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Practical Medical Physics: Head and Neck Contouring

AAPM 2011

Vancouver, British Columbia

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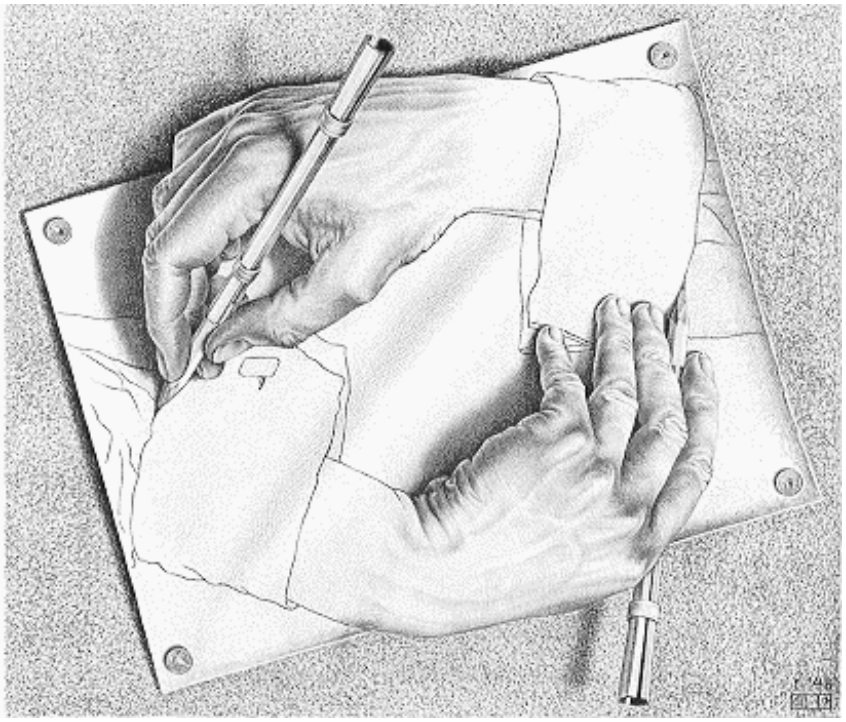
Objectives

Review Selection of Normal Organs

- Brachial Plexus
- Pharyngeal Constrictors
- Salivary Glands
  - Parotid
  - Submandibular

Target Audience:

- Physicists
- Dosimetrists
- Radiation Therapists



Outline

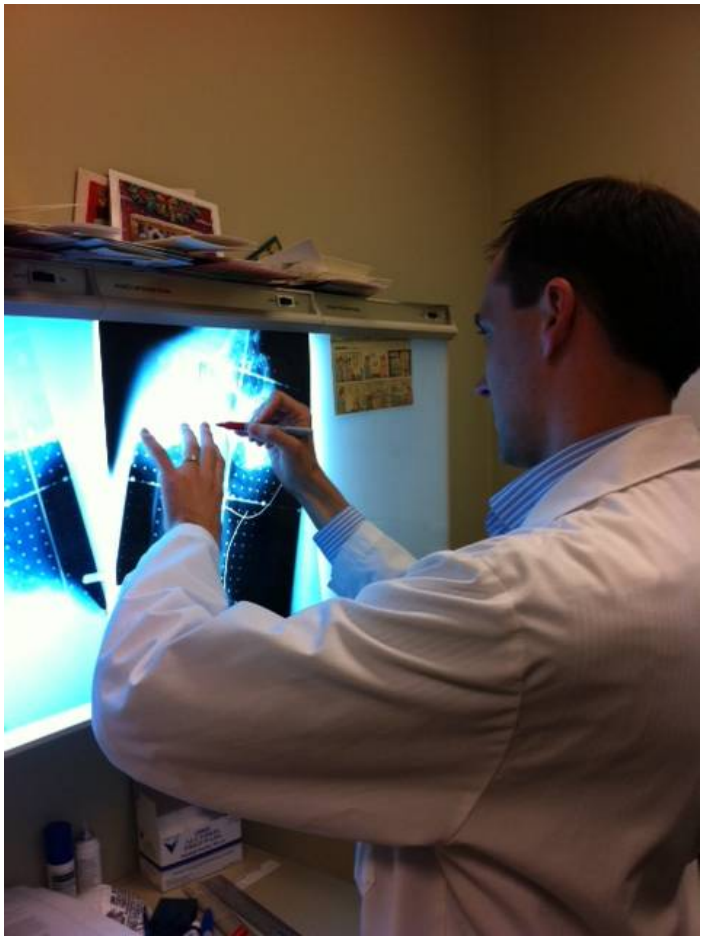
Why do we have to Contour?

Which Organs are Important?

How *I* contour?

3 Important Organ Systems

- Xerostomia: Salivary Glands
  - Parotid
  - Submandibular
- Dysphagia: Pharyngeal Constrictors
- Brachial Plexus



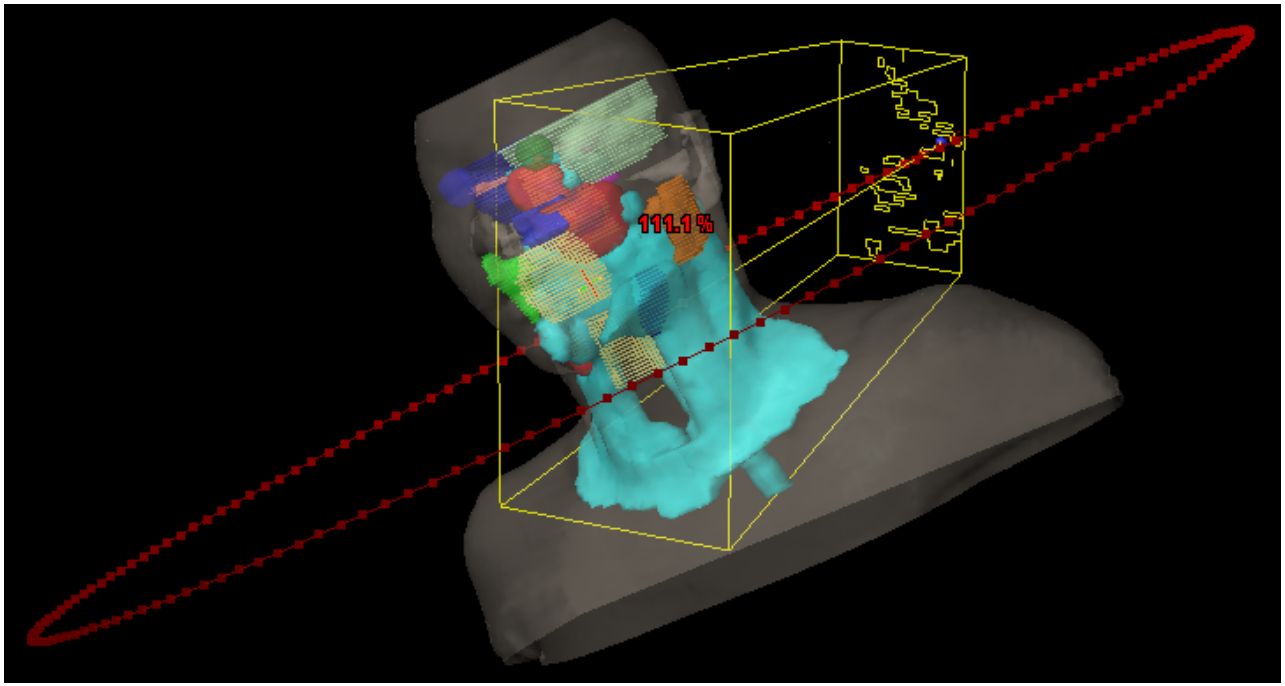
Outline (cont)

For Each Organ System

- Anatomy
- Literature
- Examples

Why do we have to contour?

- Target delineation
- Organ avoidance



2D → 3D → IMRT

(your fault)

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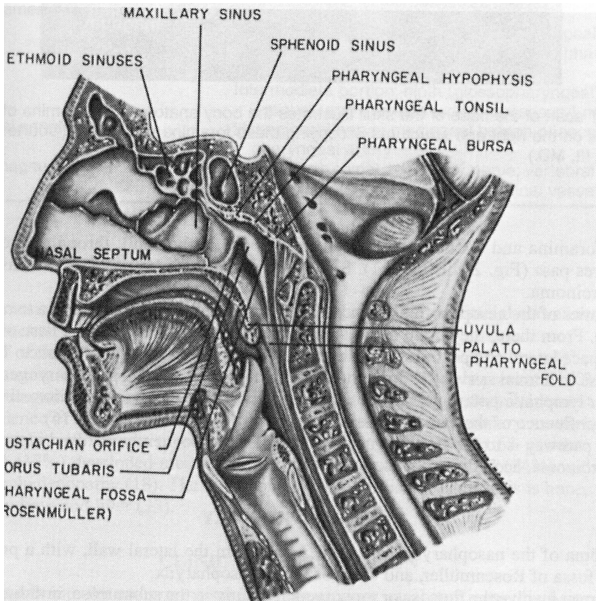
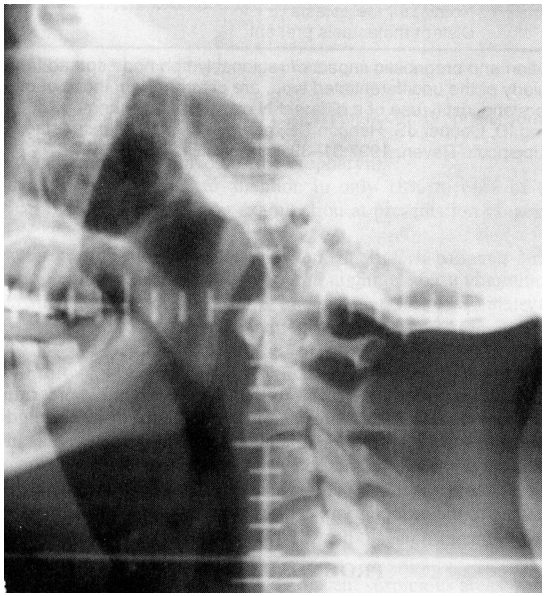
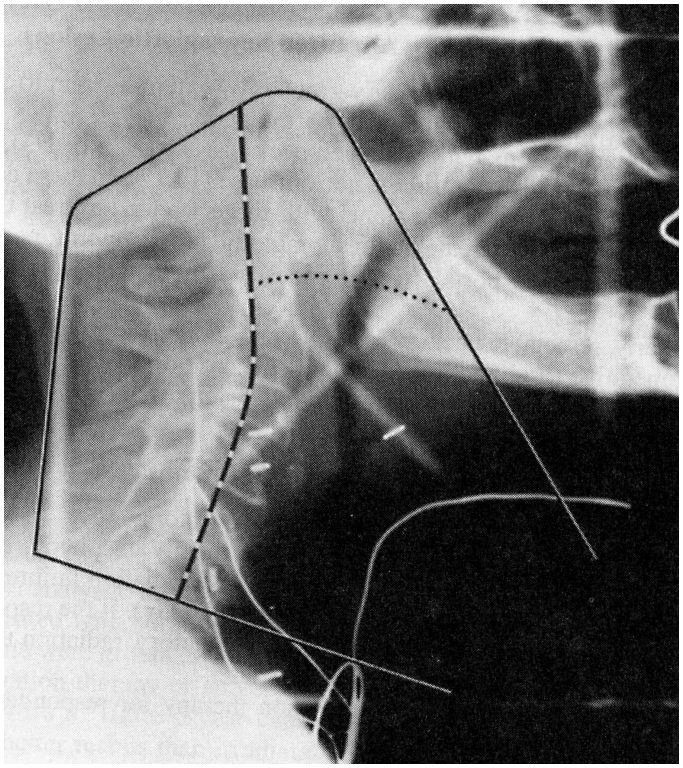
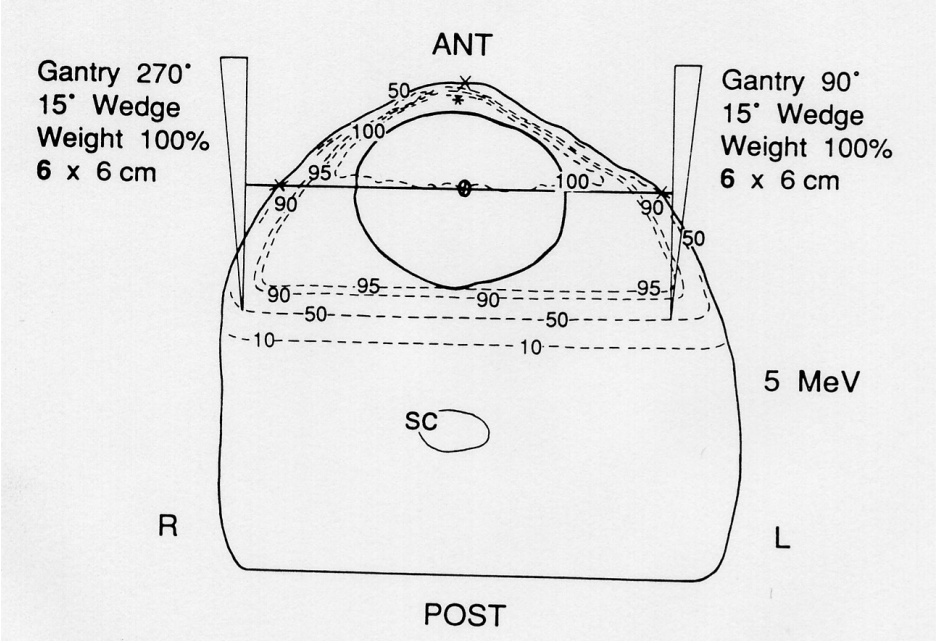
2D Planning


MAXILLARY SINUS
SPHENOID SINUS
ETHMOID SINUSES
PHARYNGEAL HYPOPHYSIS
PHARYNGEAL TONSIL
PHARYNGEAL BURSA
NASAL SEPTUM
UVULA
PALATO
PHARYNGEAL
FOLD
USTACHIAN ORIFICE
ORUS TUBARIS
HARYNGEAL FOSSA
ROSENMÜLLER)

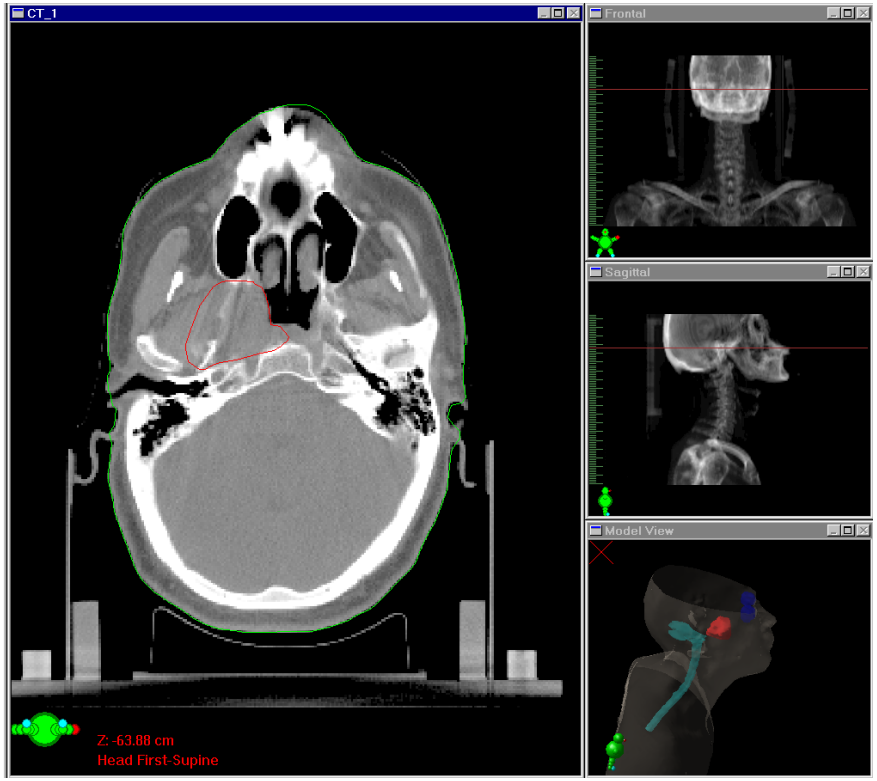


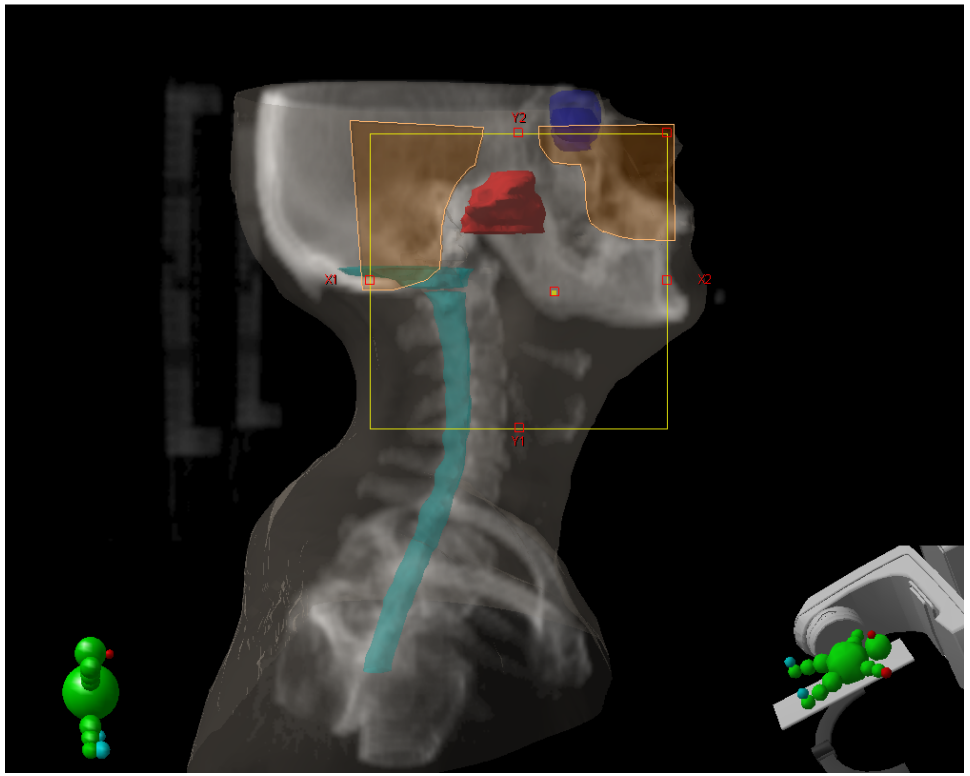
2D Planning



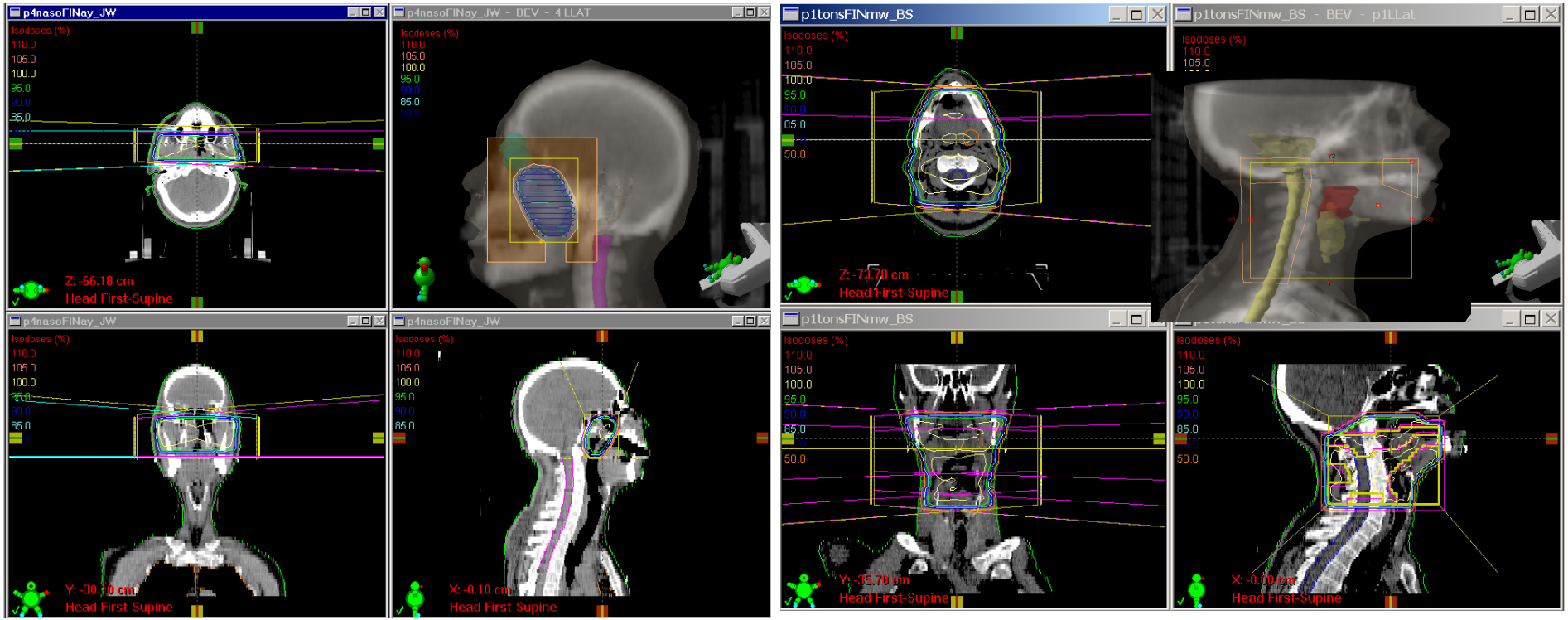

ANT
Gantry 270°
15° Wedge
Weight 100%
6 x 6 cm
Gantry 90°
15° Wedge
Weight 100%
6 x 6 cm
50
100
95
90
100
90
50
90
95
90
95
50
50
10
10
5 MeV
SC
R
L
POST

2.5D...


