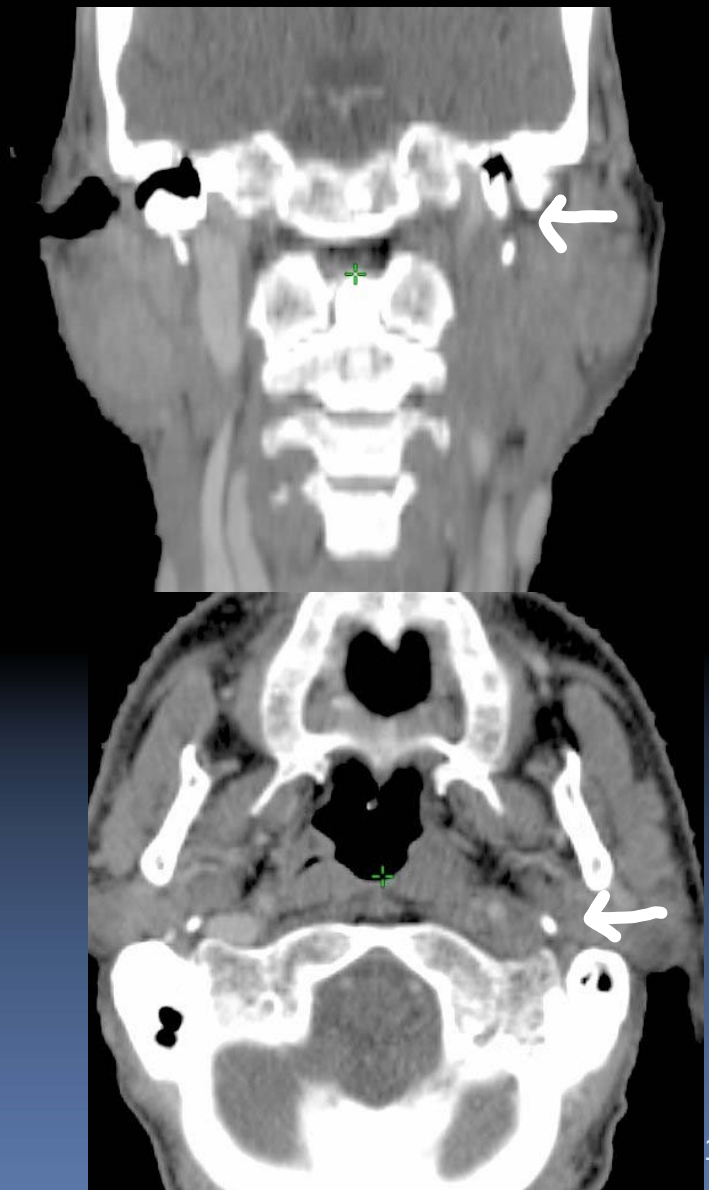
The Node Positive Neck

- What is a positive neck node (Consensus at the 43rd meeting of ASTRO, San Fransisco,2001)
  - >1 cm in size (1.5 cm if jugulodigastric)
  - Shape spherical rather than ellipsoidal
  - Necrotic center, irrespective of size
  - Cluster of 3 or more borderline nodes
- Batra Hospital Protocol: Delineate ALL clinically & radiologicaly apparent nodes, irrespective of above criteria.

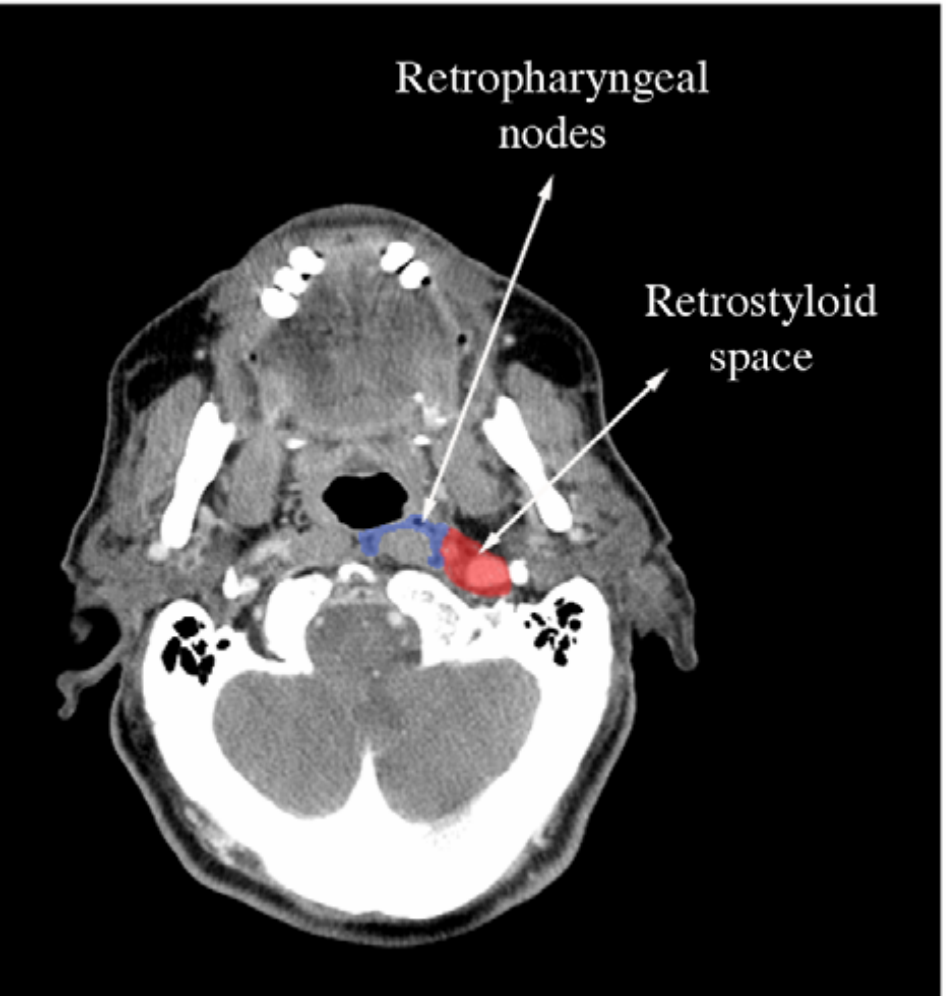
Eisbruch et al, Seminars in Rad Onco 12 238- 249

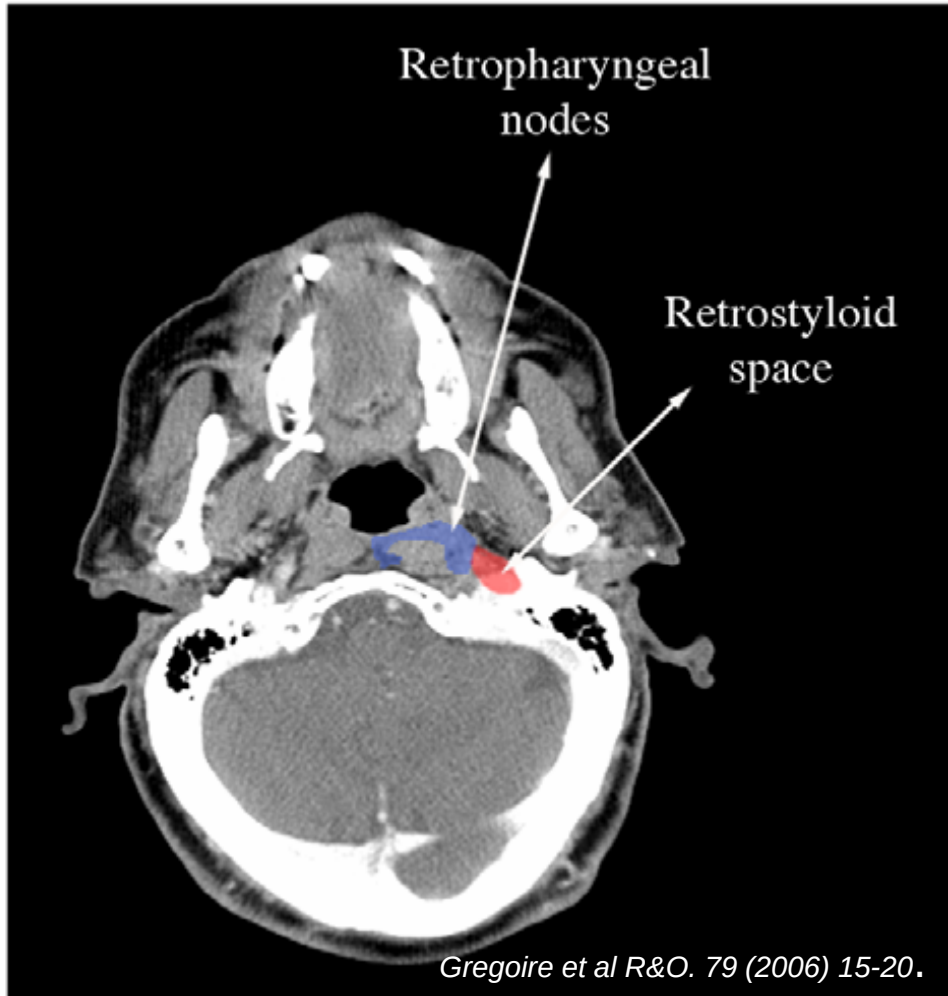
The Node Positive Neck – Special Issues

- **The boundaries of the levels change**
- **Distribution of involved but clinically negative nodes is different affecting the choice levels delineated.**
- **Extracapsular involvement needs to be taken into consideration**
- **Infiltration of non lymphatic structures**
- **Occasional venous thrombosis**



The Node Positive Neck – Impact on Boundaries of Nodal Levels II , IV, V and Supra Clavicular Fossa





Gregoire et al R&O. 79 (2006) 15-20.