CT_1
Frontal
Sagittal
Model View
Z: -63.88 cm
Head First-Supine


Y2
X1
X2
Y1

3DCRT



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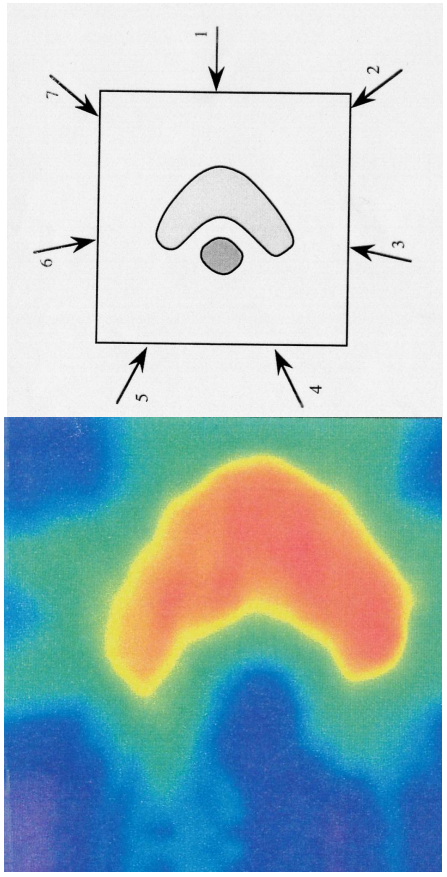
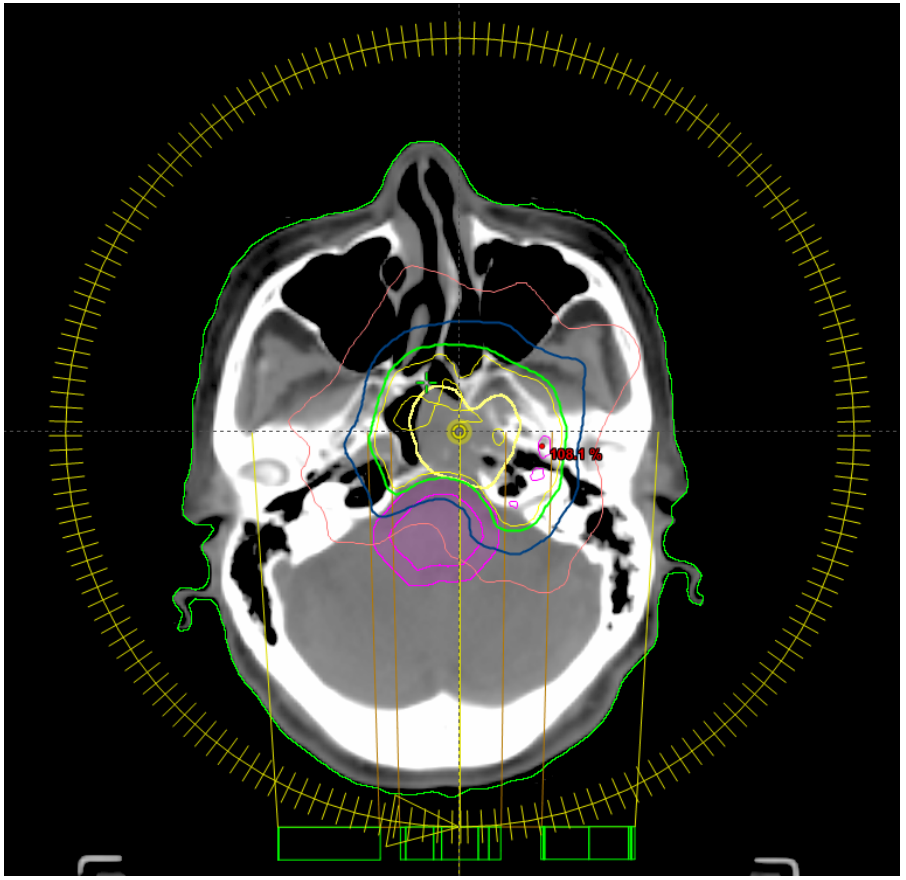
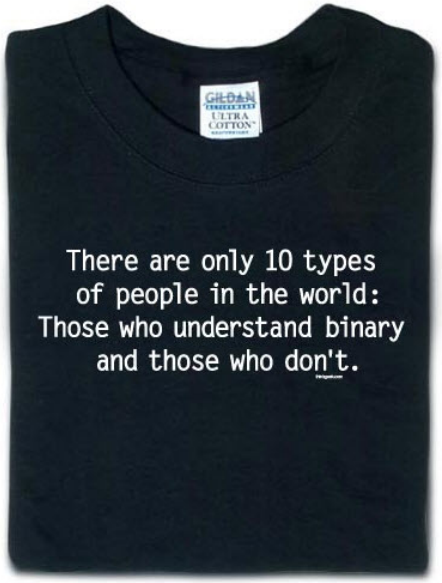
IMRT

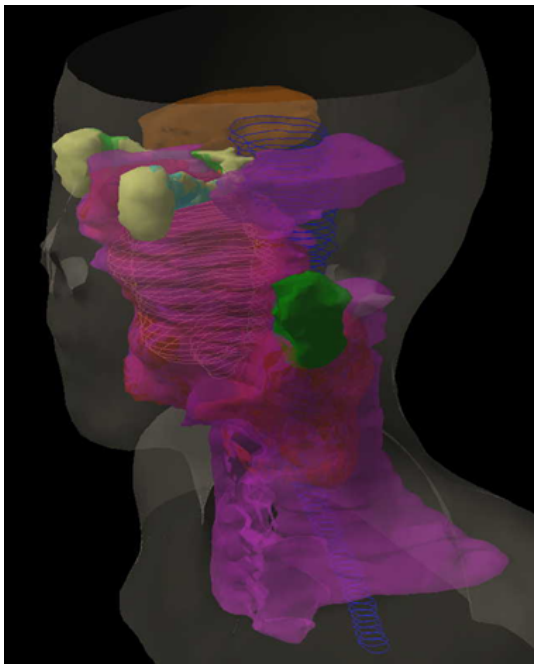


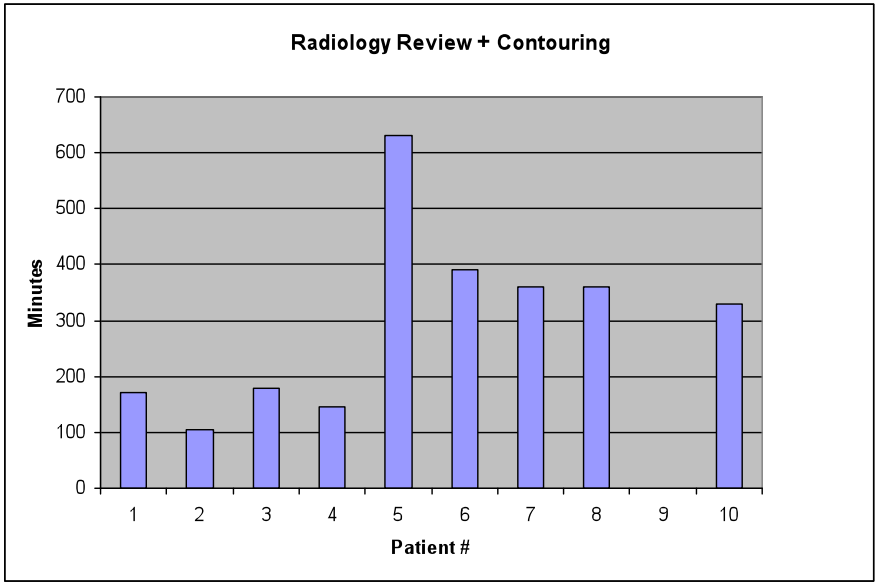


IMRT & Contours

- Inverse Planning
- Objective Cost Function
- Computers are Binary







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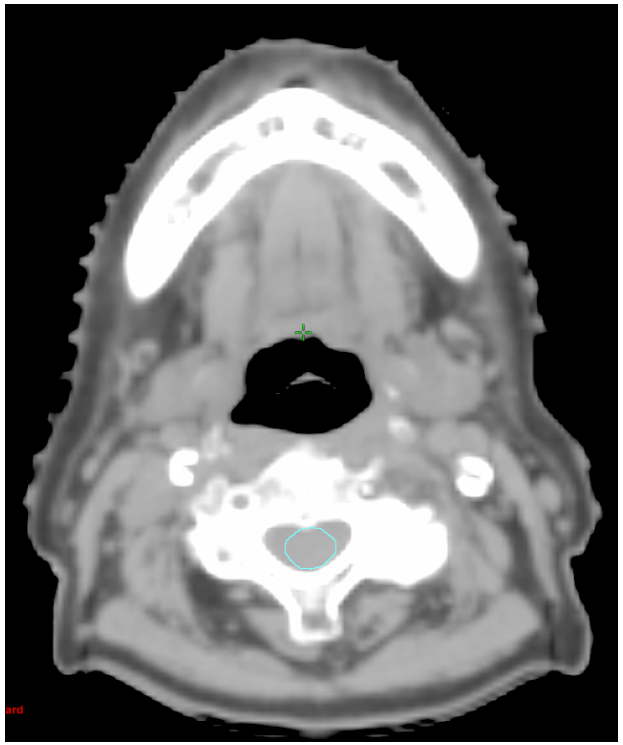
Why take a contouring course?

- IMRT and 3D = standard practice
  - Both techniques require (accurate) contours
  - Clinical trials require dose constraints
- Consistency (precision)
  - Who:
    - Intra- vs inter-contourer
    - Intra- vs inter-institutional
  - Why:
    - Good practice
    - Dose constraints
    - Dosimetric repositories

Why take a contouring course?

- No formal training
- Few reproducible guidelines
- Everyone assumes consistent contouring
    - NCIC HN6, RTOG 0920, 0615, 0225
    - Spinal Cord:
        - Intra-observer: avg 0.1 cm, max 0.7 cm
        - Inter-observer: avg 0.2 cm, max 0.9 cm



Which organs are important

Brain (temporal lobe)
Globe, retina
Lens
Optic nerve, optic chiasm
Pituitary gland
Brainstem, spinal cord
Inner ear
TMJ
Mandible
Larynx
Esophagus
Oral cavity
Thyroid
Vasculature

Xerostomia - Salivary Glands

Dysphagia - Pharyngeal Constrictors

Brachial plexus

For Each Organ System

- Anatomy
- Literature
- Examples

(No Time For)

- Targets (GTV)
- ICRU (xTVs, PRV)
- Contour editing (surface cropping, overlapping)
- Autosegmentation
- Imaging modalities
- Intra-treatment changes
- Dose volume constraints

How *I* Contour

- Standard CT technique
  - 2.5mm slices, 2.5mm spacing
  - Matrix size 512 x 512
  - IV Contrast
- HU Settings
  - Window 400, Level 50
- Maximize visual real estate
- **Scrolling**
- Software tools: above/below
- Tablet/Pen
- Consultation: RO, DI

Holistic Contouring

Digital & Physical Optimization

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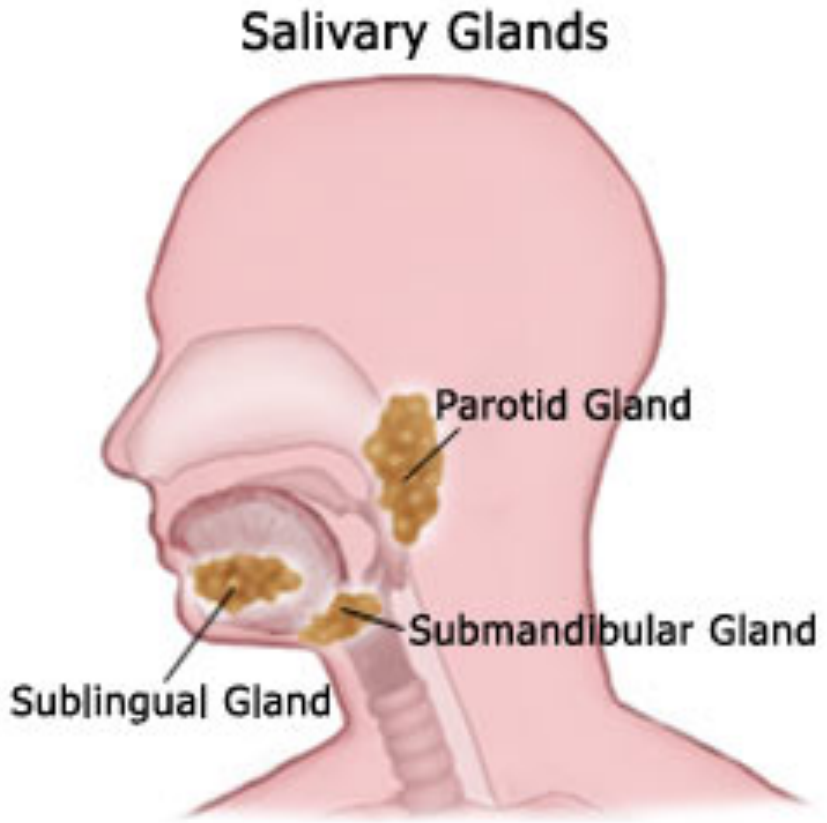
Xerostomia: Salivary Glands

- Anatomy
- Literature
- Examples

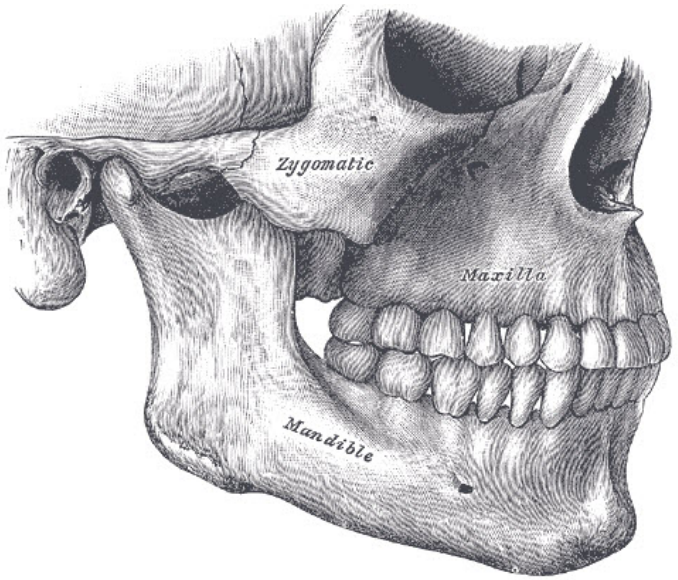


Salivary Glands: Anatomy

- Major Salivary Glands
    1. Parotid
    2. Submandibular
    3. Sublingual
- Secrete saliva
    - Speech, taste, swallowing
    - Digestive enzymes
    - Prevent inflammation and dental caries
- Saliva
    - 0.5 L secreted per day
        - **Resting**: 0.3 mL/min
            - Parotid = 20%
            - **Submandibular = 65%**
            - **Sublingual, Minor = 15%**
        - Stimulated: 1.5–2 mL/min
            - **Parotid** = 50%

Salivary Glands: Parotid

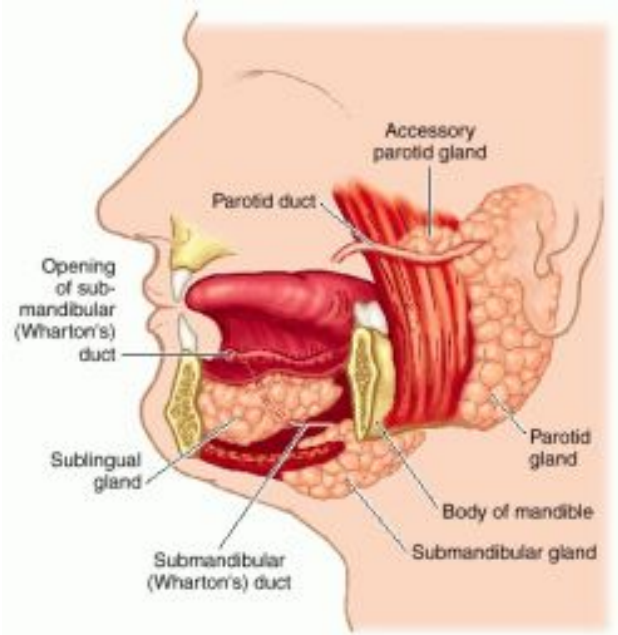
- paired, 25-30 g, accessory gland: 20%
- borders:
    - superior: zygomatic arch
    - inferior: hyoid bone
    - anterior: anterior ramus mandibular arch
    - posterior: mastoid process
    - medial: carotid sheath or masseter muscle
    - lateral: skin



- Structures within Parotid
    - External carotid artery, Retromandibular vein
    - Facial nerve
- Parotid Duct:
    - 5 cm long, 3 mm wide
    - Crosses masseter, right angle, buccal fat pad/buccinator, runs obliquely forwards, opens @ second upper molar

Salivary Glands: Submandibular

- 10-20 g, size of walnut
- Borders:
    - Superior: medial surface of mandible, lingual N
    - Inferior: soft tissues of neck, hypoglossal N
    - Medial/Anterior: floor of mouth (mylohyoid, hypoglossus mm)
    - Posterior: submandibular LN, carotid sheath
    - Lateral: skin



Salivary Glands: Literature

Organ at risk	Anatomic boundaries					
	Cranial	Caudal	Anterior	Posterior	Lateral	Medial
Parotid gland	External auditory canal, mastoid process	Post. part submandibular space	Masseter m., post. border mandibular bone, medial and lateral pterygoid m.	Ant. belly sternocleidomastoid m., lat. side post. belly of the digastric m. (posterior-medial)	Subcutaneous fat, platysma	Post. belly of the digastric m., styloid process, parapharyngeal space
Submandibular gland	Medial pterygoid m., mylohyoid m.	Fatty tissue	Lat. surface mylohyoid m., hyoglossus m.	Parapharyngeal space, sternocleidomastoid m.	Med. surface medial pterygoid m., med. surface mandibular bone, platysma	Lat. surface mylohyoid m., hyoglossus m., superior and middle pharyngeal constrictor m., anterior

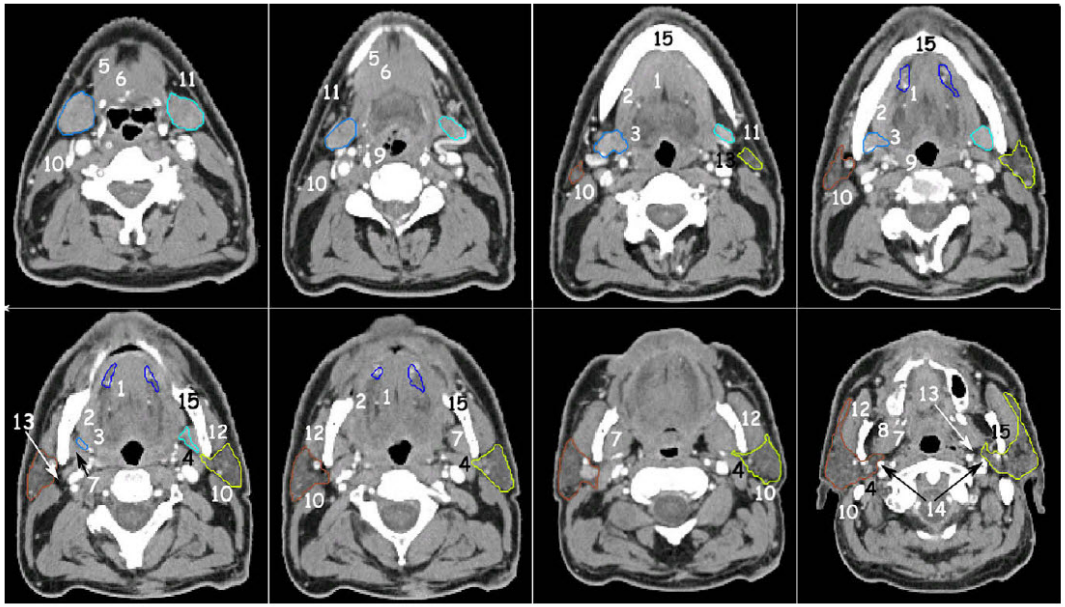
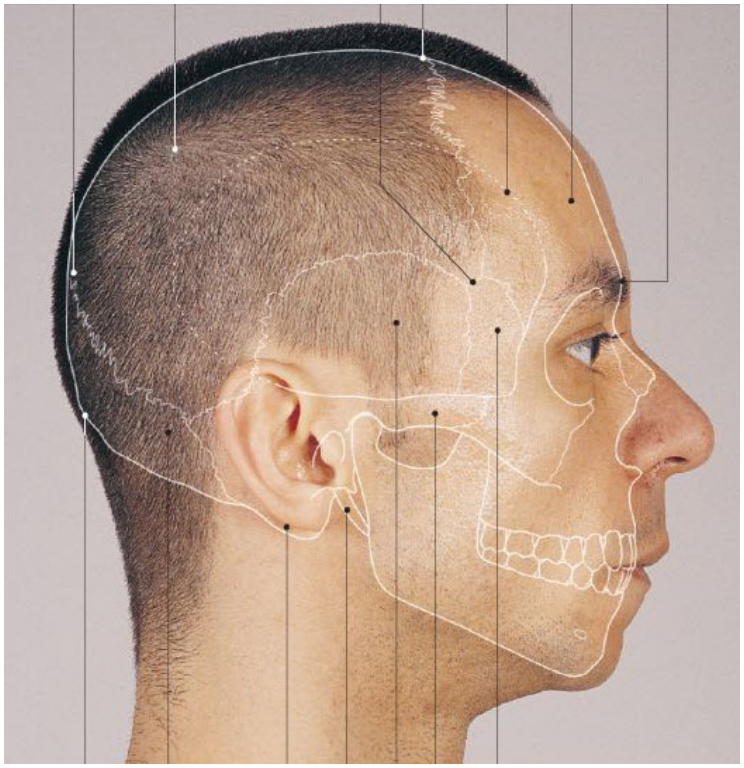


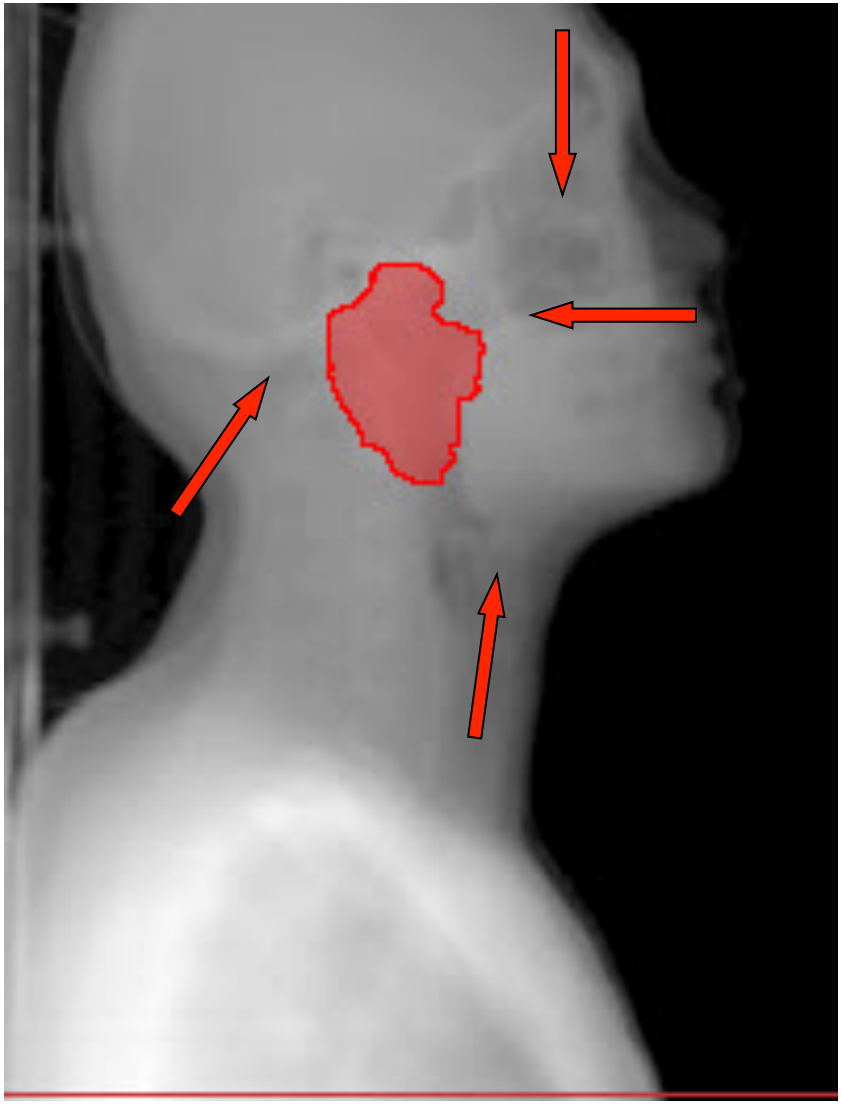
Fig. 2. Major salivary glands: the parotid glands are depicted in brown (left) and green (right), the submandibular glands are depicted in blue (the left one is brighter than the right one) and the sublingual glands are coloured dark blue (anterior part oral cavity). (1) Genioglossus m., (2) mylohyoid m., (3) hyoglossus m., (4) posterior belly digastric m., (5) anterior belly digastric m., (6) geniohyoid m., (7) medial pterygoid m., (8) lateral pterygoid m., (9) pharyngeal constrictor m., (10) sternocleidomastoid m., (11) platysma, (12) masseter m., (13) parapharyngeal space, (14) styloid process, (15) mandibular bone.

Van de Water et al, RO, 2009

Parotid Glands: Examples

- superior: zygomatic arch
- inferior: hyoid bone
- anterior: anterior ramus mandibular arch
- posterior: mastoid process
- medial: carotid sheath or masseter muscle
- lateral: skin





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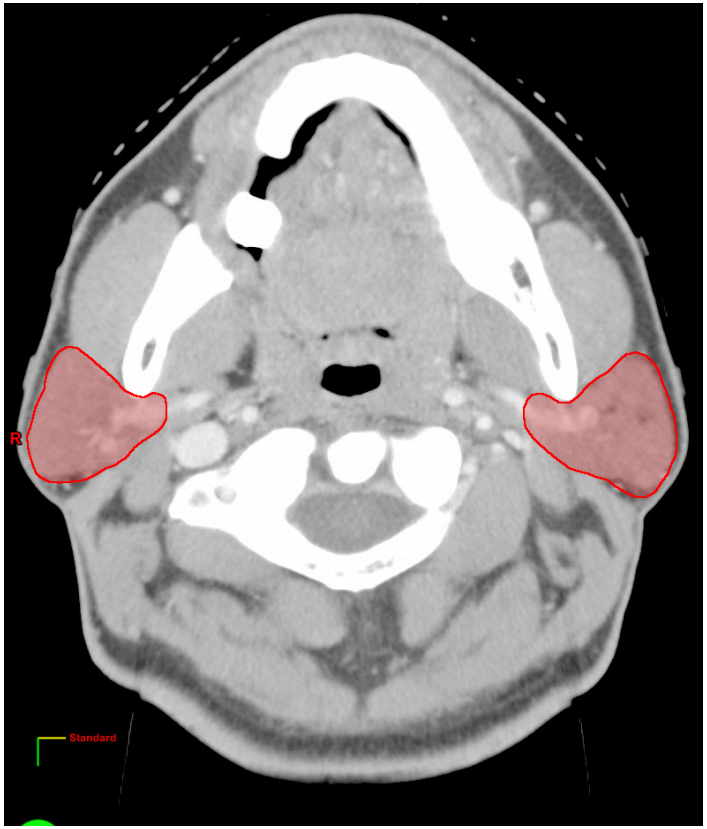
Parotid Glands: Examples



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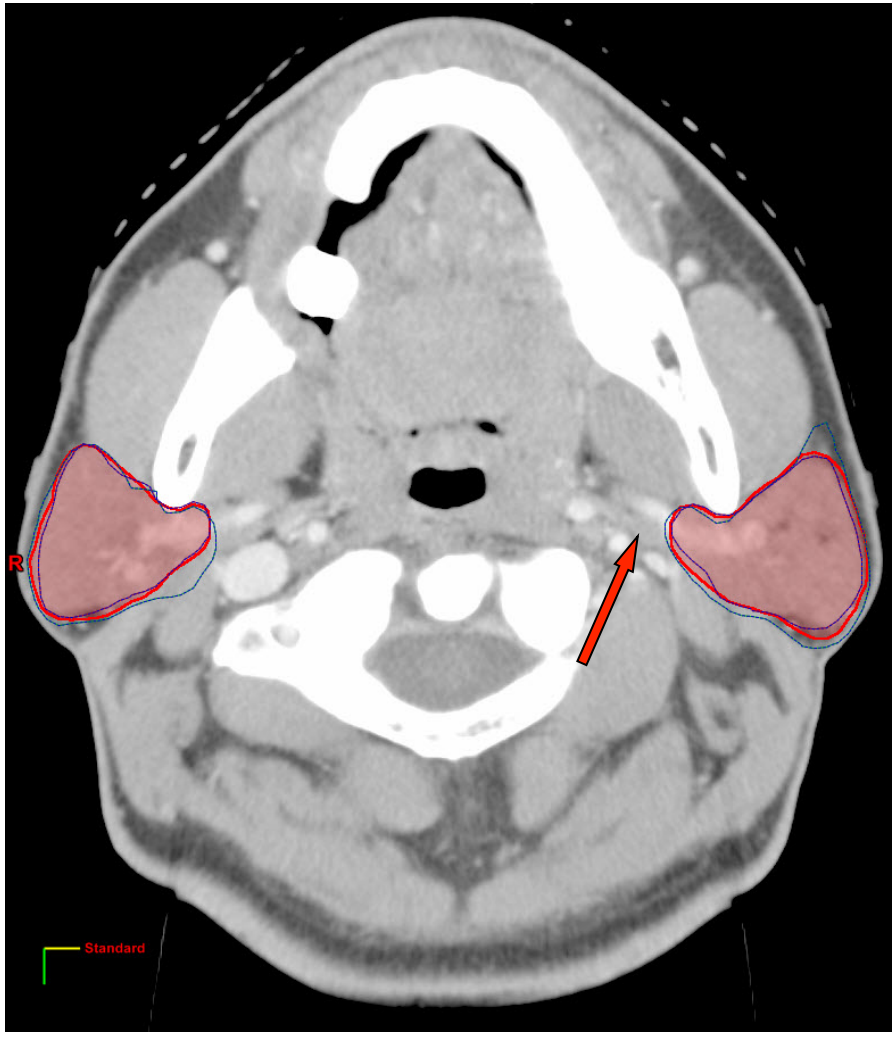
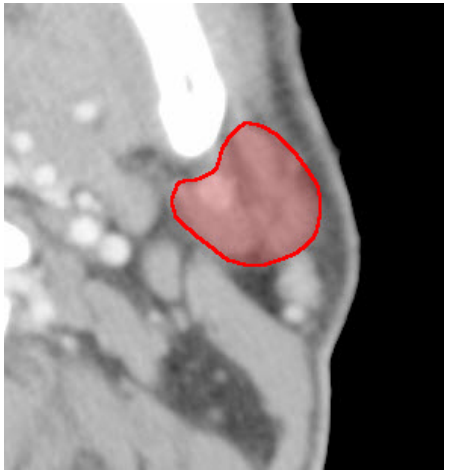
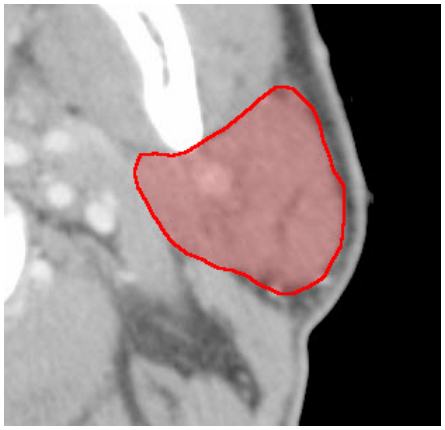
Parotid Glands: Use your tools.







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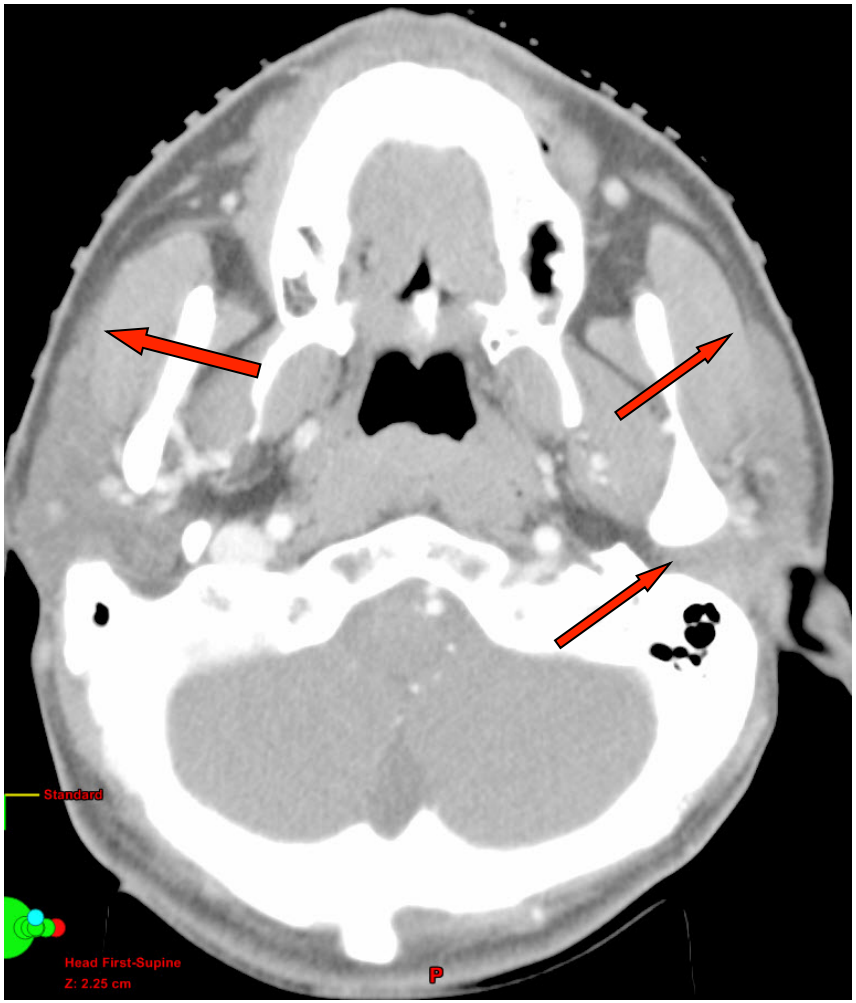
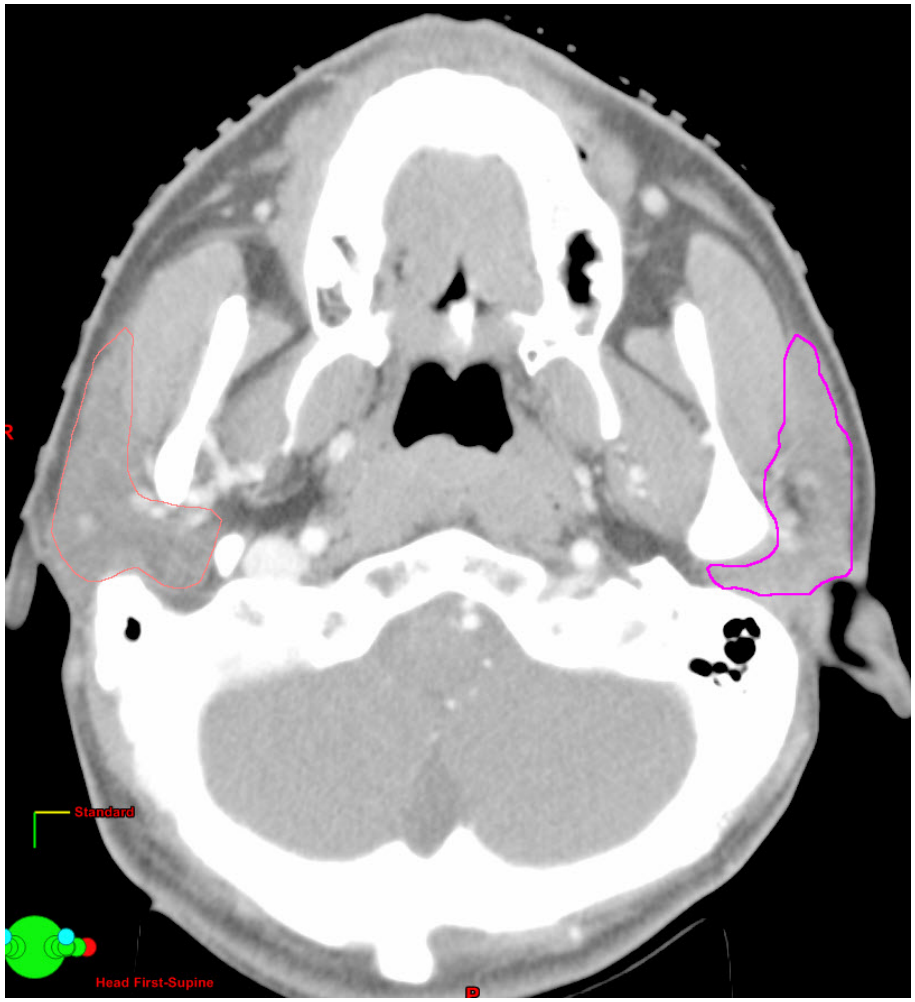
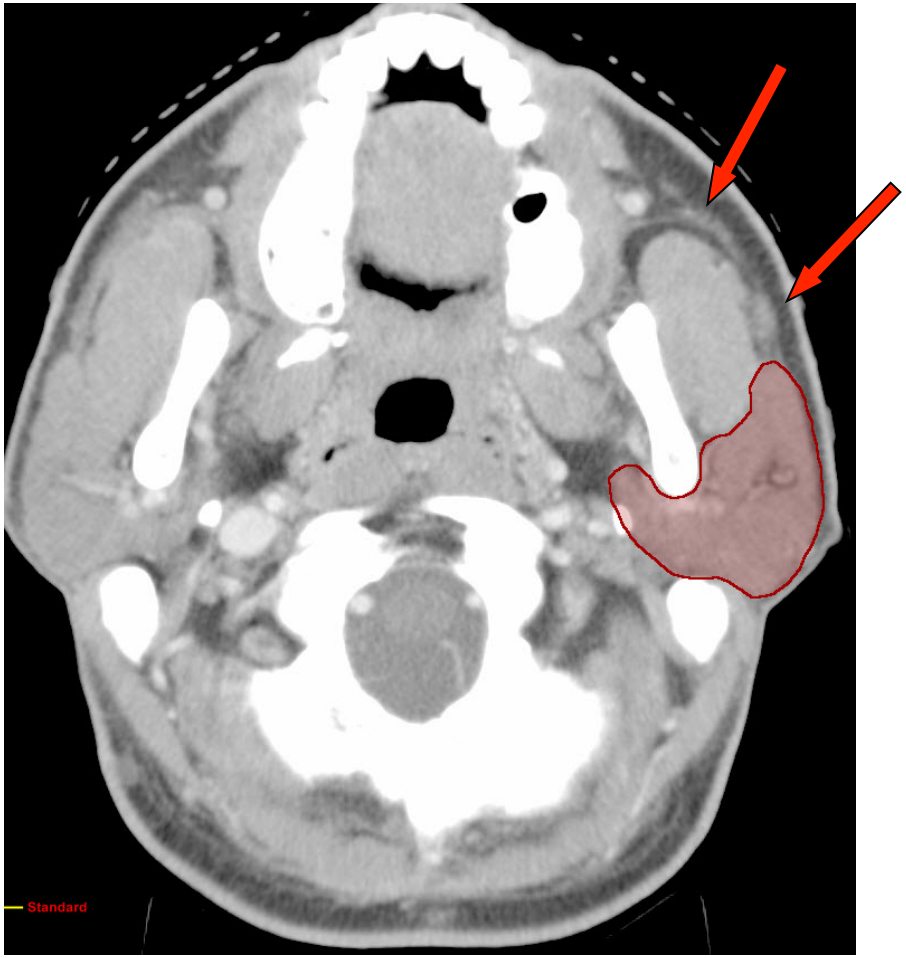
Parotid Glands: Examples



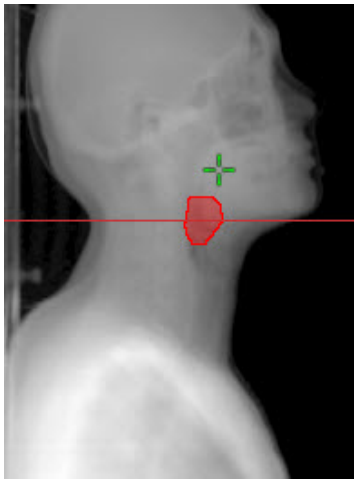


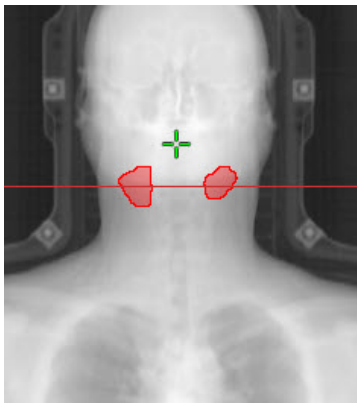
Parotid Glands: Examples

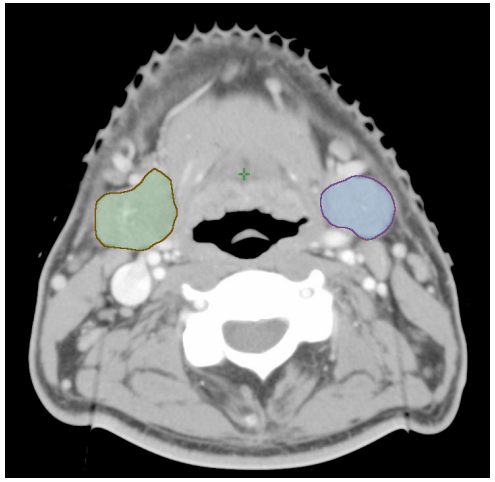


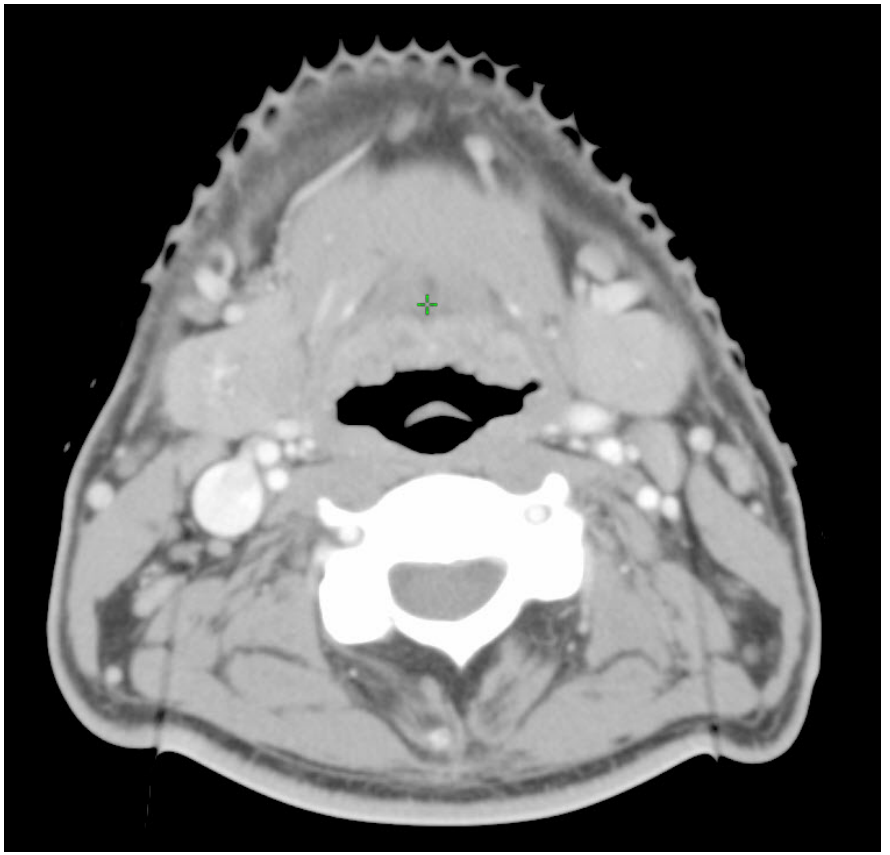
Submandibular Glands

- Superior: medial surface of mandible, lingual N
- Inferior: soft tissues of neck, hypoglossal N
- Medial/Anterior: floor of mouth (mylohyoid, hypoglossus mm)
- Posterior: submandibular LN, carotid sheath
- Lateral: skin









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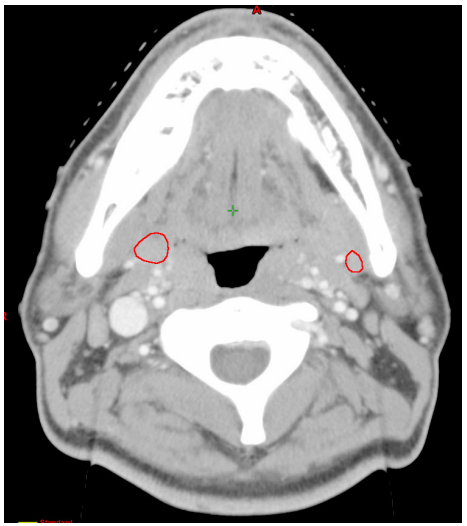
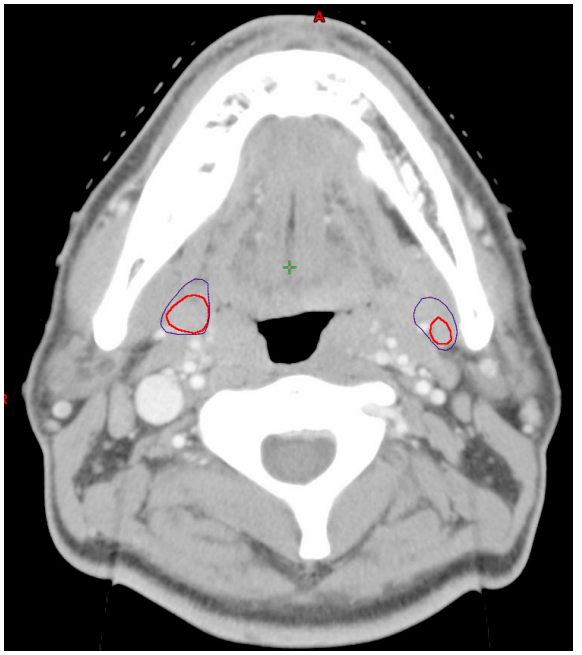
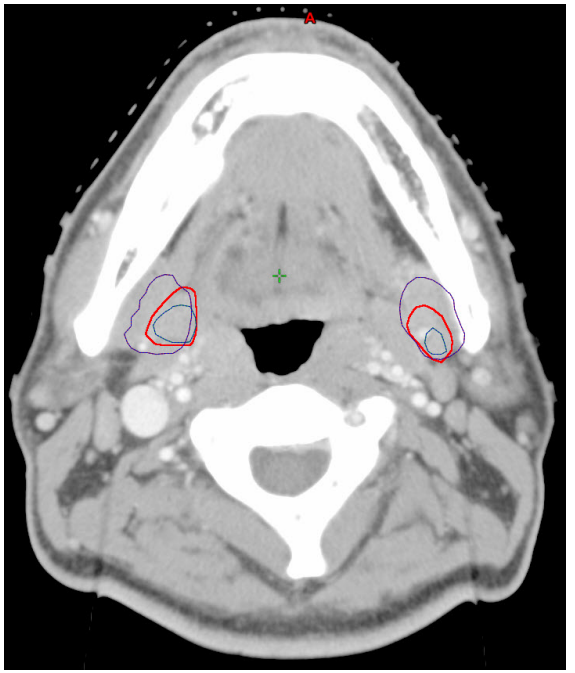
Submandiblar Glands: Examples