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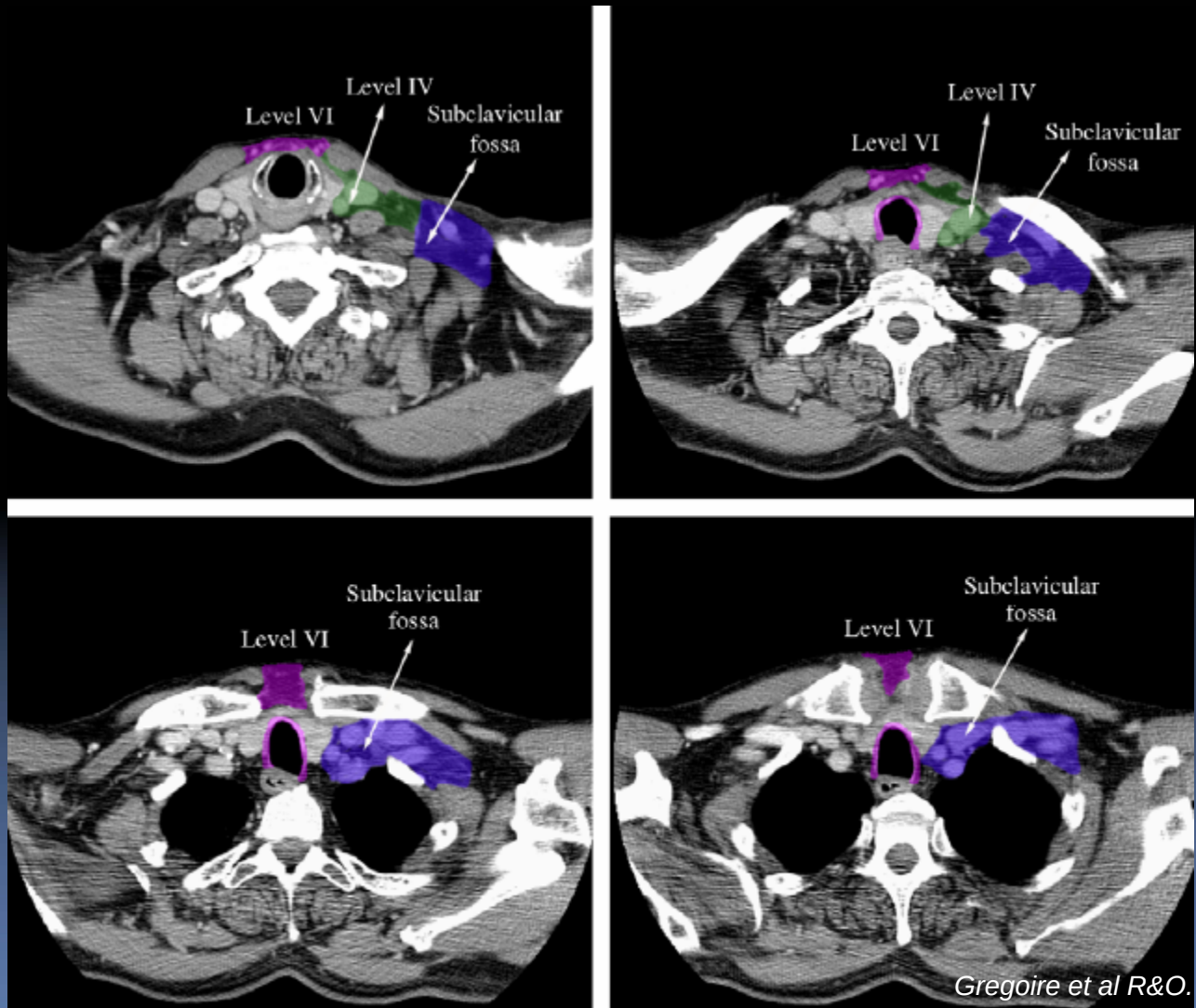