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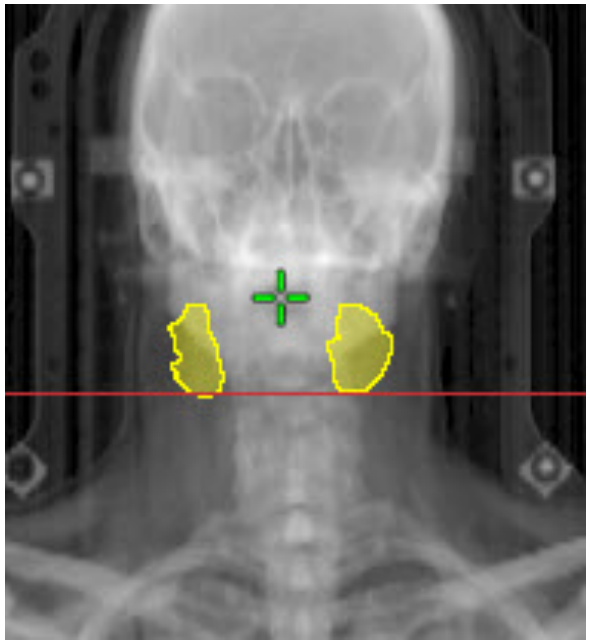
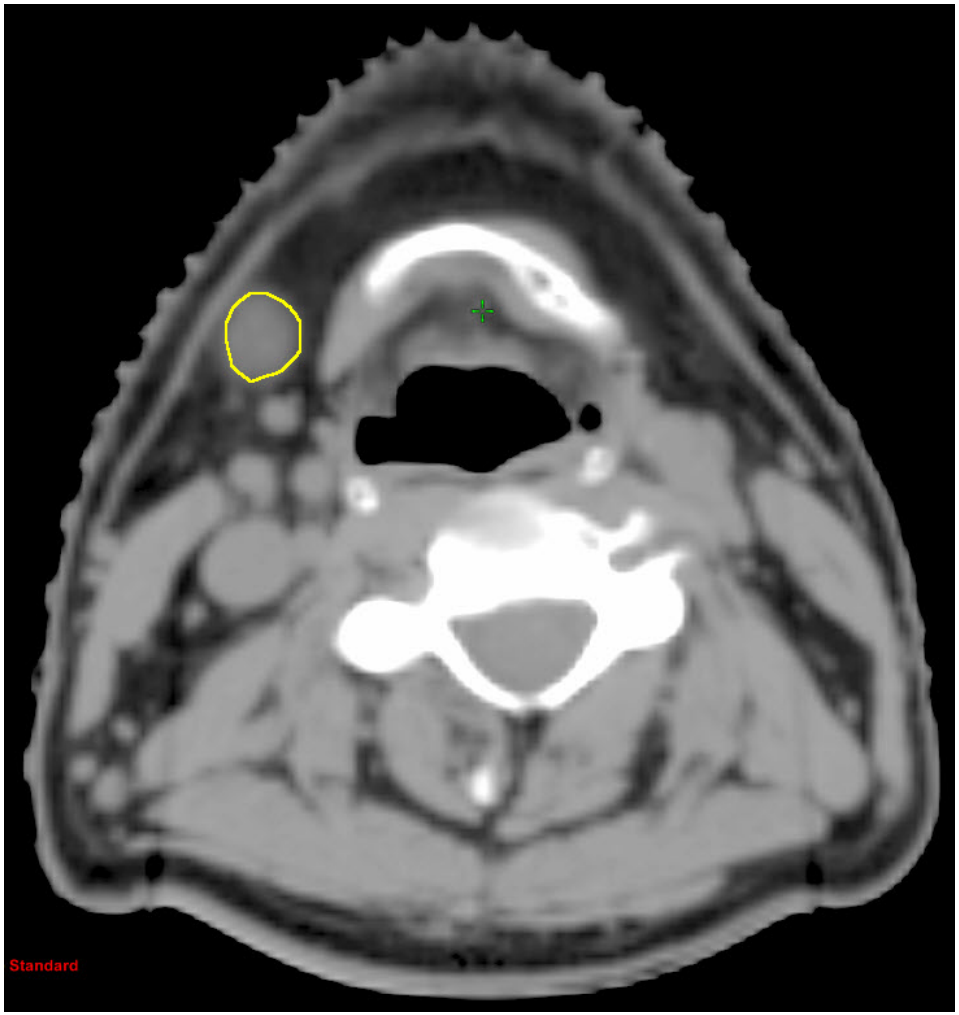
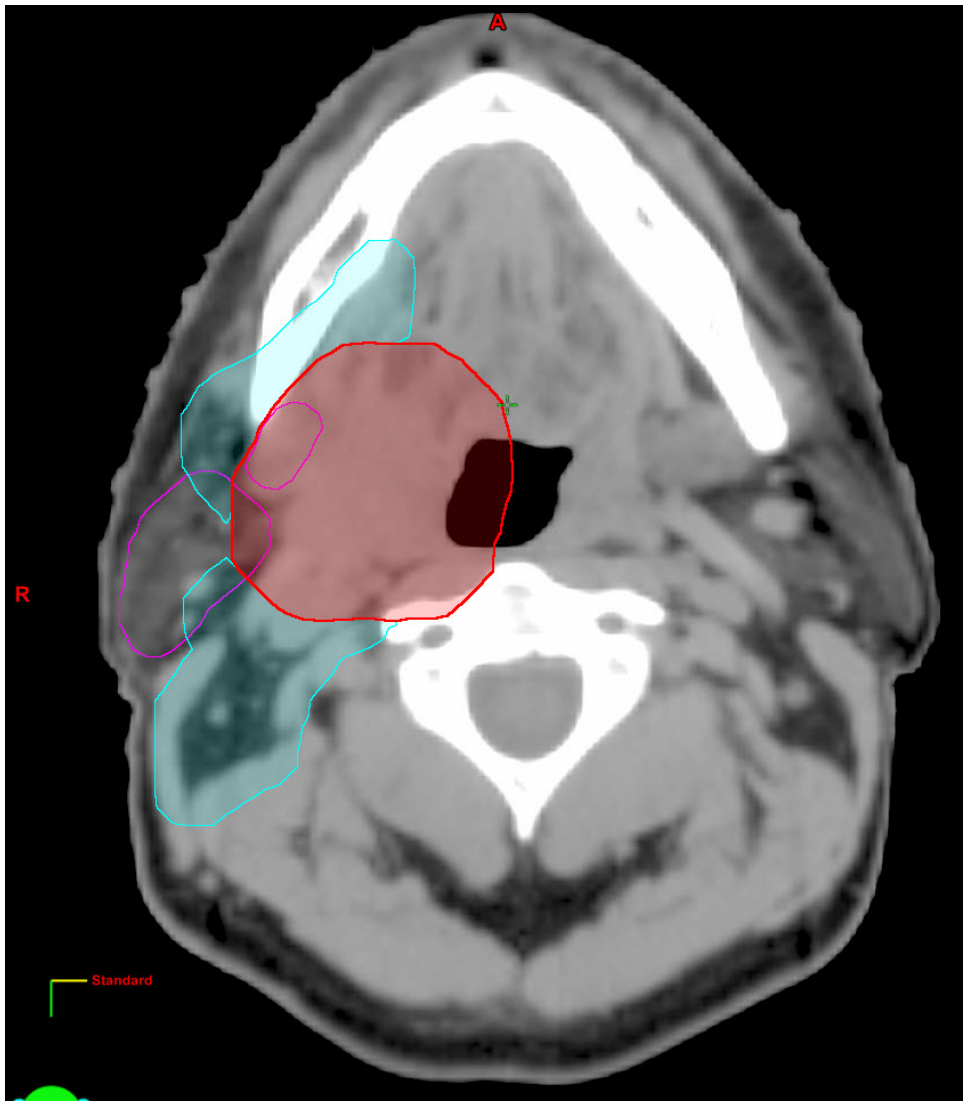
Submandibular Glands: Inferior





Salivary Glands: Summary

- Parotid most variable
- Know potential limits
- Scroll
- Sup/Inf tool



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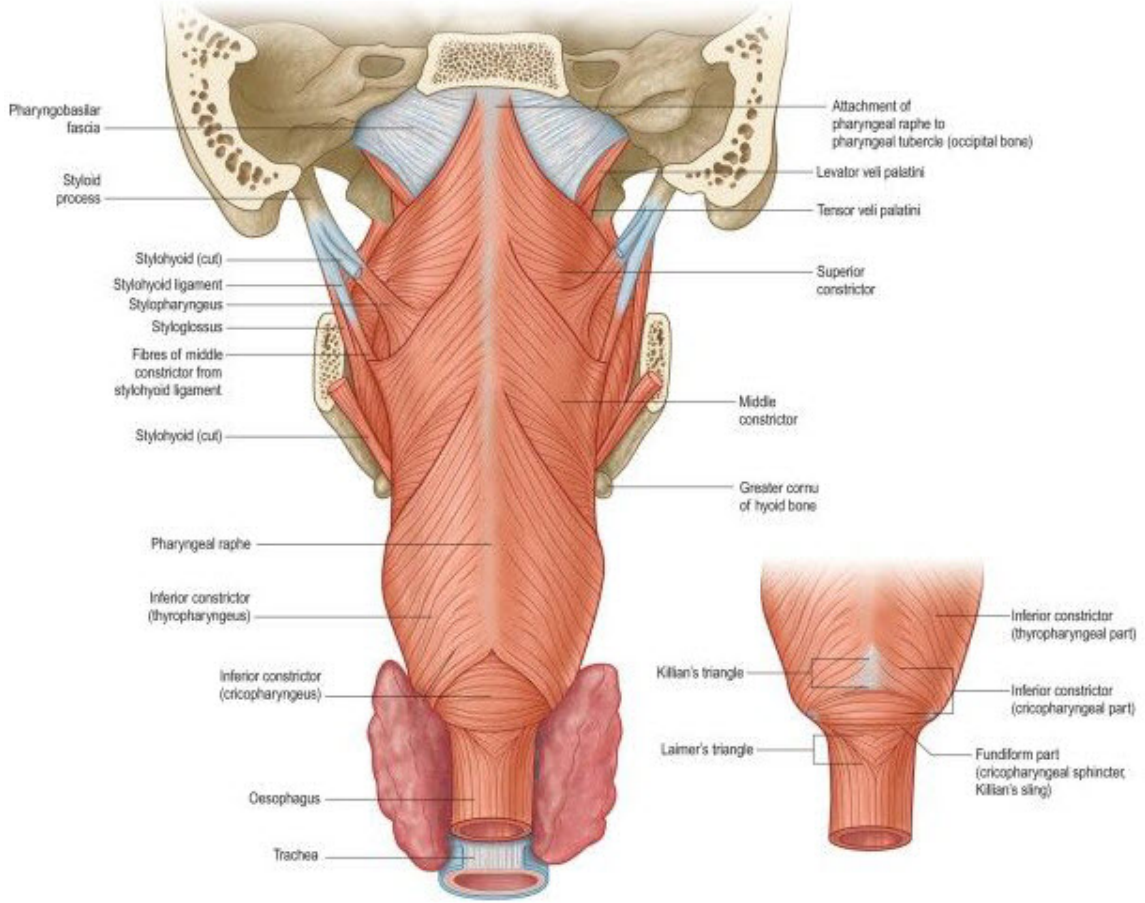
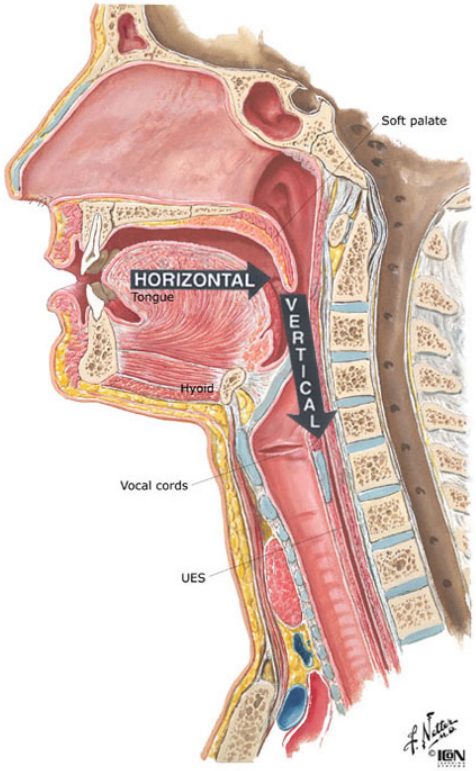
Dysphagia: Pharyngeal constrictors

- Anatomy
- Literature
- Examples



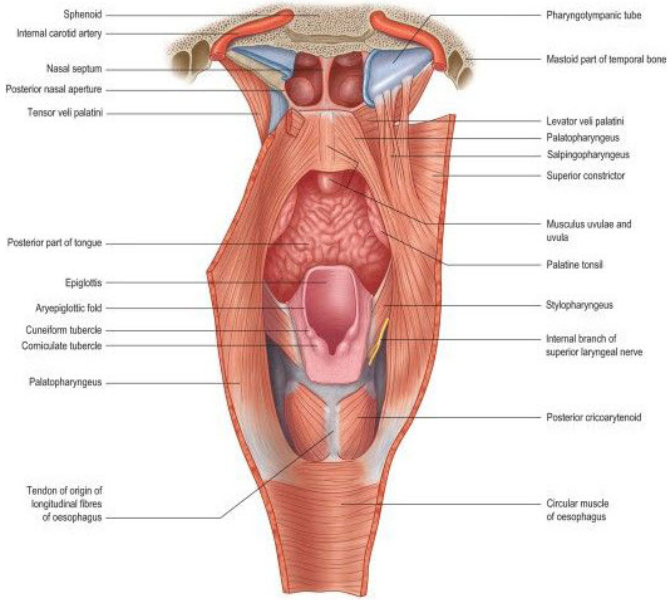
Pharyngeal Constrictors: Anatomy

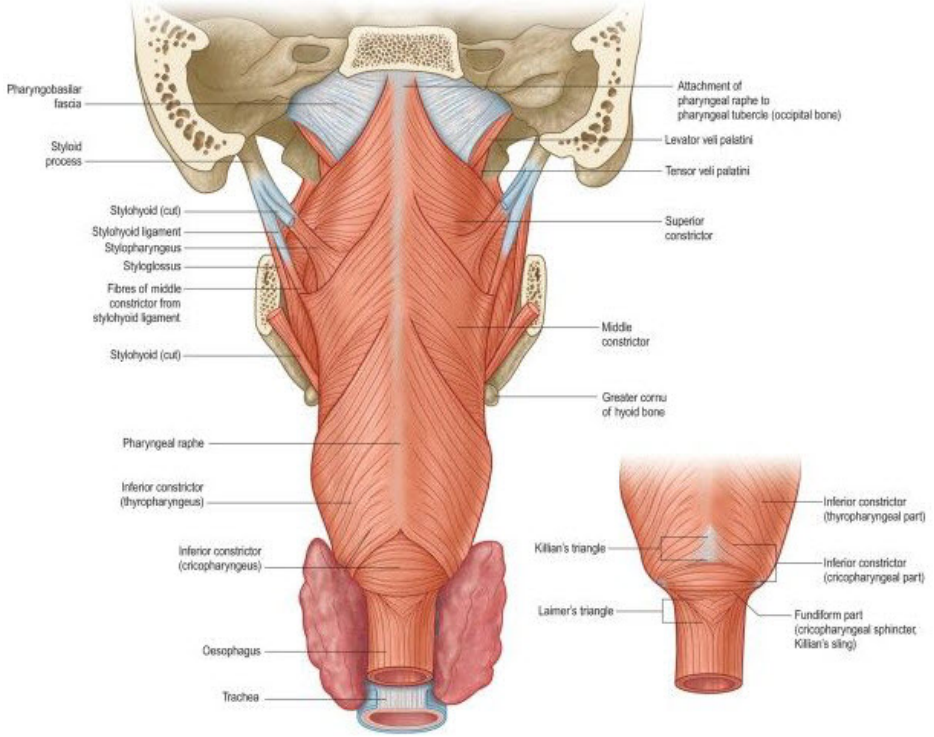


- Programmed motor behaviour
    - seconds
- Stimulation of sensory nerves in the oropharynx
- 600 and 1000 times in 24 hours
- Eating and drinking are basic human pleasures
    - significant impact upon the quality of life
- Four phases:
    - Oral preparatory
    - Oral transit
    - Pharyngeal
    - Esophageal

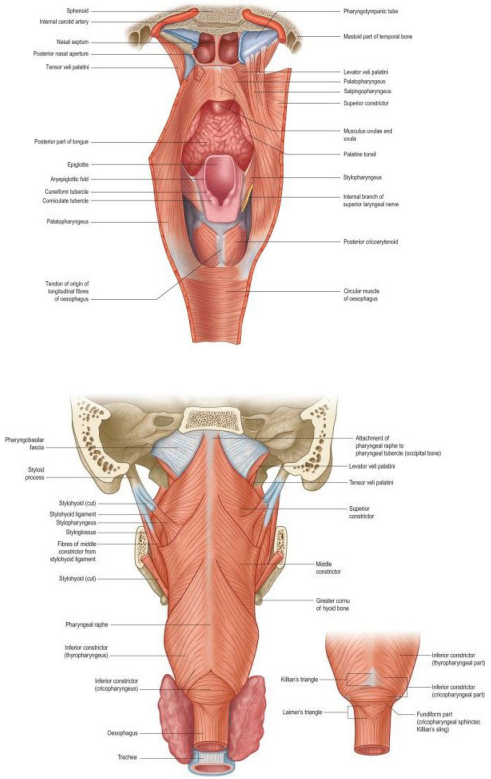
Pharyngeal Constrictors: Anatomy

- longitudinal muscles: stylopharyngeus, salpingopharyngeus, palatopharyngeus
- circular constrictors: superior, middle, and inferior
- epiglottis, larynx
- posterior surface of base of tongue
- suprahyoid muscles (geniohyoid, mylhyoid, digastric)





Pharyngeal Constrictors: Anatomy



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Pharyngeal Constrictors: Anatomy, Literature

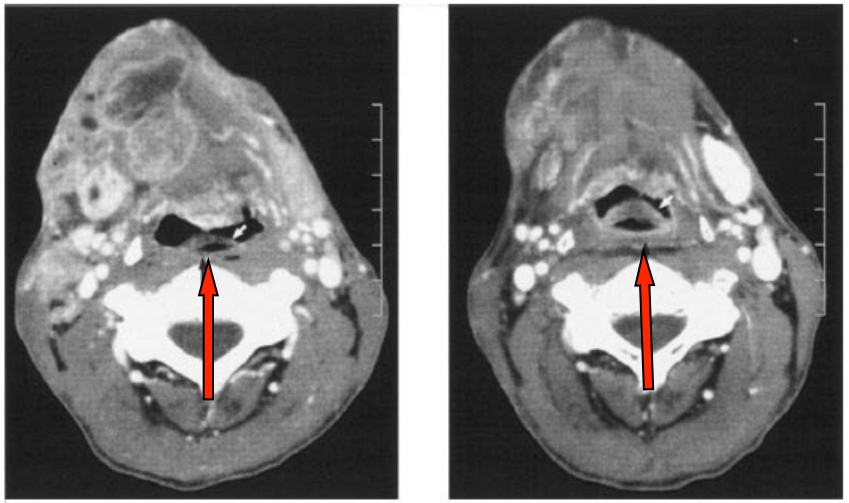
DARS: dysphagia aspiration related structures

CT:

- Constrictors: median medial thickness – 2.5 mm to 7 mm
- Larynx (supraglottic + glottic): 2 mm to 4 mm

** Primary Structures:

1. Pharyngeal Constrictors
2. Larynx



Eisbruch IJROBP, 2004

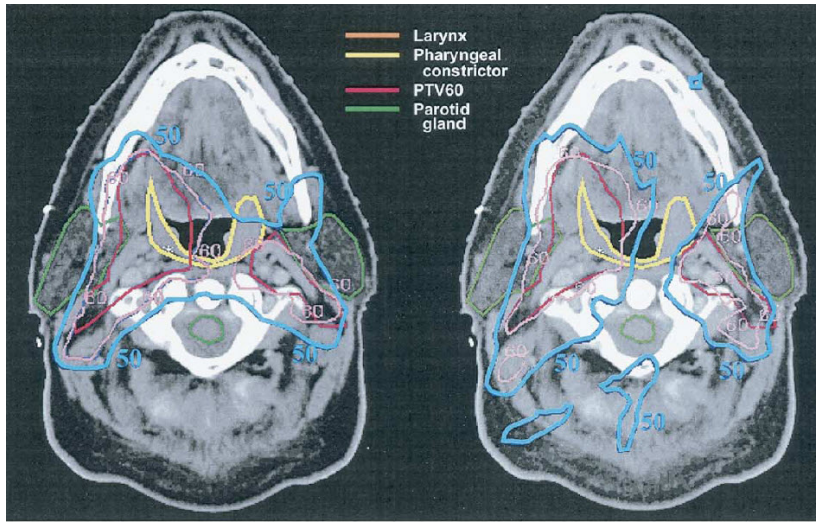
Pharyngeal Constrictors: Eisbruch

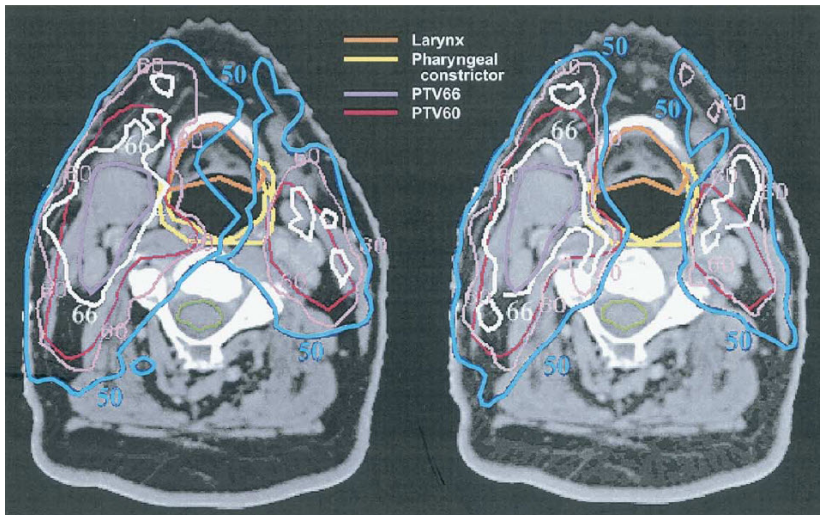
Pharyngeal constrictors

- lateral and posterior pharyngeal walls
  - superior: to pterygoid plates
  - middle: to hyoid bone
  - inferior: to thyroid cartilage
  - contoured as single organ