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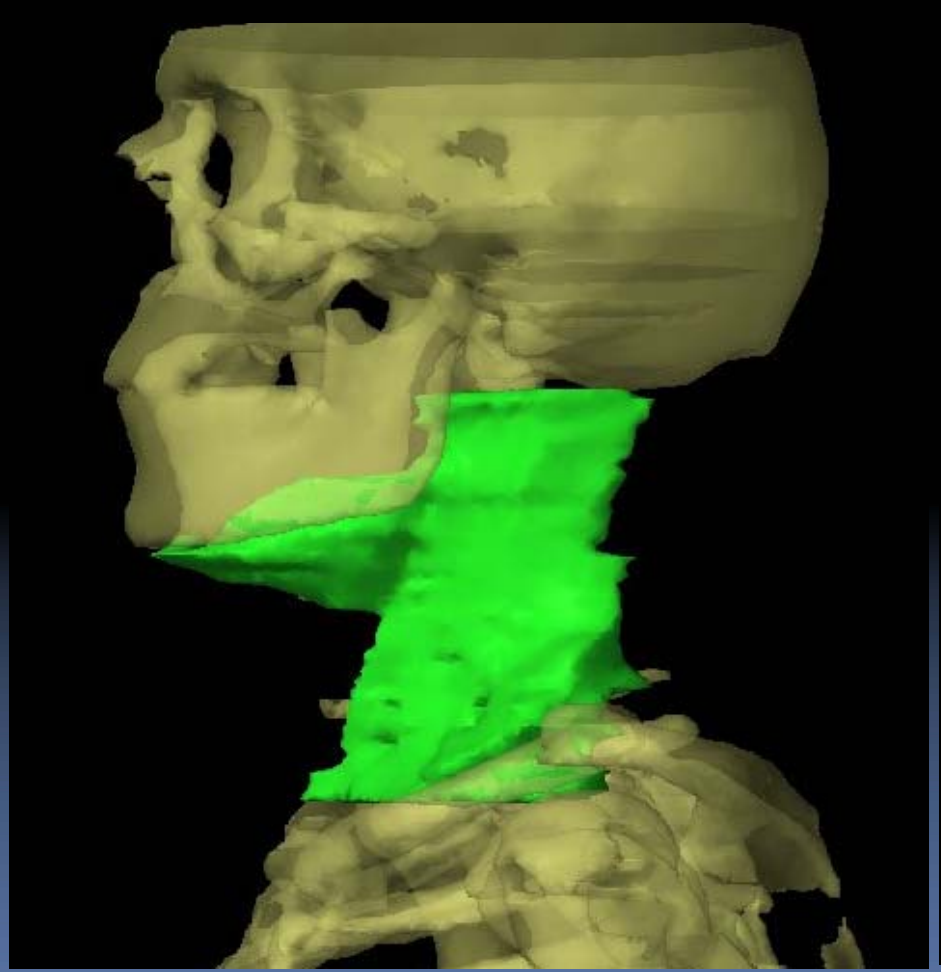
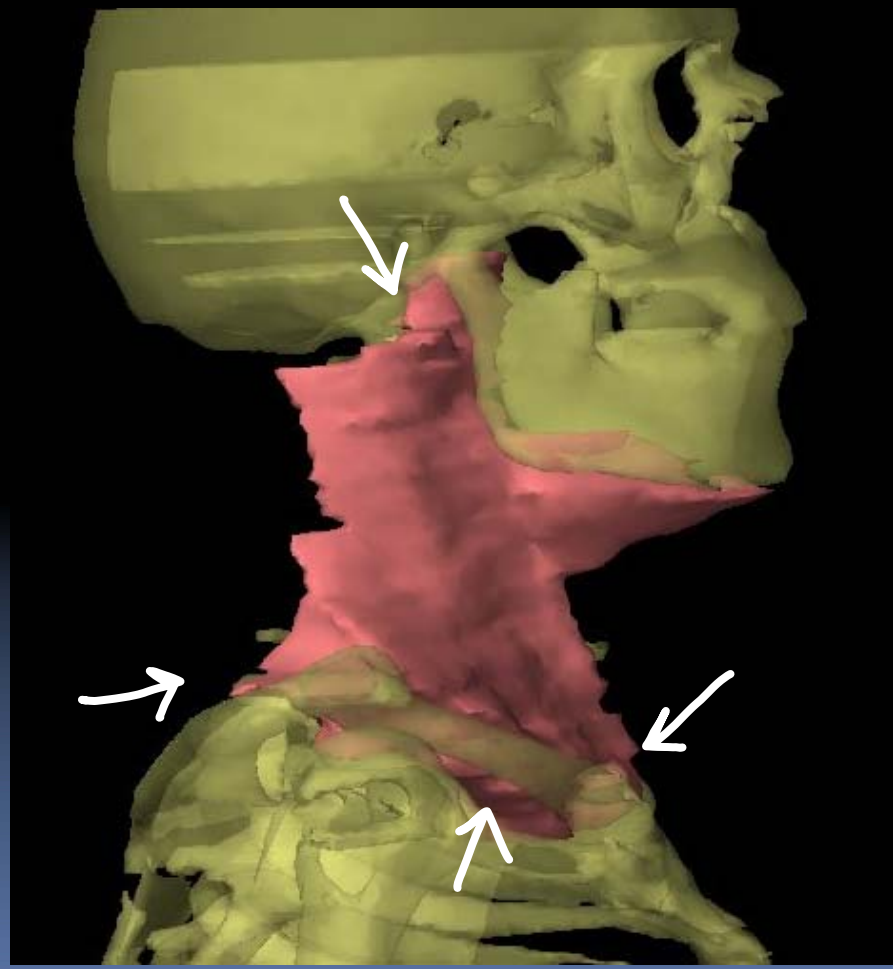