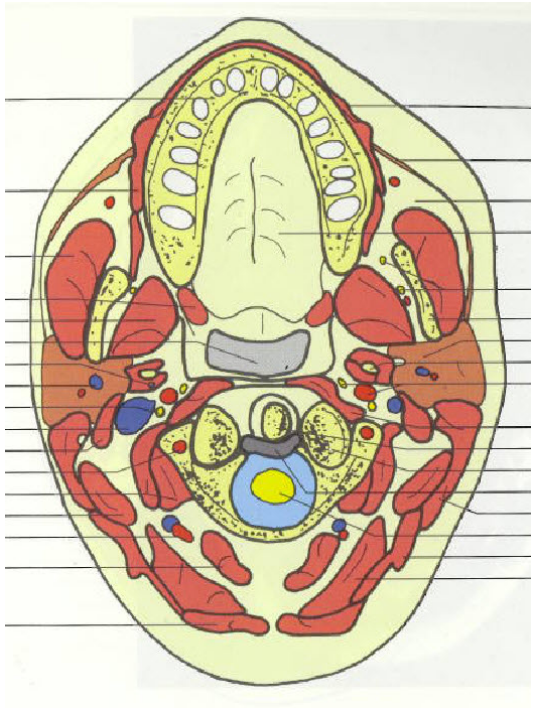
Supraglottic and glottic larynx

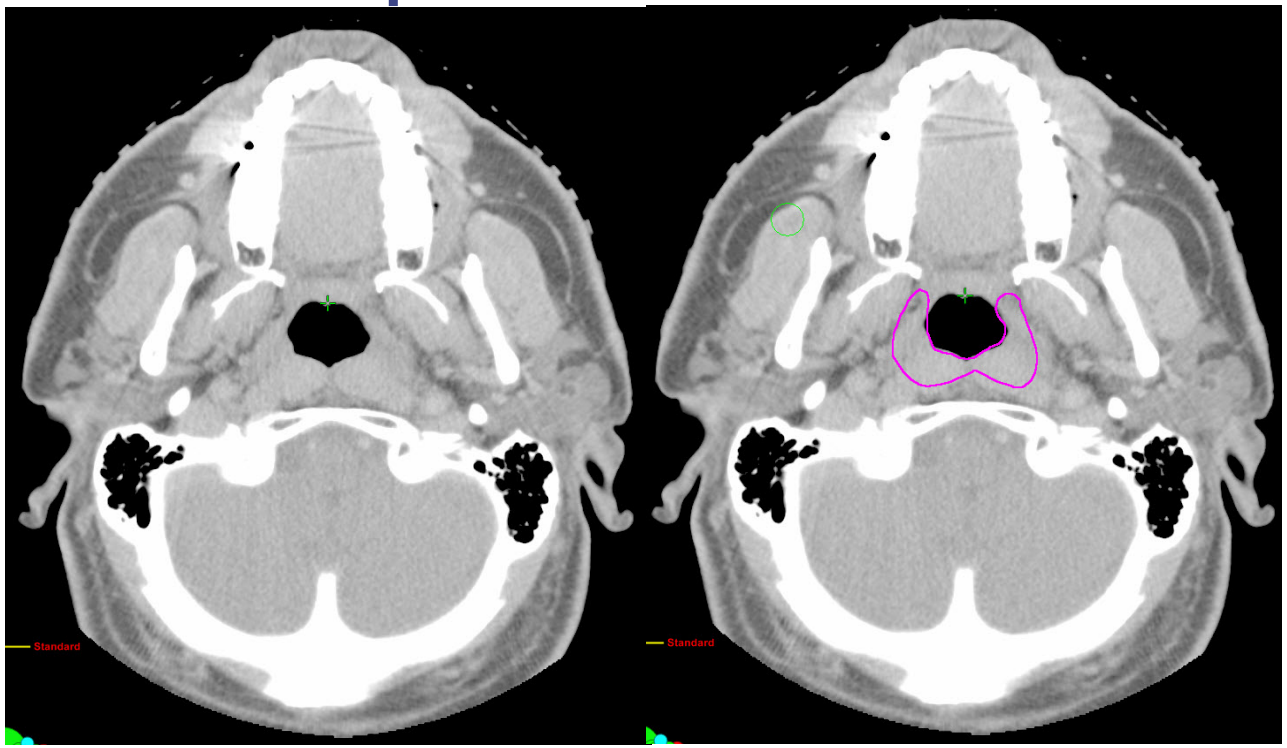
- contoured as single organ

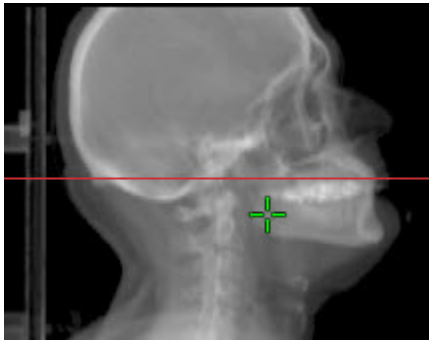




Pharyngeal Constrictors: Superior Neck







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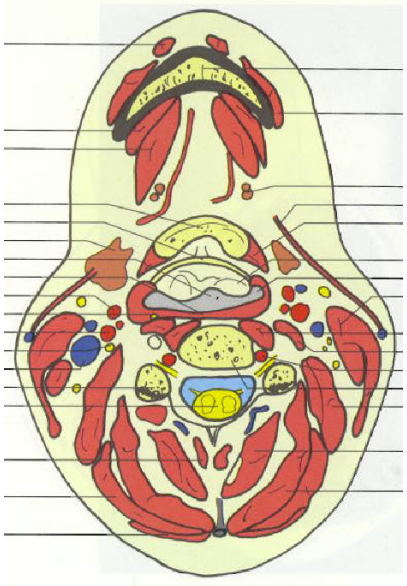
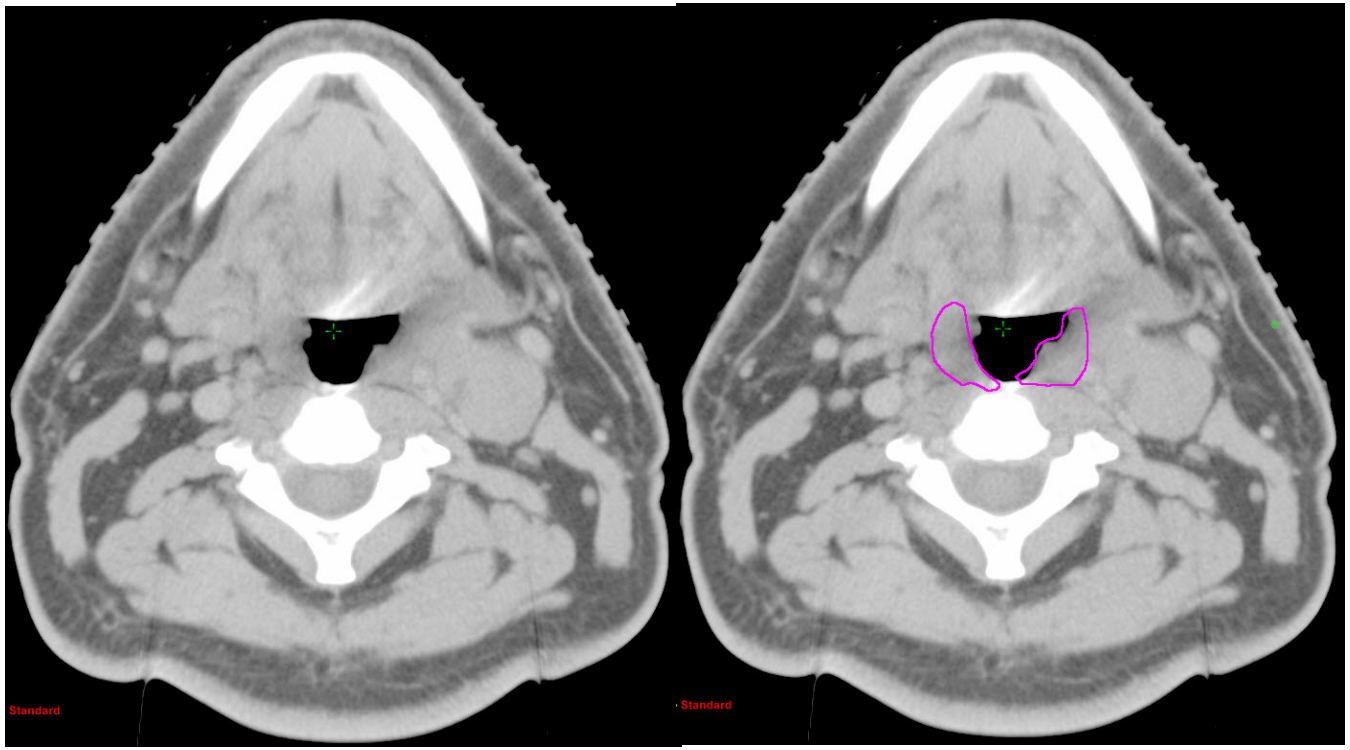
Pharyngeal Constrictors: Hyoid Bone





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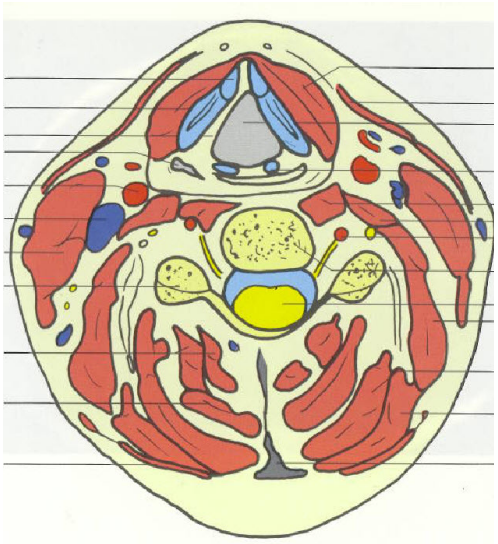
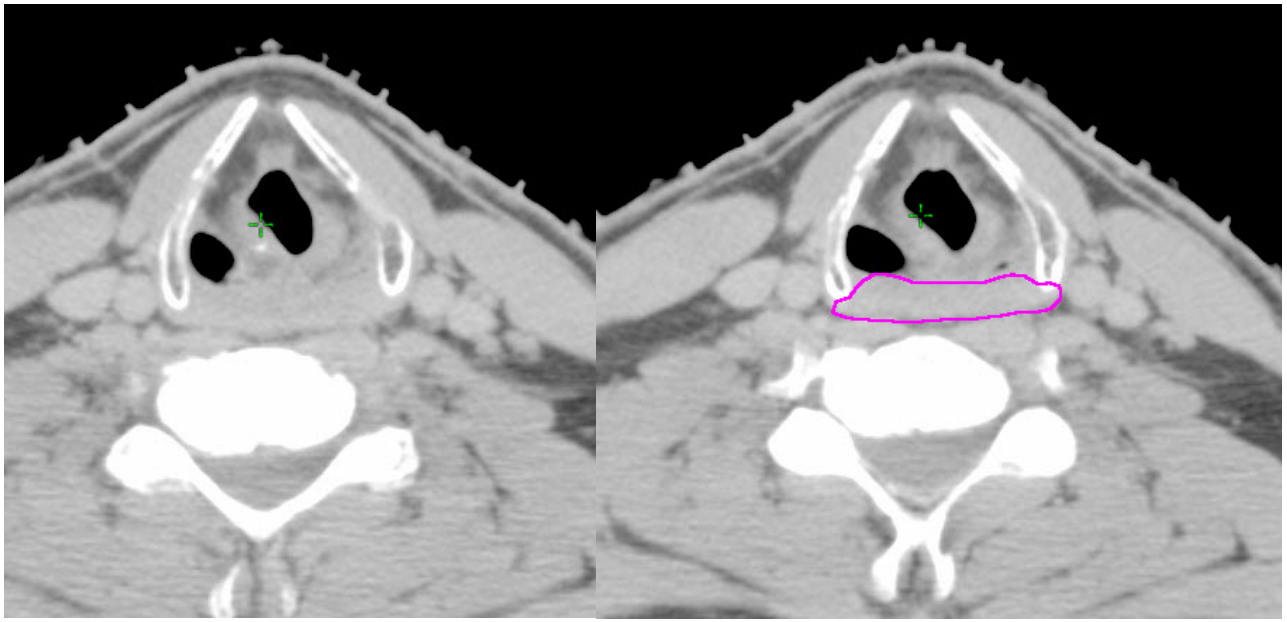
Pharyngeal Constrictors: Thyroid Cartilage





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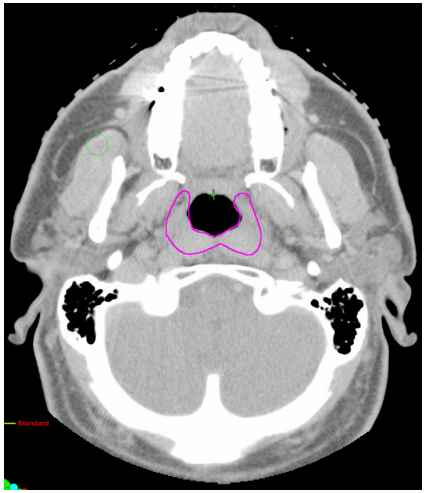
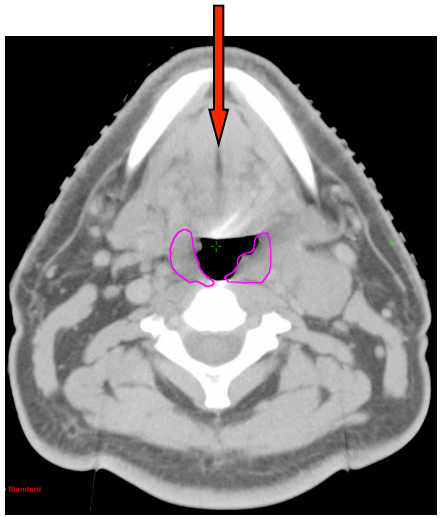
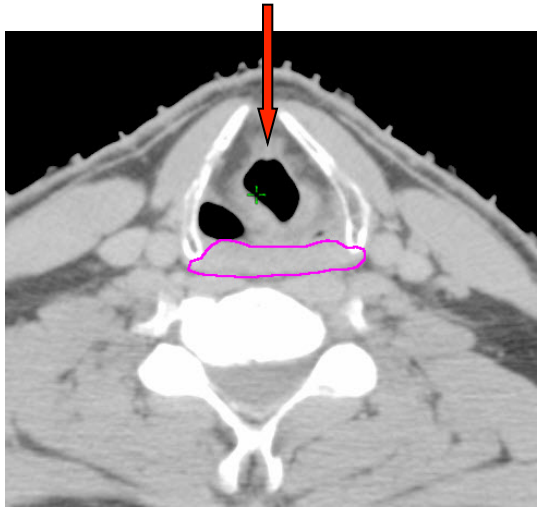
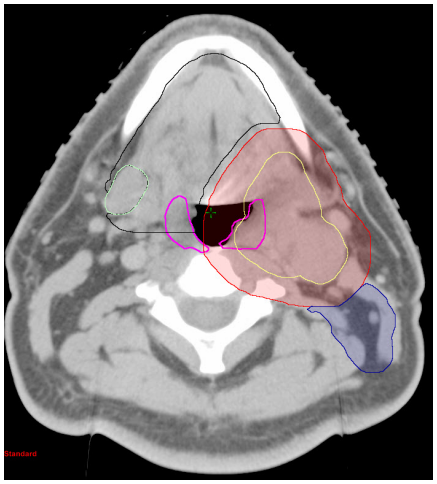
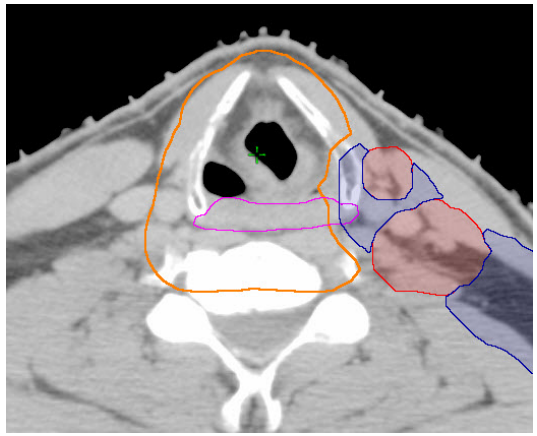
Pharyngeal Constrictors











- Larynx
- Oral Cavity
- PTV overlap

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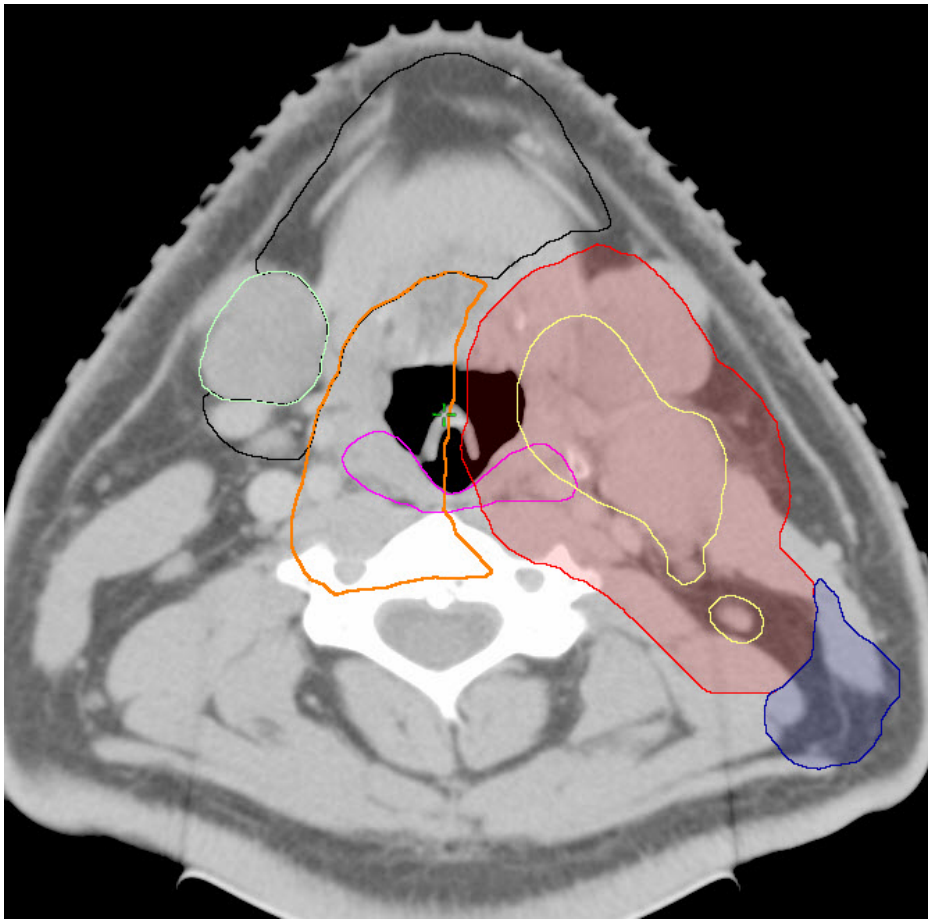
Pharyngeal Constrictors: Unilateral PTV



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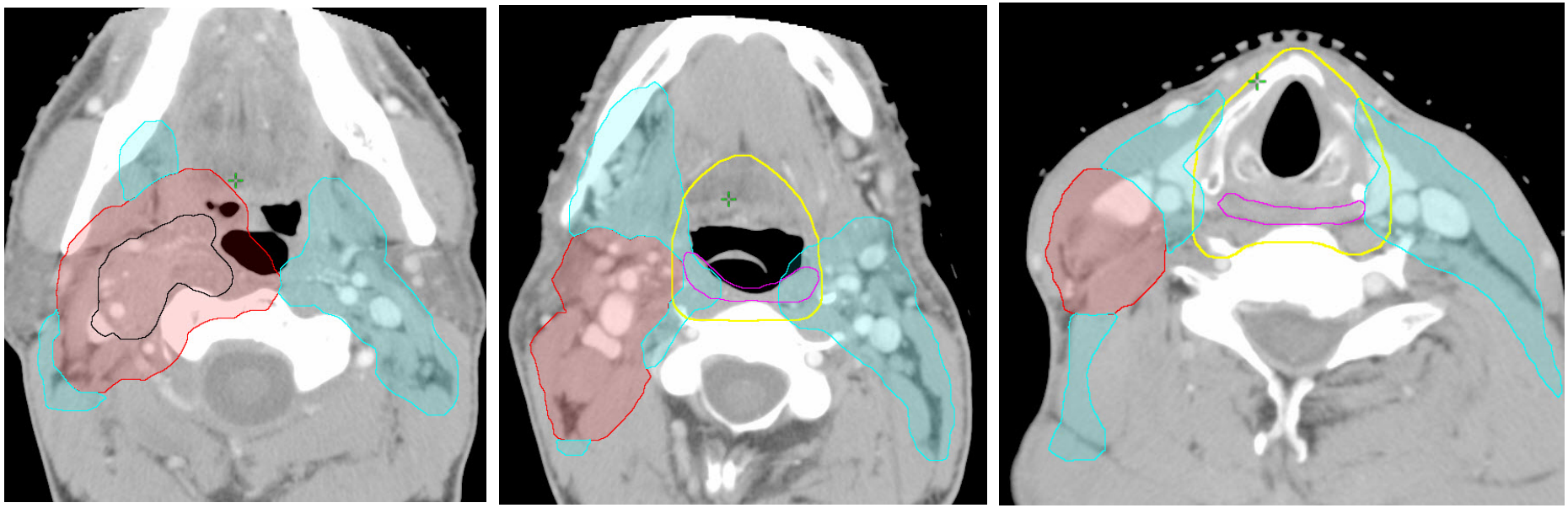
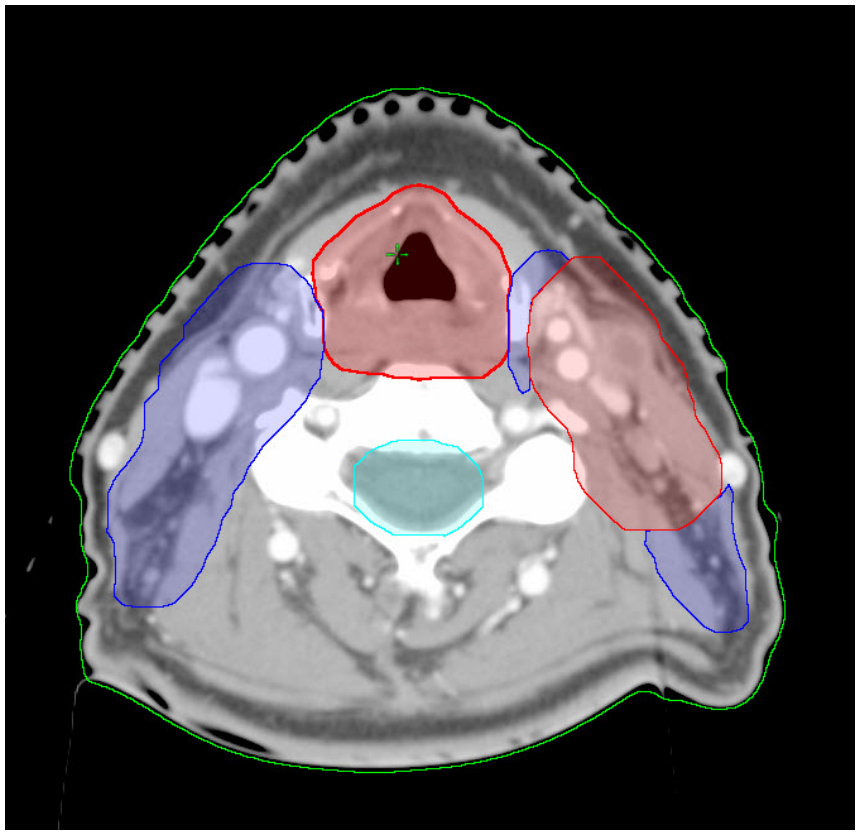
Pharyngeal Constrictors: Bilateral PTV



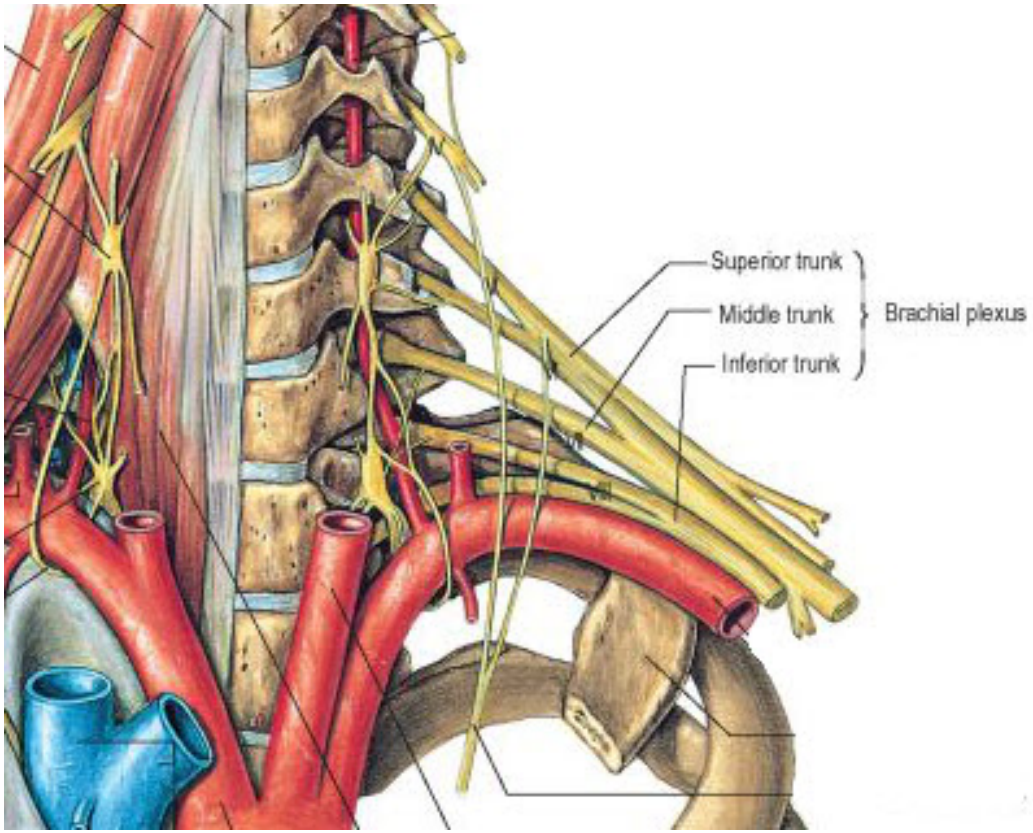
Pharyngeal Constrictors: Summary

- Clinically important
- Difficult to spare, depending on adjacent targets
    - Ipsilateral vs bilateral RT
- Adjacent structures:
    - Larynx
    - Oral Cavity

- Consider combination:
    - Laryngopharynx
    - Oral Cavity/Pharynx



Brachial Plexus



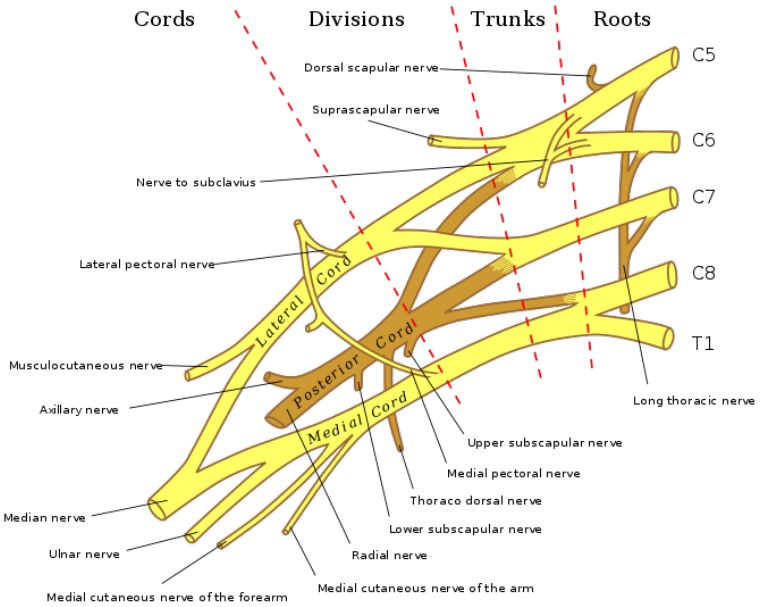
- Anatomy
- Literature
- Examples

Brachial Plexus: Anatomy

- Cutaneous and muscular innervation “most” of upper limb
  - Two exceptions:
    - trapezius muscle (spinal accessory nerve [CN XI])
    - area of skin near axilla (intercostobrachial nerve)

- The five **roots** merge to form three **trunks**:
  - Super: C5, C6
  - Middle: C7
  - Inferior: C8, T1

Hard To See!