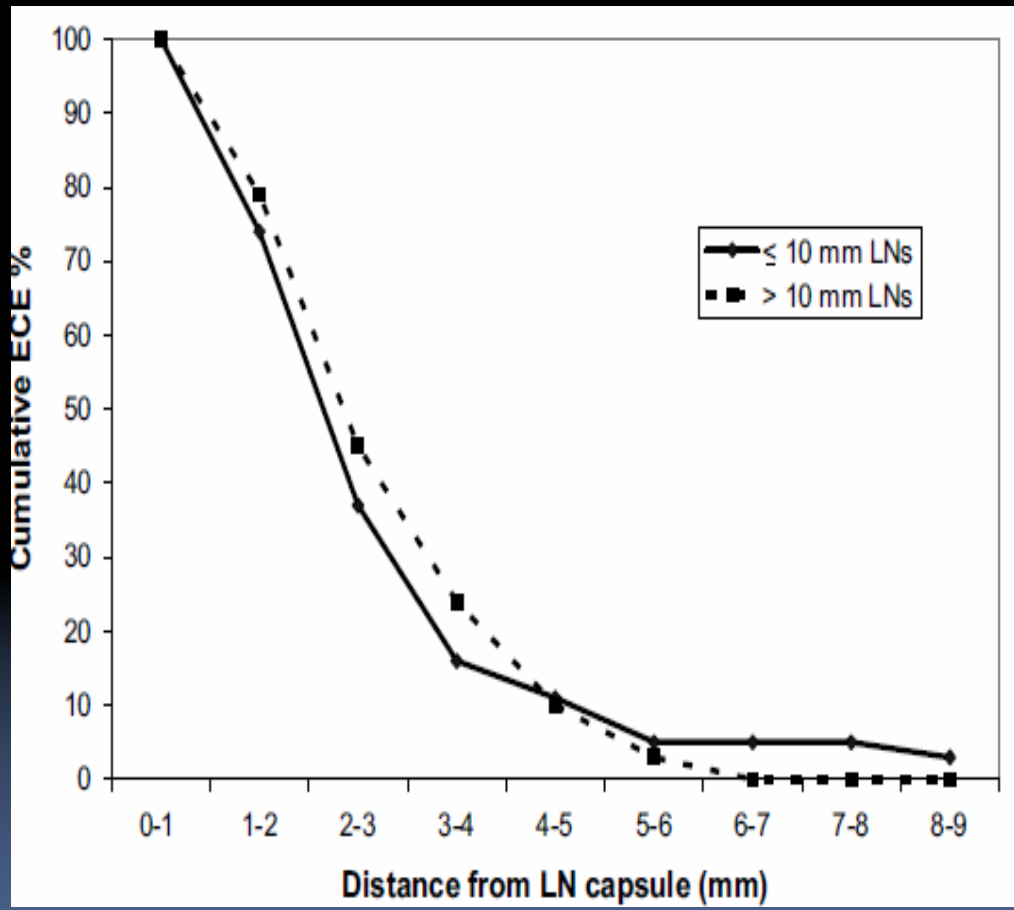
The Node Positive Neck – Choosing lymph node levels to be included

- The levels included change as the risk of > 5% involvement changes e.g.
- Oropharynx
  - N0: Level II to IV
  - N+: Level IB to V, RP
- Supraglottic Larynx
  - N0: Level II to VI
  - N+: Level II to VI , RP

The Node Positive Neck – Accounting for Extra Capsular Extension

Incidence of Extracapsular Extension of Metastatic Neck Node by Size

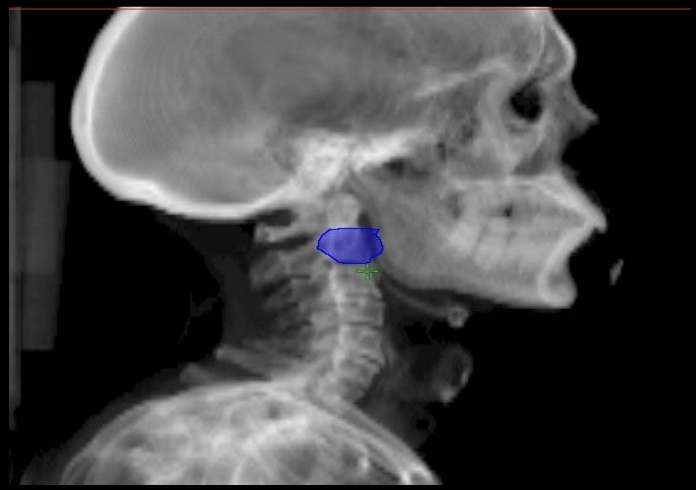
Nodal size	<1cm	1-3cm	>3cm
Annyas 1979	23%	53%	74%
Johnson 1981	-	65%	75%
Carter 1987	17%	83%	95%
Hirabayashi 1991	43%	-	81%



A clinical target volume of 1cm encompasses all areas of ECE

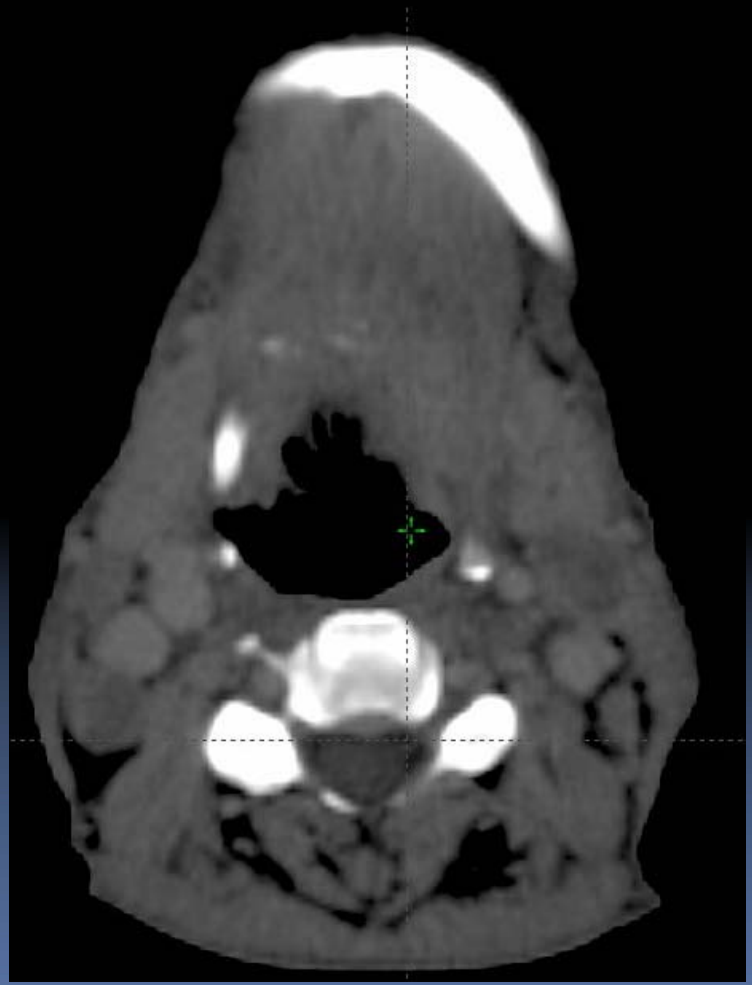
Chao IMRT in Head & Neck Cancer.pdf
Apisarnthanarax IJROBP. 64 (2006) 678–683

The Node Positive Neck – Defining a CTV



- One cm margin around node.
- Include entire space in case of multiple lymph nodes in the same horizontal plane.
- Bone to be excluded from CTV
- In patients treated with neoadjuvant chemotherapy, pre treatment involvement determines high dose volume

The Node Positive Neck – Infiltration of Sternocleidomastoid



- Include muscle in CTV at the level of involvement and 1.s cm superior & inferior

Nodal Irradiation in the Era Of 3D CRT – Making An Informed Decision

- Data From Surgical Series: Treat Levels with > 5% risk of involvement

Incidence (%) of pathologic lymph node metastasis in squamous cell carcinomas of the oral cavity[a]

Tumor site	Distribution of metastatic lymph nodes per level (percentage of the neck dissection procedures)											
	Prophylactic RND[b] (192 patients; 192 procedures)						Therapeutic (immediate or subsequent) RND (308 patients; 323 procedures)					
	No. of RNDs	I[c]	II	III	IV	V	No. of RNDs	I	II	III	IV	V
Tongue	58	14	19	16	3	0	129	32	50	40	20	0
Floor of mouth	57	16	12	7	2	0	115	53	34	32	12	7
Gum	52	27	21	6	4	2	52	54	46	19	17	4
Retromolar trigone	16	19	12	6	6	0	10	50	60	40	20	0
Cheek	9	44	11	0	0	0	17	82	41	65	65	0
Total	192	20	17	9	3	1	323	46	44	32	16	3

Gregoire et al R & O 56 (2000) 135±150

Nodal Irradiation in the Era Of 3D CRT – Making An Informed Decision

- Data From Surgical Series: Treat Levels with > 5% risk of involvement

Suggested guidelines for the treatment of the neck of patients with head and neck squamous cell carcinomas (AJCC 1997)

Location of primary tumor	Appropriate node levels to be treated	
	Stage N0–N1	Stage N2b
Oral cavity	I, II, and III (+IV for anterior tongue tumors)	I, II, III, IV and V[a]

Gregoire et al R & O 56 (2000) 135±150

Nodal Irradiation in the era of 3D CRT – Application of surgical concepts in radiation planning

- **Gavilan et al, retrospective analysis of functional neck dissection (FND)vs radical neck dissection(RND) in 242 patients with ca larynx: equivalent results.**

- **Bocca et al. 1200 dissections in 843 patients, equivalent reuslts with FND vs RND.**

- **Byers et al Noted the importance of adding Level IV dissection to suparaomohyoid dissection for the N0 neck in ca of oral tongue.**
- **Functional Neck Dissection**
  - **Supraomohyoid Levels I, II & III**
  - **Lateral Levels II, III & IV**
  - **Posterolateral Levels II, III IV, V & Retroauricular**

Bocca et alLaryngoscope.94 (1984):942-5
Gavilan Arch Otolaryngol Head Neck Surg.115(1989):1193-6
Byers et al Head Neck. 19(1997):14-9

Nodal Irradiation in the Era Of 3D CRT – Making An Informed Decision

- Data from patterns of failure

Results	Impact on Practice
Dawson et al & Eisbruch et al **2/58 failure & 21/133failures ,all in**	**Safe to omit contralat high level II if c/l neck negative**
3 RP node failures, all superior to CI vert	**Superior extent of RP nodes is base of skull**
Ipsilat high Level II failure in OC & OP Primaries	**Consider treating ipsilateral high Level II in case of OP primaries, even if N0**
Bussels et al **2/72 failures at matchline .**	**Consider including supraclavicular fossa in a single IMRT plan.**

Gregoire et al R & O 56 (2000) 135±150

Nodal Irradiation in the Era Of 3D CRT – Making An Informed Decision

- Data from patterns of failure

Results	Impact on Practice
Cannon et al Noted 3 periparotid failures, two in patients with bilateral disease. Retrospectively, insignificant nodules noted in periparotid region	? Do not disregard any nodules in a node positive neck, even if radiologicaly / PET insignificant
One dermal failure in periparotid region in ipsilateral neck	?Consider sparing only the contralateral neck
Nangia , Chufal et al 30/83 locoregional failures , 28 of which were within the high dose	Investigation into dose ecscalation , hypoxia sensitisation
No failure in the area outlined as low risk volume, using RTOG guidelines for delineation of levels and using the 5 % cut off for deciding which nodal levels to include	Nodal delineation criteria validated