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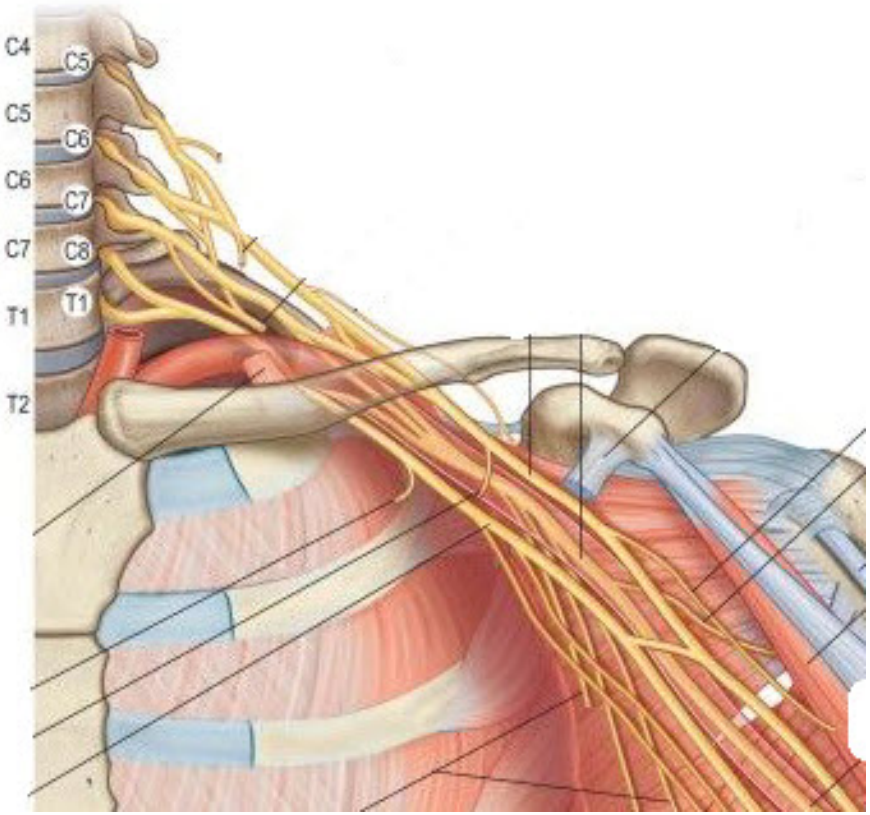
Brachial Plexus: 5 Roots → 3 Trunks

** Note **

- Seven cervical vertebrae (C1-C7)
- Eight cervical nerves (C1-C8)
  - C1-C7: emerge *above Cx*
  - C8: emerges *below C7*
  - T1 etc emerge *below T1*



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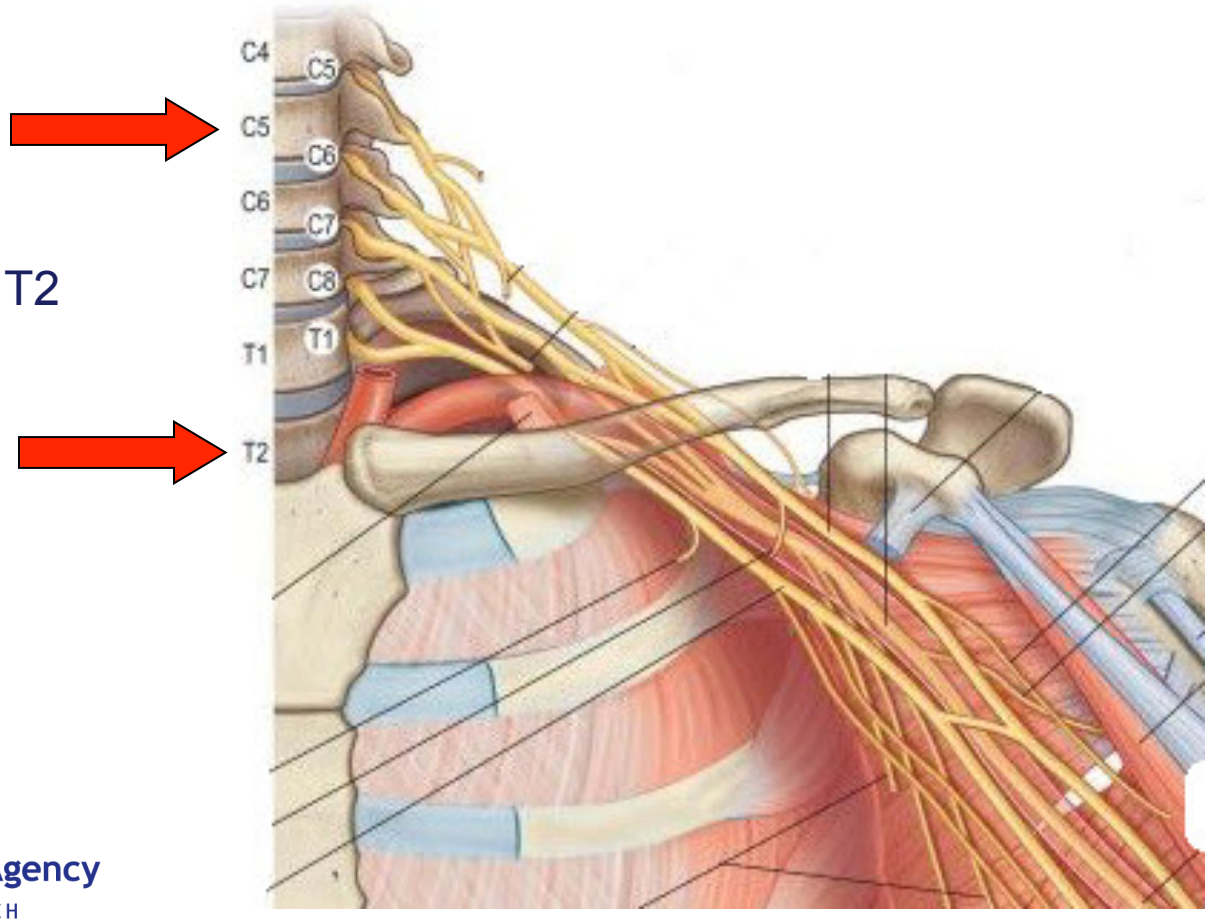
Brachial Plexus: Landmarks

C5, T2



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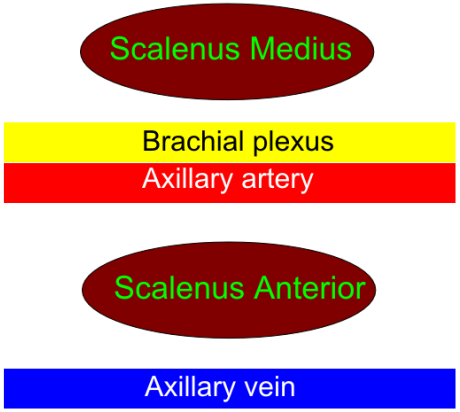
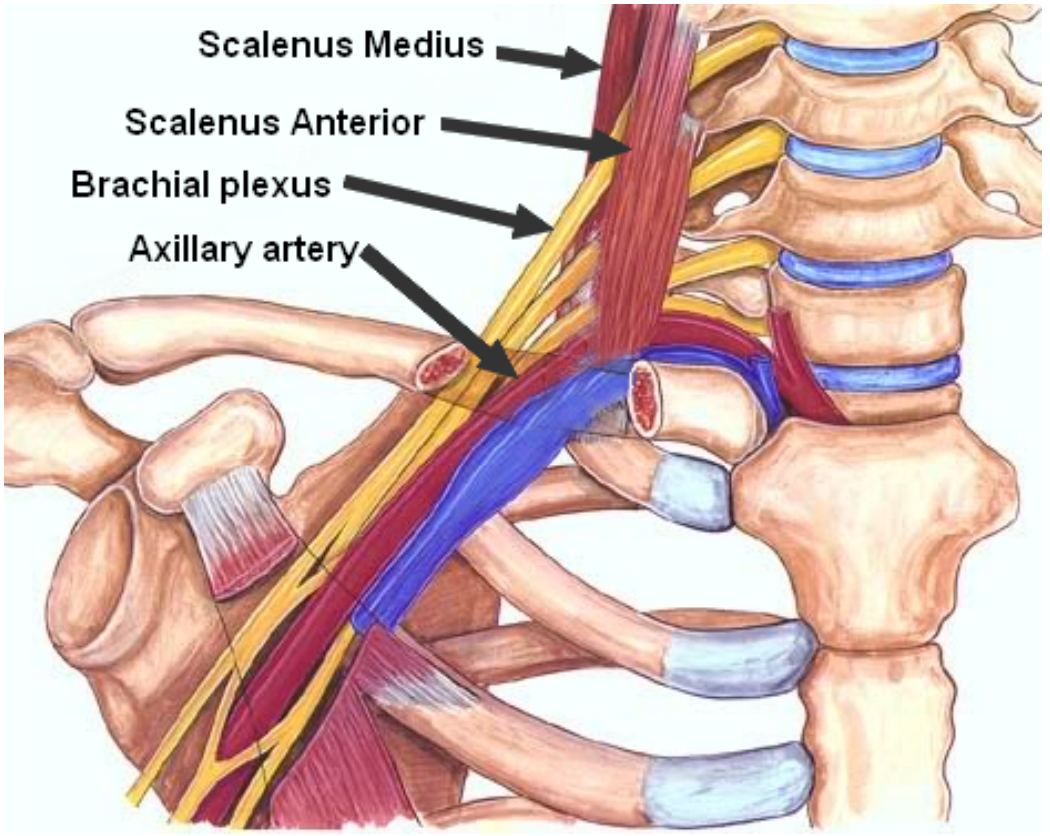
Brachial Plexus: Landmarks

Brachial Plexus travels between:

- **Scalenus Anterior**
- **Scalenus Medius**





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Dr. Monty Martin, BCCA (Chief, Neuroradiology)

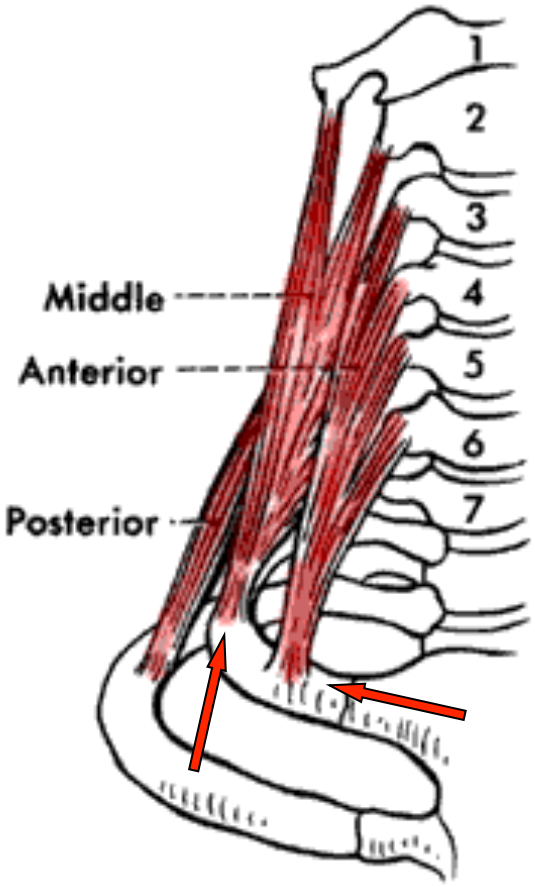
Brachial Plexus: Ant/Med Scalenus

Anterior Scalenus:

- aka scalenus anterior, scalenus anticus
- transverse processes of C3-C6 to first rib
    - anterior to medial scalenus

Medial Scalenus:

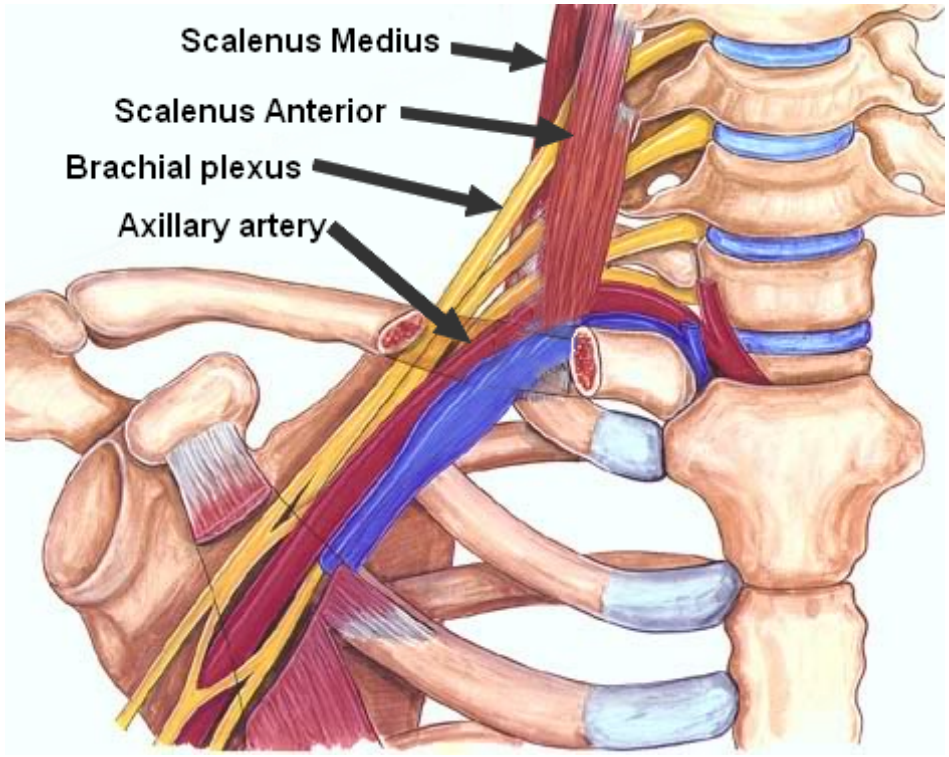
- largest and longest of the three scalene muscles
- posterior tubercles of transverse processes C2-C7 to first rib



The scalene muscles.

Brachial Plexus: Axilla

- Behind **Axillary Artery**



Posterior

Scalenus Medius

Brachial plexus

Axillary artery

Scalenus Anterior

Axillary vein

Anterior

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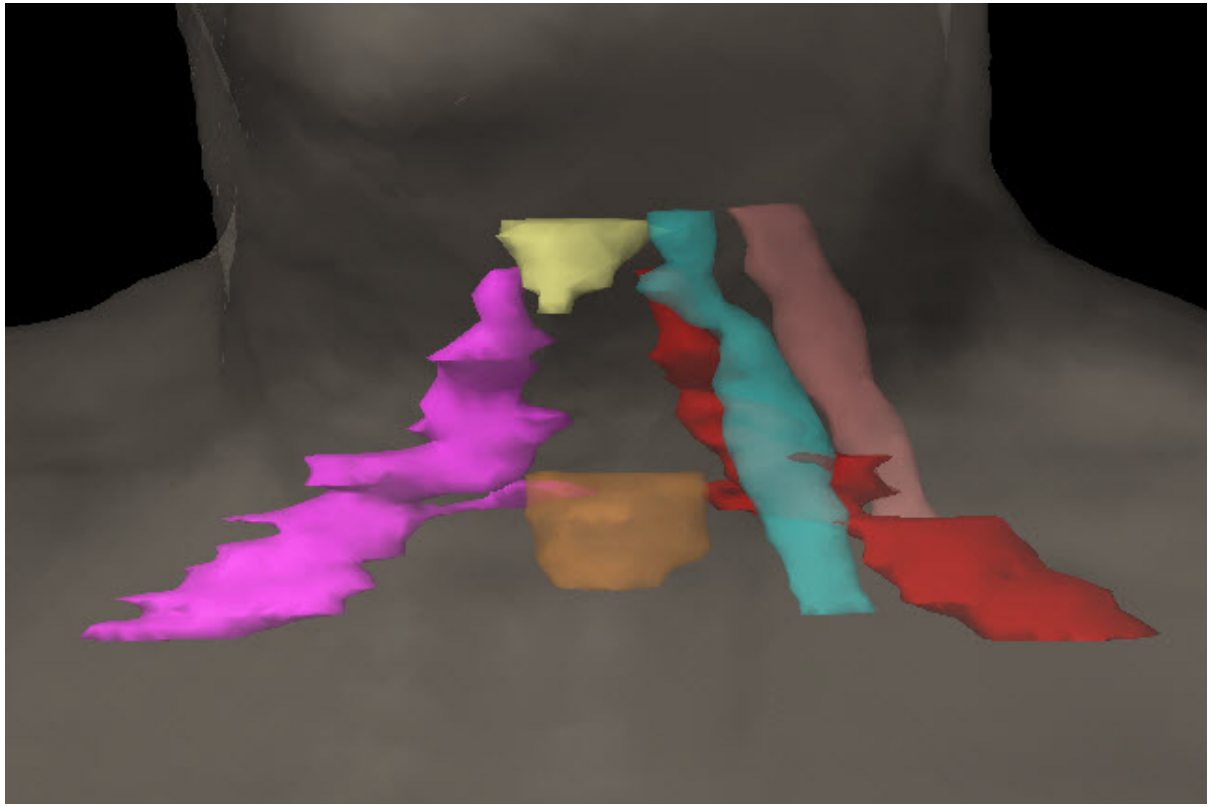
Brachial Plexus: Landmarks

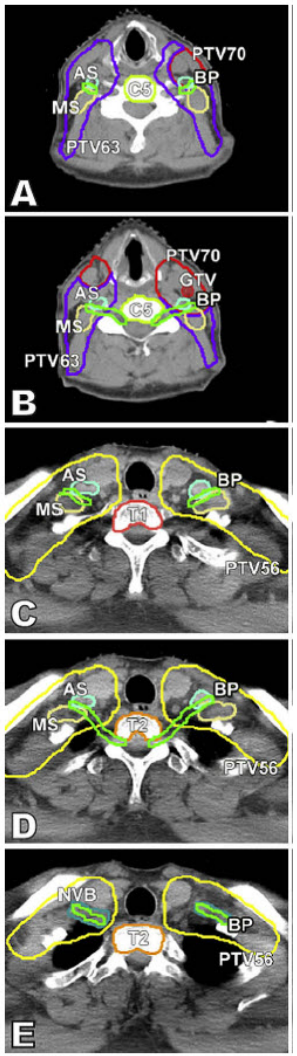
- C5
- T1 or T2
- Anterior scalenus
- Medial scalenus

Axilla:

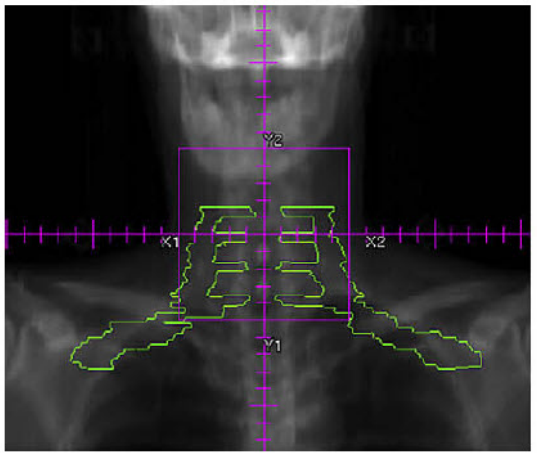
- Axillary artery



Brachial Plexus: Literature

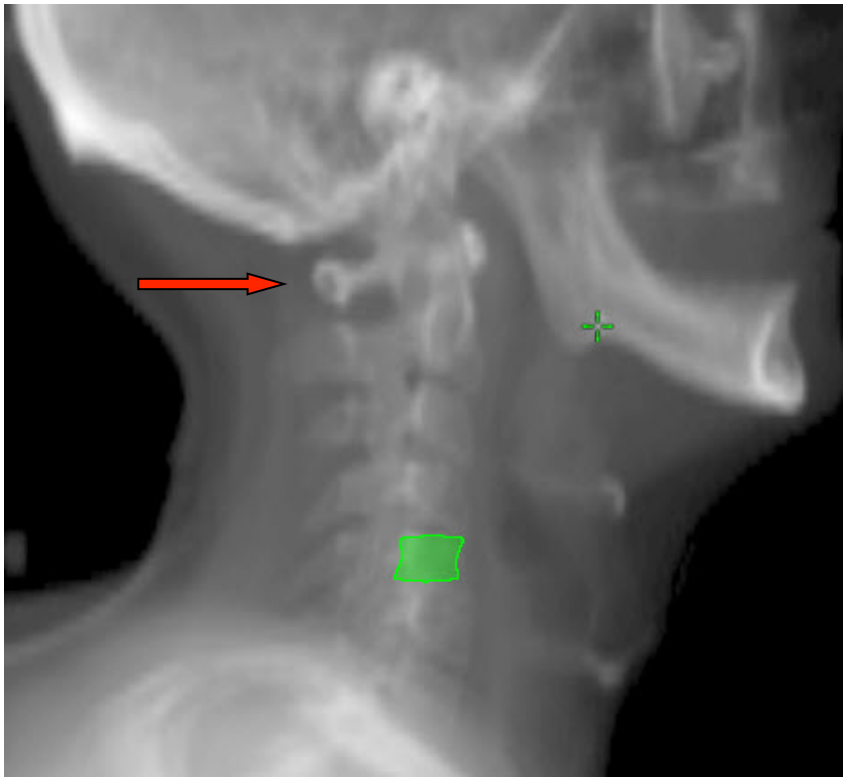


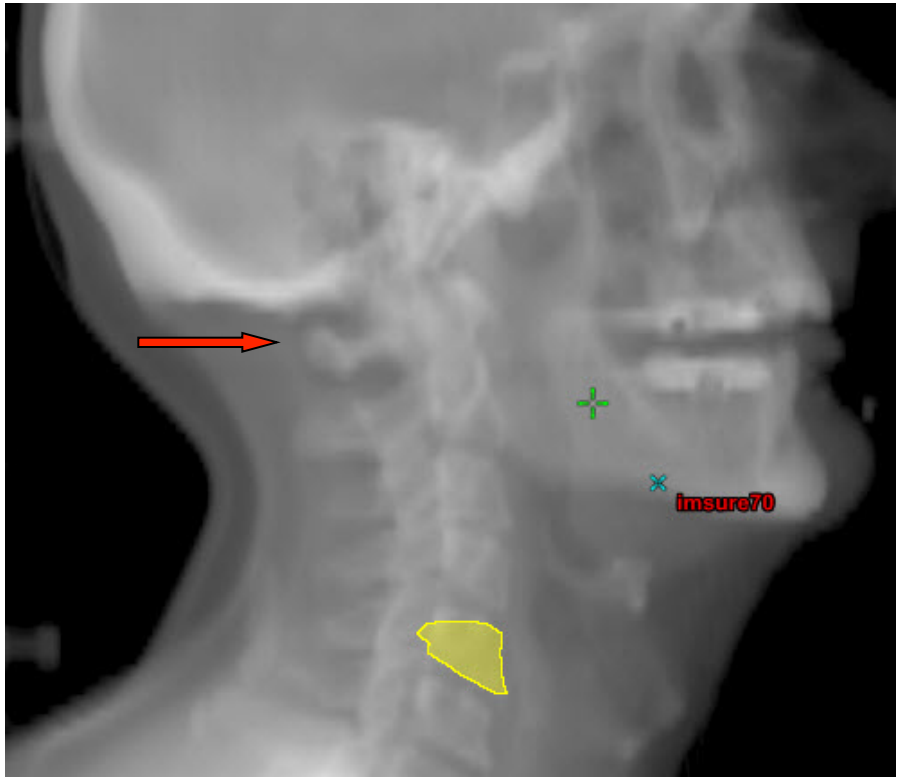
1. Identify and contour C5, T1, and T2.
2. Identify and contour the subclavian and axillary neurovascular bundle.
3. Identify and contour anterior and middle scalene muscles from C5 to insertion onto the first rib.
4. To contour the brachial plexus OAR use a 5-mm diameter paint tool.
5. Start at the neural foramina from C5 to T1; this should extend from the lateral aspect of the spinal canal to the small space between the anterior and middle scalene muscles.
6. For CT slices, where no neural foramen is present, contour only the space between the anterior and middle scalene muscles.
7. Continue to contour the space between the anterior and middle scalene muscles; eventually the middle scalene will end in the region of the subclavian neurovascular bundle.
8. Contour the brachial plexus as the posterior aspect of the neurovascular bundle inferiorly and laterally to one to two CT slices below the clavicular head.
9. The first and second ribs serve as the medial limit of the OAR contour.