Cannon et alIJROBP 70, (2008)660–665,
Nangia et al, IJROBP In press

Why Selective Node Irradiation

- Spare
  - Parotid/s and impact QOL
  - Minor salivary glands, oral mucosa
  - Mandible and decrease risk of osteoradionecrosis
  - Temporal lobes
  - Optic apparatus
  - Pharyngeal musculature and impact swallowing
  - Middle & Inner ear
  - Temporo-mandibular joints
- DOSE ESCALATE
- Certain structures drain viz. retromolar trigone, middle ear drain strictly into the ipsilateral neck

Delineating The Neck- Broad Guidelines

- **Always treat the contralateral neck if the ipsilateral neck N1. (N2 if buccal mucosa or RMT)**
- **If ipsilateral neck N+ / if primary oropharyngeal, treat high level II. In all others, omit.**
- **Treat IB and V if II or III or IV involved.**
- **Treat VI if IV involved.**
- **Treat retropharyngeals in all hypopharyngeal and if oropharyngeal primary results in involvement of II or III or IV.**
- **Certain guidelines (e.g. Chao et al) are based on stage & site**

Delineating The Neck
Oropharynx

Incidence (%) of pathologic lymph node metastasis in squamous cell carcinomas of the oropharynx[a]

Tumor site	Distribution of metastatic lymph nodes per level (percentage of the neck dissection procedures)											
	Prophylactic RND (47 patients; 48 procedures)						Therapeutic (immediate or subsequent) RND (157 patients; 165 procedures)					
	No. of RNDs	I[b]	II	III	IV	V	No. of RNDs	I	II	III	IV	V
Base of tongue + vallecula	21	0	19	14	9	5	58	10	72	41	21	9
Tonsillar fossa	27	4	30	22	7	0	107	17	70	42	31	9
Total	48	2	25	19	8	2	165	15	71	42	27	9

	Level IB	Level II	Level III	Level IV	Level V	Level VI	RP
N0/ CLN0	X include if ant tongue inv.	Up to Base of skull ✓	✓	✓	X	X	X
N+	✓	Up to Base of skull ✓	✓	✓	✓	X	✓

Delineating The Neck
Hypopharynx

	Level IB	Level II	Level III	Level IV	Level V	Level VI	RP
N0/ CLN 0	X	✓	✓	✓	X	In post cricoid cancer	✓
N+	✓	Up to Base of skull ✓	✓	✓	✓	✓	✓

- Derived from posterolateral dissection for hypopharyngeal cancers
- High risk of retropharyngeal lymph node involvement ; 62% pathologically positive nodes noted in surgical series

Delineating The Neck

Oral Cavity – Anterior Tongue & Floor of Mouth

Omit Neck if negative on HPE; Treat No neck only if not addressed surgically

	Level I A	Level IB	Level II	Level III	Level IV	Level V	Level VI	RP
N0/ N1	Only If FOM involved	✓	✓	✓	✓	X If N1	X	X
Cl N0 Only in FOM*						X	X	X
N2	✓	✓	✓	✓	✓	✓	X	X

***Treat only ipsilateral neck in an ant tongue lesion, < 4cm in size, not involving floor of mouth and well or moderately differentiated.**

Delineating The Neck
Oral Cavity – Buccal Mucosa & Retro Molar Trigone (Postoperative)

	Level I A	Level I B	Level II	Level III	Level IV	Level V	Level VI	RP
N+	✓	✓	✓	✓	✓	✓	X	X
CL N0	X	✓	✓	✓	✓	X	X	X

Buccal mucosa & RMT mostly treated in the postoperative setting, hence nodes addressed by radiotherapy only if pathologically positive

Supraglottic larynx, T3 T4 Glottic Larynx

	Level IB	Level II	Level III	Level IV	Level V	Level VI	RP
N0	X	✓	✓	✓	X	✓	X
CL N0	X	✓	✓	✓	X		X
N+	X	✓	✓	✓	✓	✓	✓

T2 Glottic Larynx with impaired cord mobility

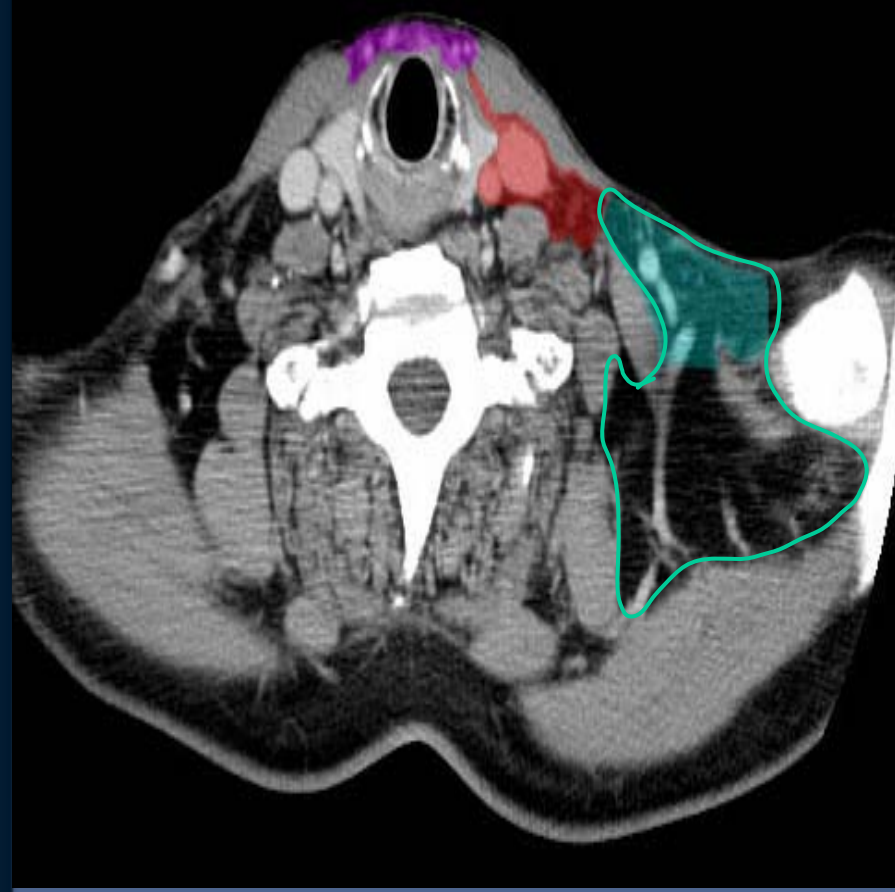
N0	X	✓	✓	✓	X	X	X
CL N0	X	✓	✓	✓	X	X	X

Subglottic N0

N0	X	✓	✓	✓	X	✓	X
CL N0	X	✓	✓	✓	X	✓	X

Delineating The Neck
Nasopharynx

- **Delineate Levels II – V and retropharyngeal nodes in No patients.**
- **Include Level I B in N+ patients.**
- **Delineate Level II till the base of skull in all patients.**
- **Delineate the entire Ho's triangle when marking Level V**



Selective Nodal Irradiation _ Clinical results

83 patients

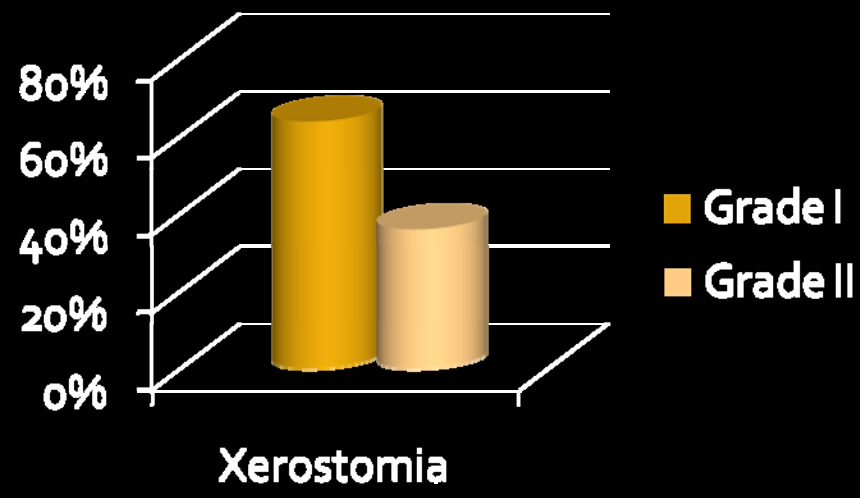
Larynx, 35; hypopharynx, 13; tonsil, 7; base tongue, 17; ant tongue, 6; oral cavity, 2; and primary unknown, 3.

T0:T2:T3:T4 = 3:29:37:14

N0:N1:N2:N3 = 36:10:32:5

OS at 3 yrs 81.7%; LRFS 60.8%

30/83 failures locoregional only two outside volume delineated as high dose volume.



NO FAILURES IN THE NECK IRRADIATED ELECTIVELY. NO FAILURES IN NECK NODE LEVELS SPARED.

In Conclusion

Essential Reading

1. **Selection and delineation of lymph node target volumes in head and neck conformal radiotherapy. Proposal for standardizing terminology and procedure based on the surgical experience . V. Gregoire et al . *Radiotherapy and Oncology 56 (2000) 135-150.***

2. **CT-based delineation of lymph node levels and related CTVs in the node-negative neck: DAHANCA, EORTC, GORTEC, NCIC, RTOG consensus guidelines. V. Gregoire et al *Radiotherapy and Oncology 69 (2003) 227–236* .**

3. **Proposal for the delineation of the nodal CTV in the node-positive and the post-operative neck. V Gregoire et al *Radiother apy & Oncology 79 (2006)15-20.***

4. **Intensity –modulated radiation therapy for head and nevk cancer : emphasis on the selection and delineation of the targets. A . Eisbruch et al. *Semin Radiat Oncol. 12 (2002):238-49.***

5. **Determination and delineation of nodal target volumes for head-and-neck cancer based on patterns of failure in patients receiving definitive and postoperative IMRT. Chao et al. *IJROBP 53 (2002)1174-84.***

1.

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