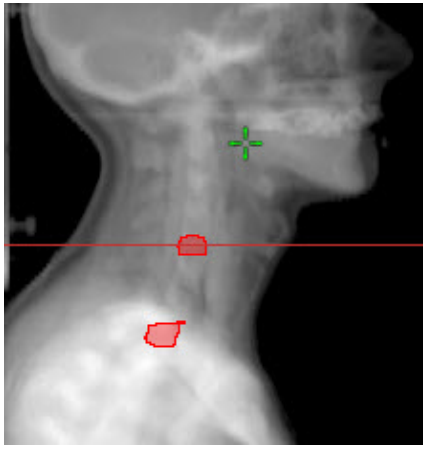
Hall et al, IJROBP, 2008

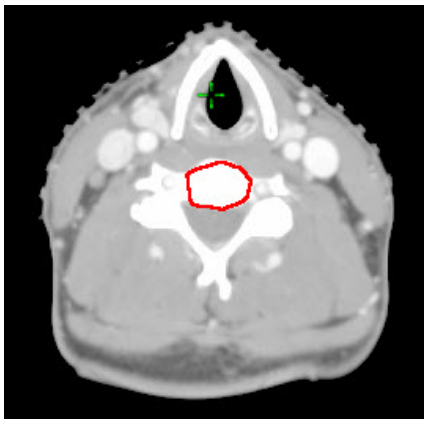
Brachial Plexus: Examples – C5

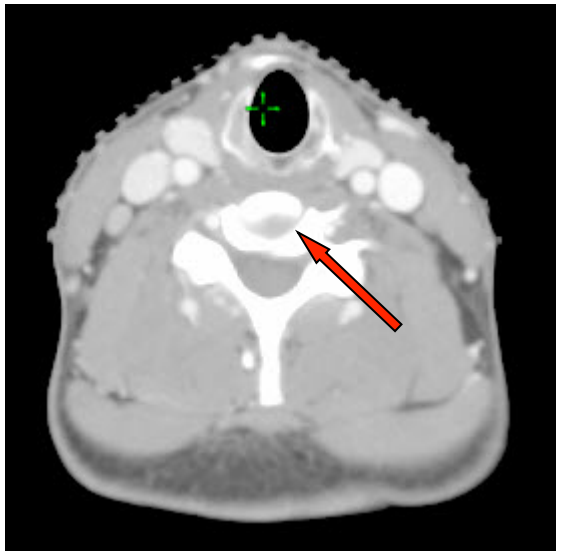


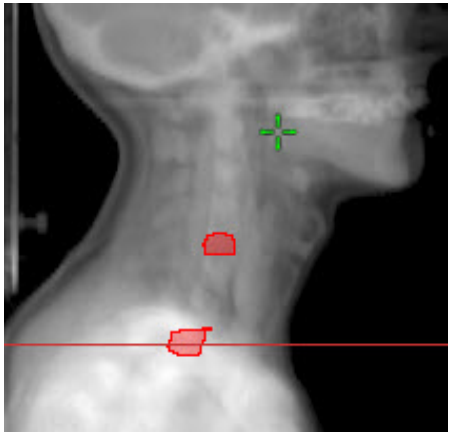


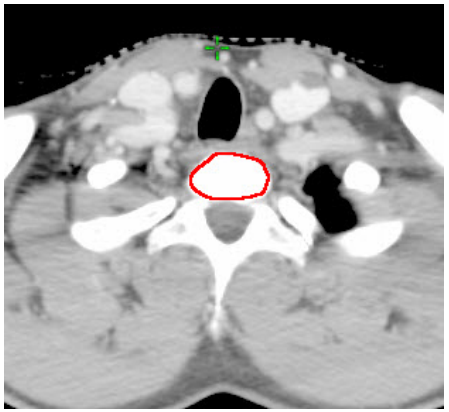
Brachial Plexus: Examples – T1











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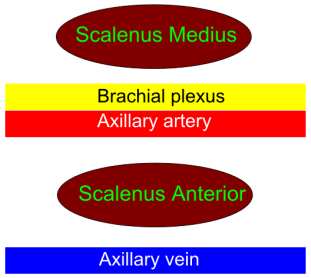
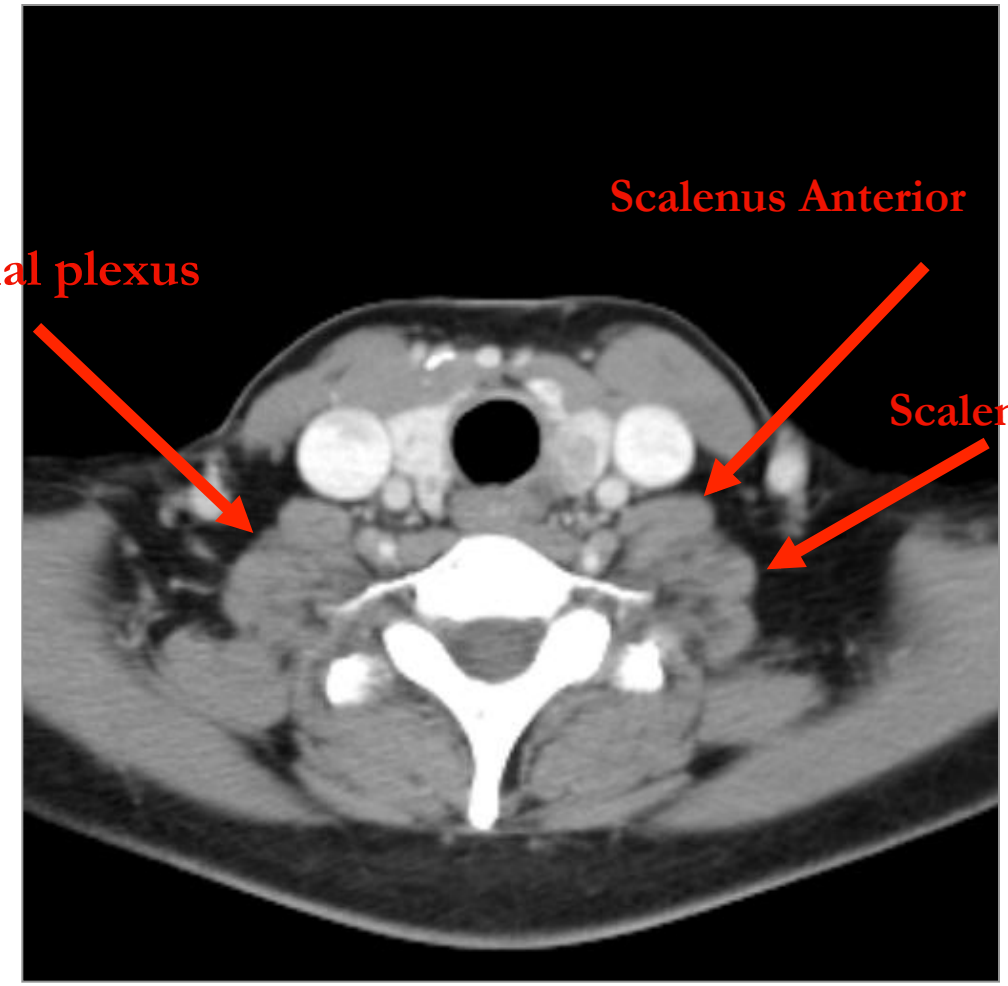
Brachial Plexus: Scalenus mm





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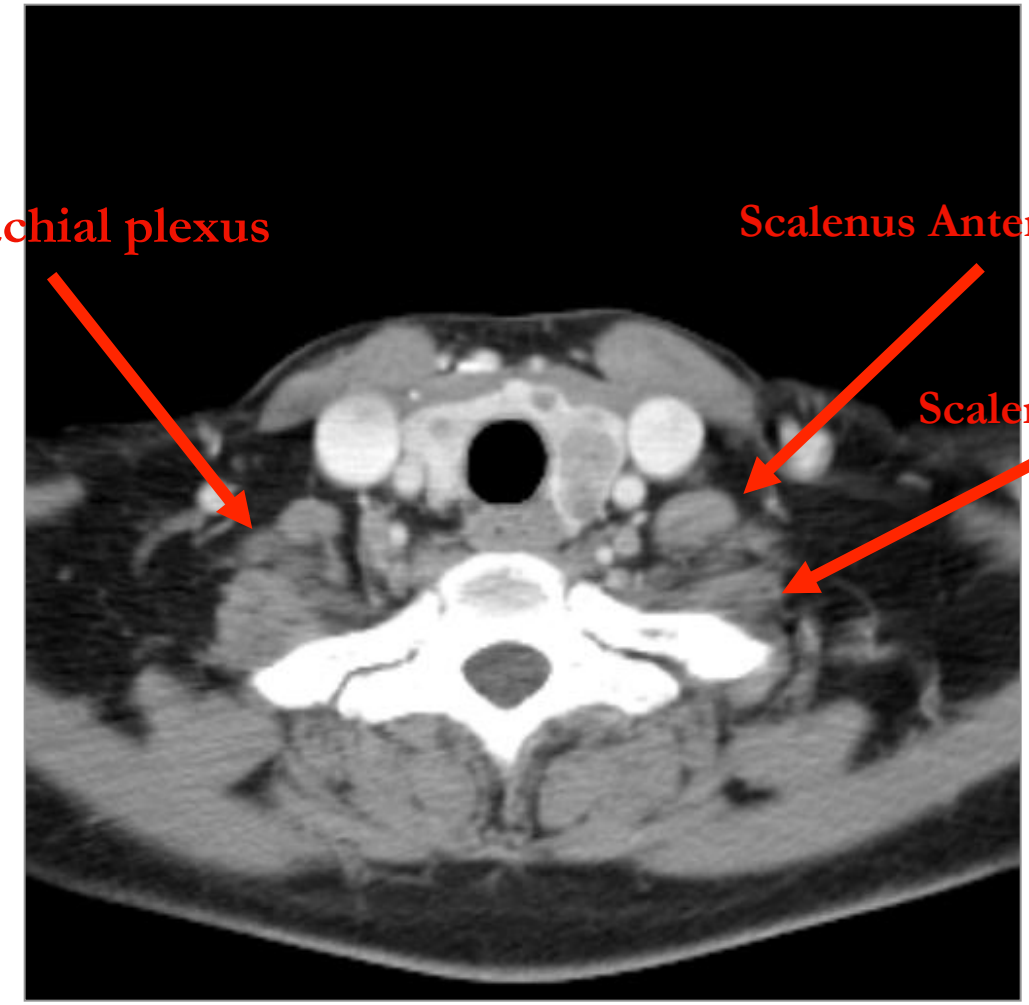
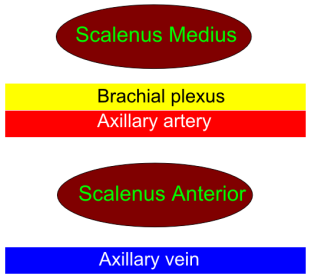
Brachial Plexus: Scalenus mm





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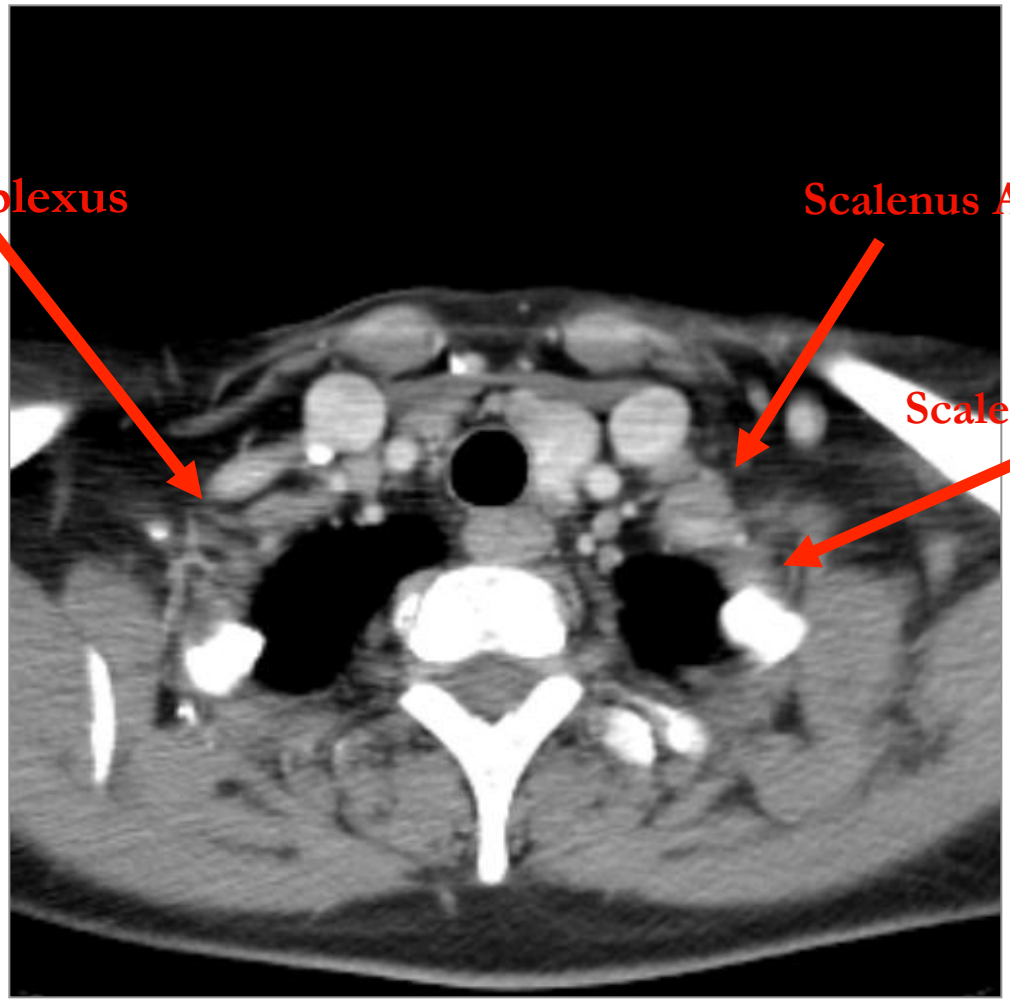
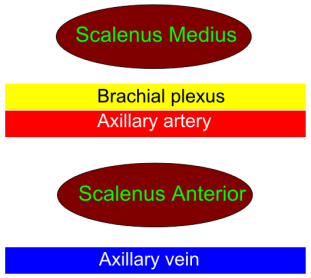
Brachial Plexus: Scalenus mm





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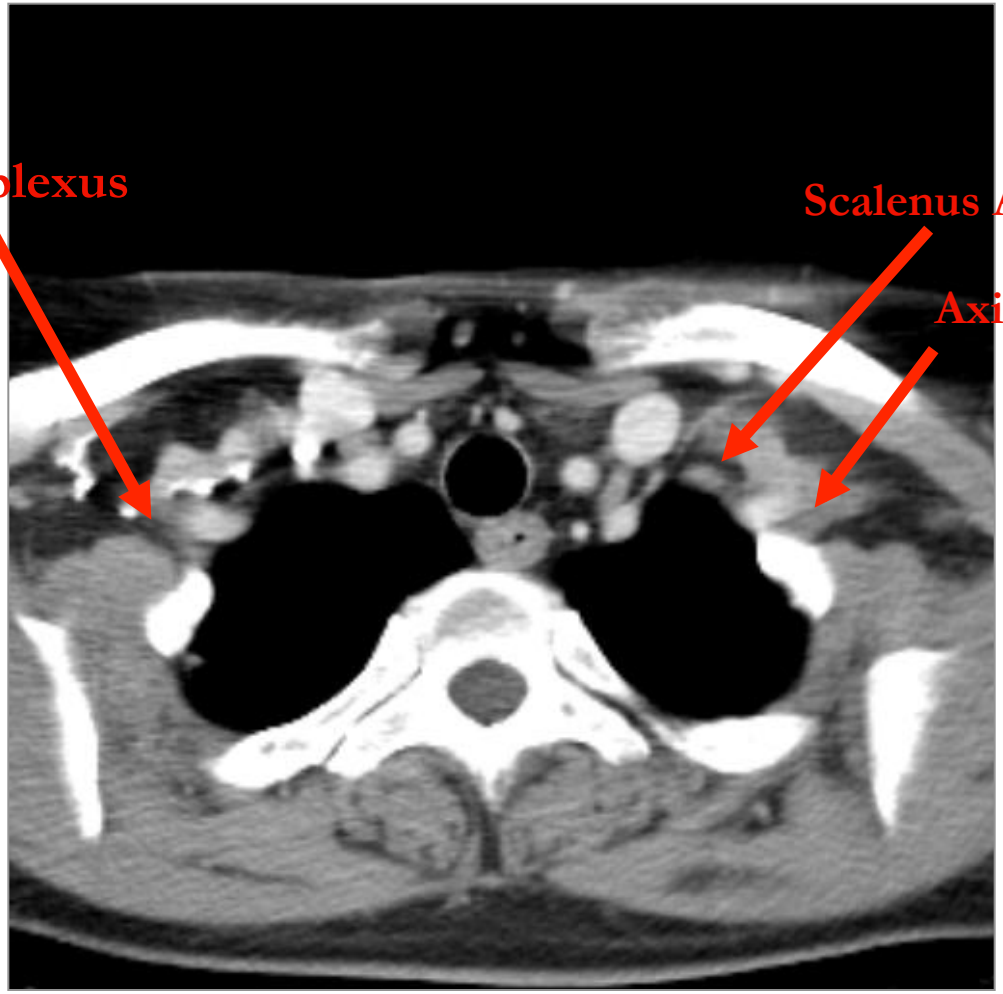
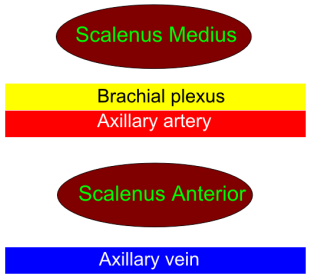
Brachial Plexus: Scalenus mm





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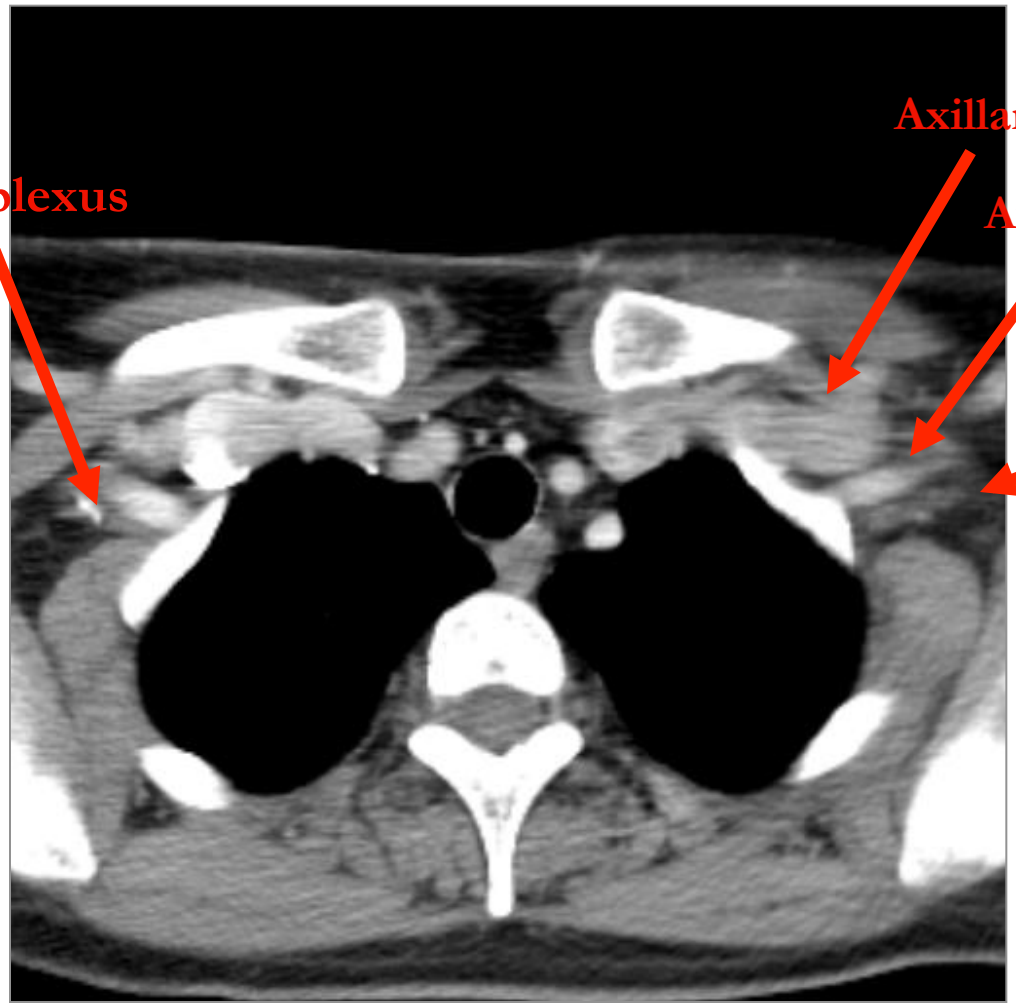
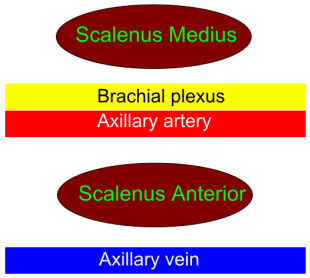
Brachial Plexus: Scalenus mm





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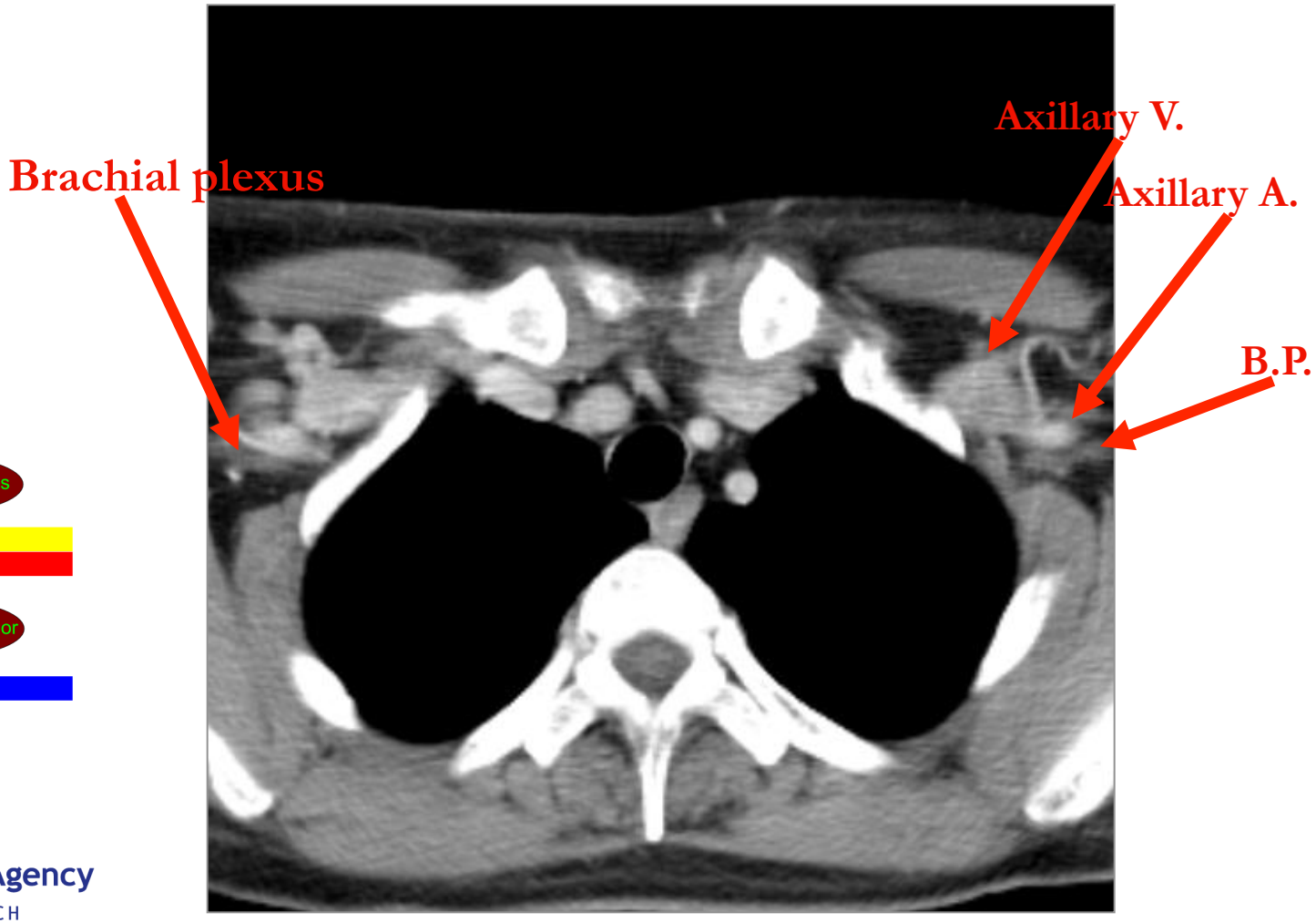
Brachial Plexus: Scalenus mm



Scalenus Medius

Brachial plexus

Axillary artery

Scalenus Anterior

Axillary vein

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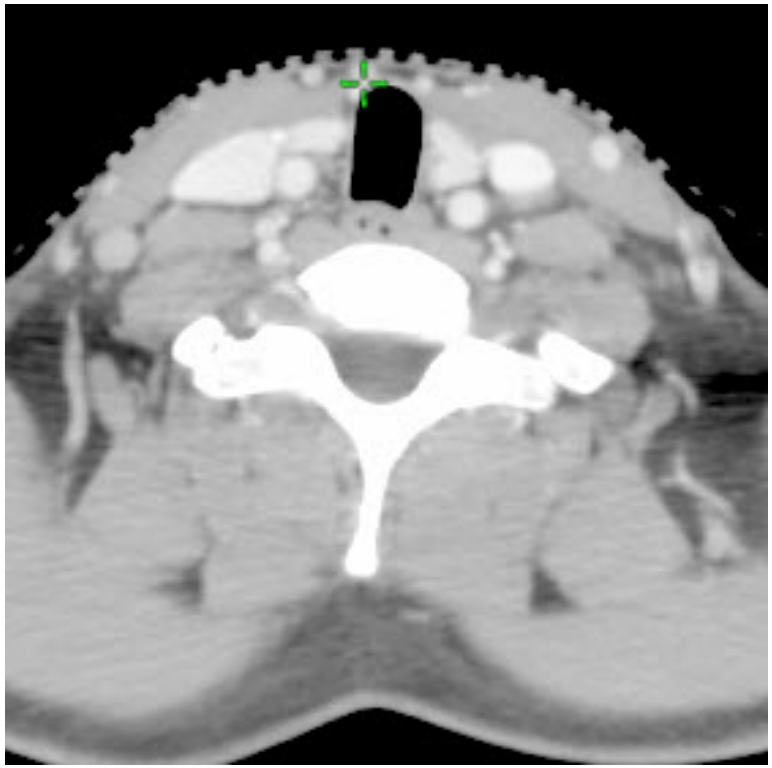
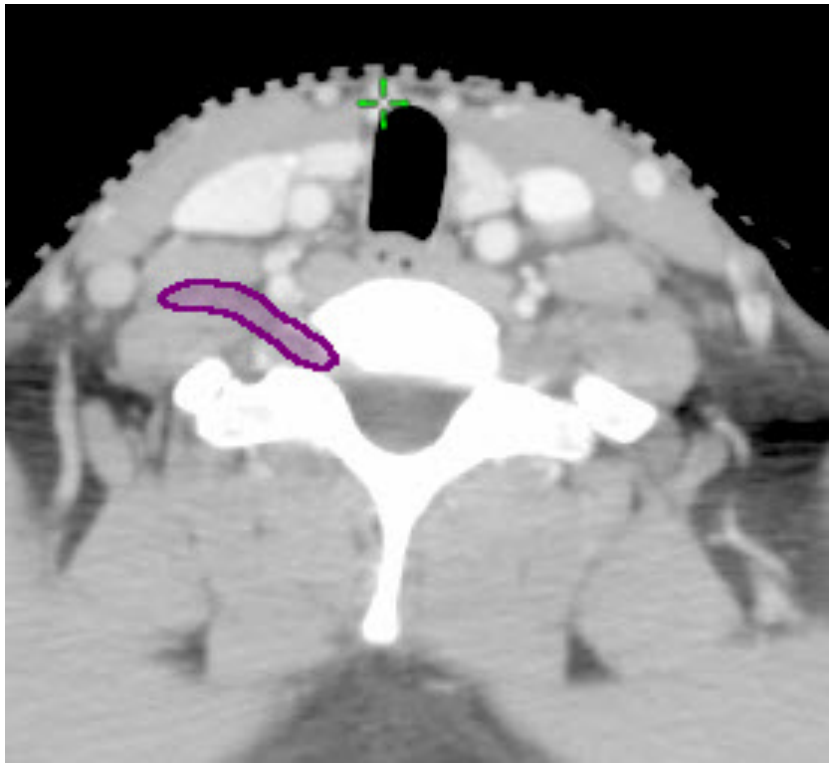
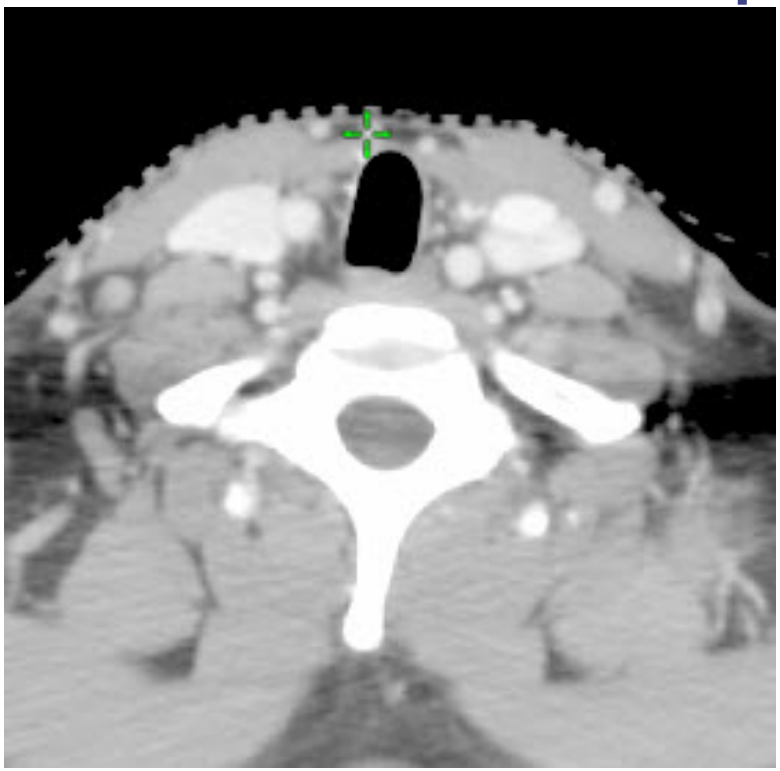
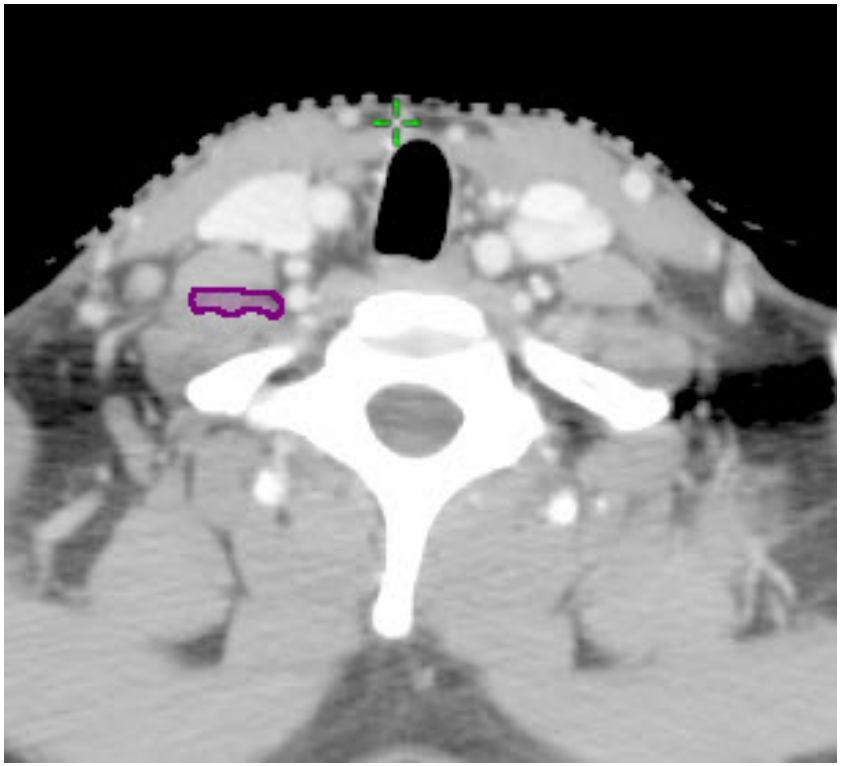
Brachial Plexus: Examples – Foramina



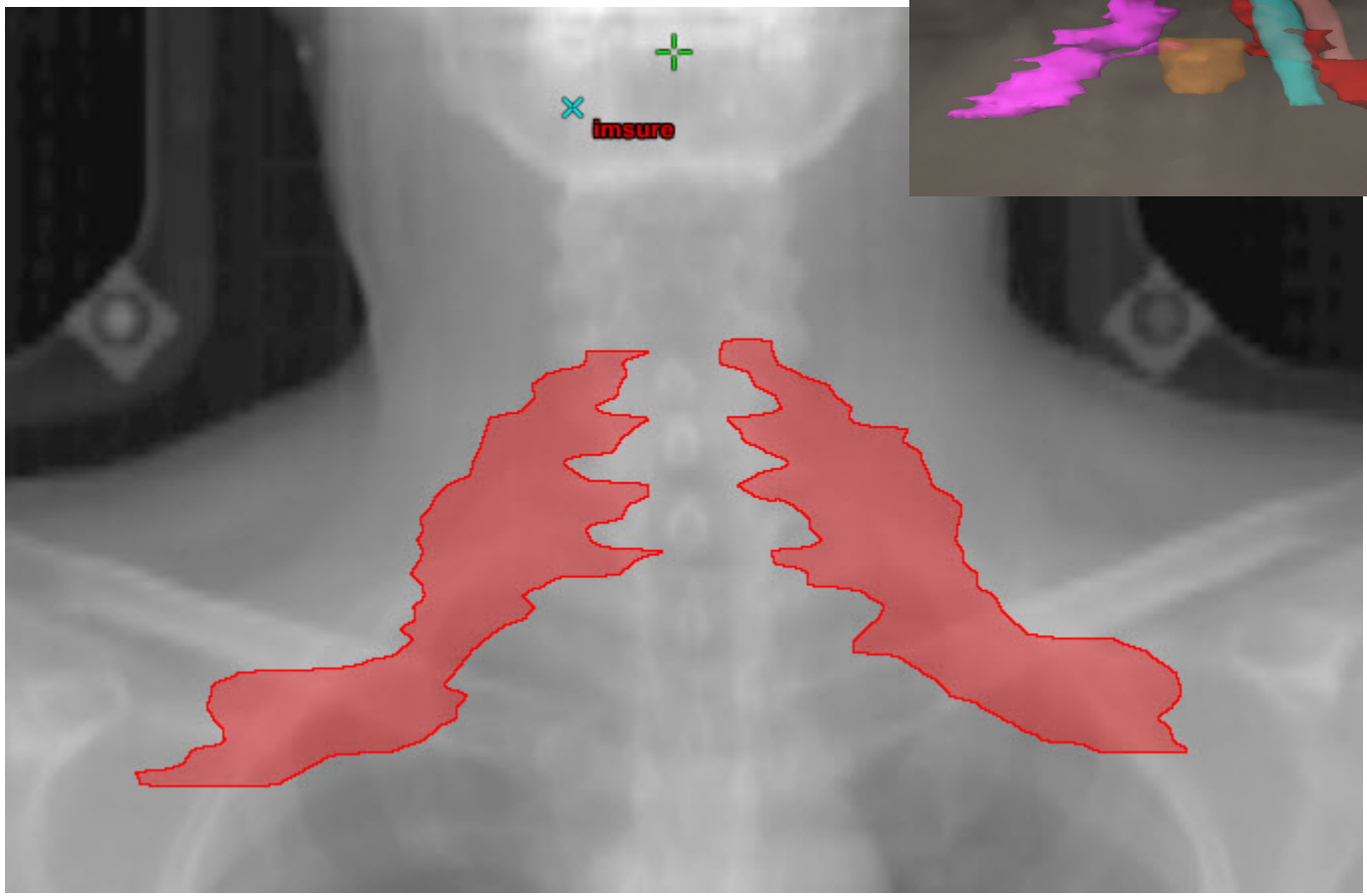


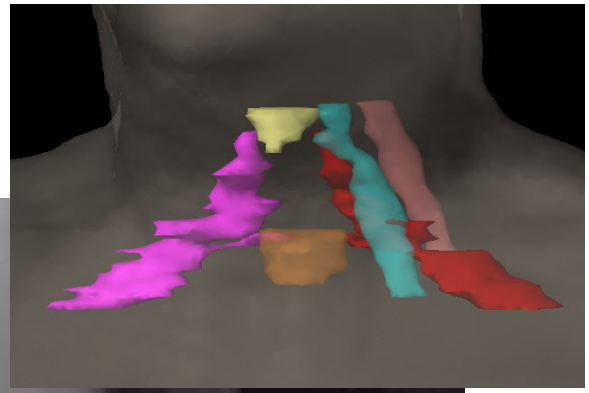
Brachial Plexus: Examples – Non-Foramina



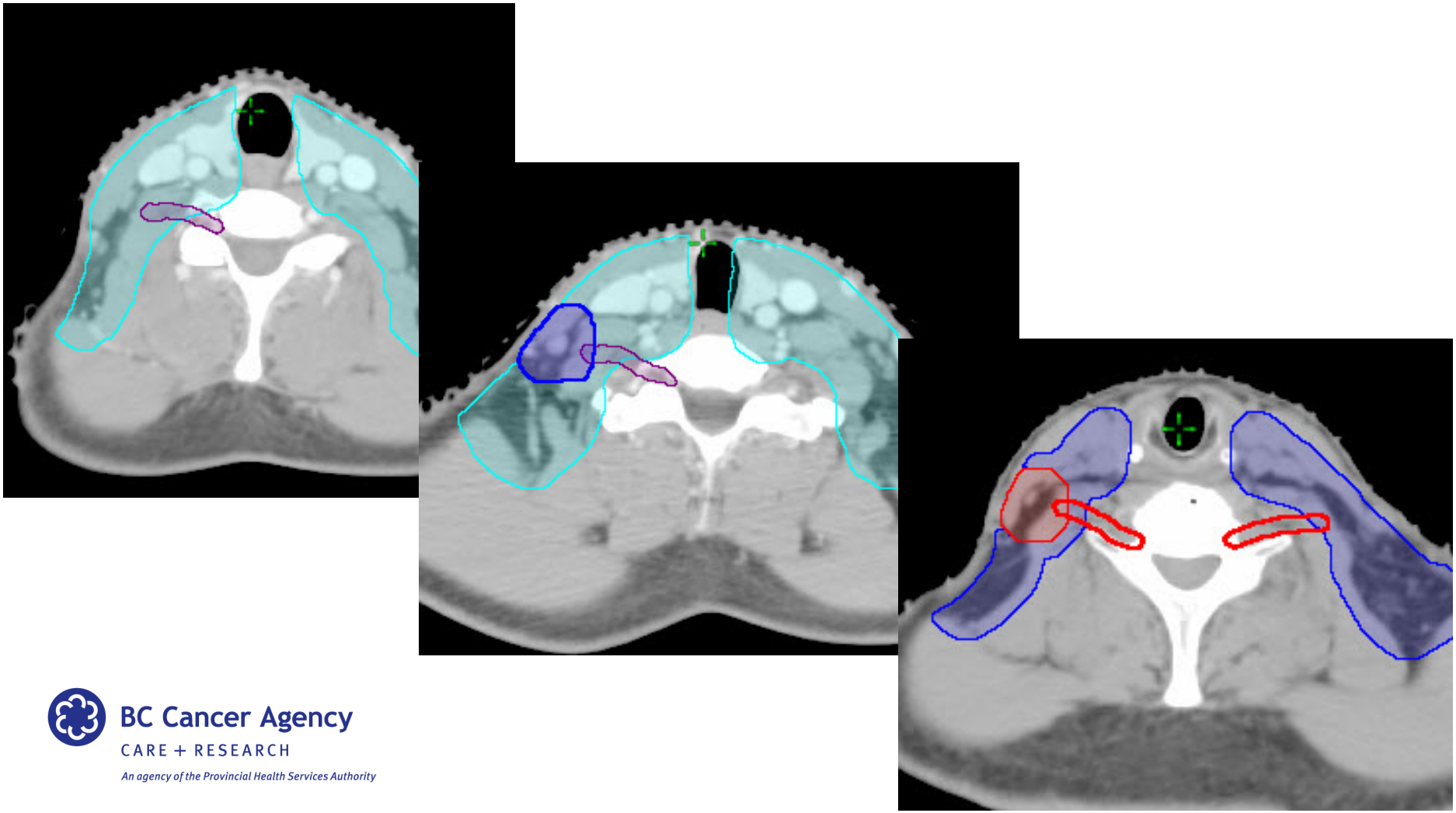


Brachial Plexus: Full Structure





Brachial Plexus: Examples



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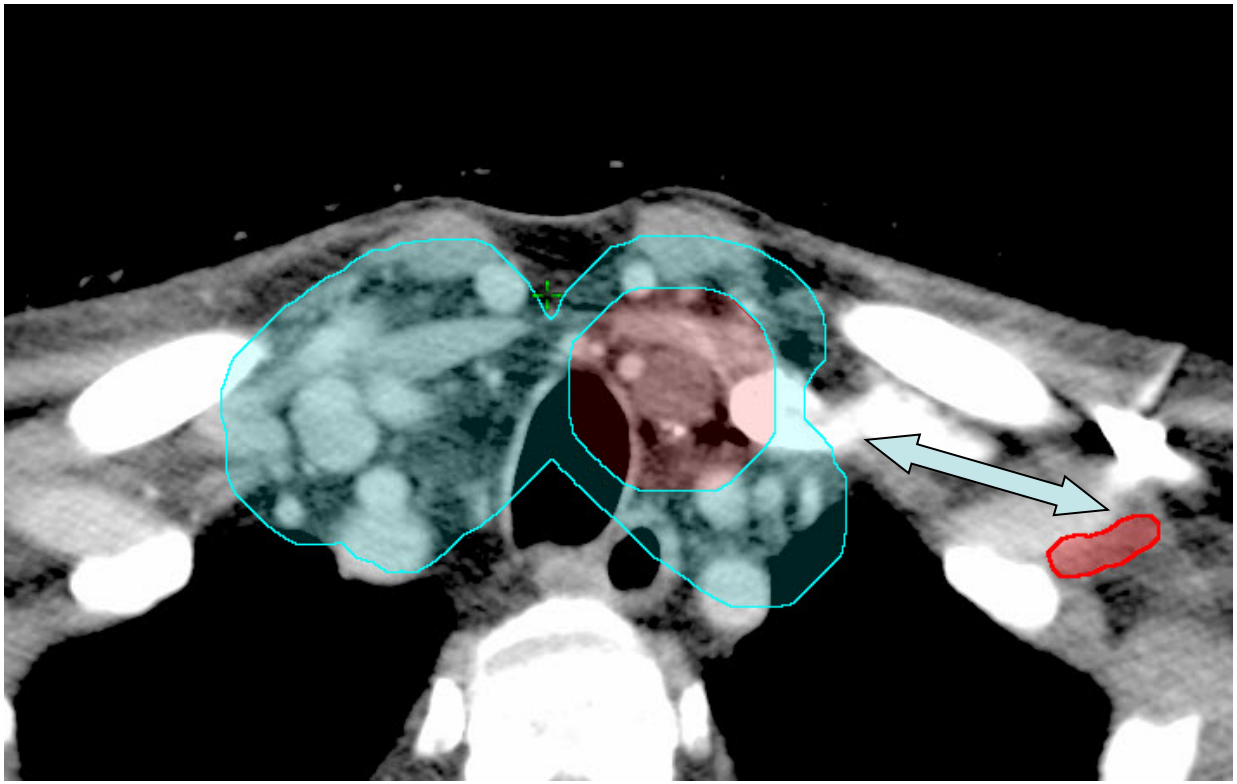
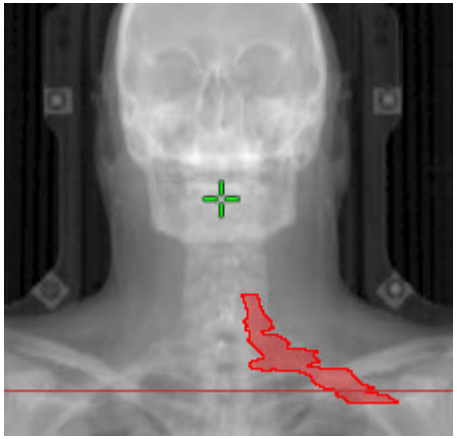
Brachial Plexus: Axilla





Brachial Plexus: Comments

- Brachial Plexopathy = rare
- Adjacent GTV/LN
- Not contoured off-study @ BCCA
- Reproducible contours possible
- Axilla?
- Further research
    - Dosimetric Repository

H&N Contouring: Summary

- Parotid Gland: variable in shape
- Submandibular Gland: superior end
- Pharyngeal Constrictors: Consider -
    - Laryngopharynx
    - Oral Cavity/pharynx
- Brachial Plexus: requires further study
- General technique:
    - Scroll
    - Superior/Inferior tool
    - Window level, maximize screen real estate
    - Tablet/Pen
    - Consultation: RO, DI

Acknowledgements

Dr. John Hay (Radiation Oncologist)
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