Practical Guides in Radiation Oncology
Series Editors: Nancy Y. Lee · Jiade J. Lu

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Yao Yu *Editors*

Target Volume Delineation and Field Setup

A Practical Guide for Conformal and Intensity-Modulated Radiation Therapy

Second Edition

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The series Practical Guides in Radiation Oncology is designed to assist radiation oncology residents and practicing radiation oncologists in the application of current techniques in radiation oncology and day-to-day management in clinical practice, i.e., treatment planning. Individual volumes offer clear guidance on contouring in different cancers and present treatment recommendations, including with regard to advanced options such as intensity-modulated radiation therapy (IMRT) and stereotactic body radiation therapy (SBRT). Each volume addresses one particular area of practice and is edited by experts with an outstanding international reputation. Readers will find the series to be an ideal source of up-to-date information on when to apply the various available technologies and how to perform safe treatment planning.

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Editors

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Nasopharyngeal Carcinoma

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Irene Karam, Nancy Y. Lee, Quynh-Thu Le, Brian O'Sullivan, Jiade J. Lu, and Ian Poon

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1.1 General Principles of Planning and Target Delineation

- Both physical examination and imaging data are required for accurate delineation of the primary tumor. A detailed endoscopic examination should be performed focusing on the anterior nasal space, nasopharynx, and oropharynx to describe the tumor extension and infiltration.
- Unless there is a contraindication (i.e. pacemaker), patients should undergo a diagnostic contrast-enhanced MRI of the nasopharynx and neck fused to the planning CT scan. Ideally, the MRI should be acquired in the treatment position with the radiation therapy immobilization device. Marrow infiltration of disease is best seen on T1-weighted non-contrast MRI sequence. MRI is critical for delineation of skull base and perineural disease.
- PET/CT should only be used as a guide for delineation of the primary site as it may underestimate or overestimate the true extent of disease, particularly at the skull base.
- PET/CT scan is extremely helpful, particularly for identifying small lymph node metastases. Simulation should be performed in the supine position with the head and neck in the neutral position with a 5-point thermoplastic mask covering from skull with or without the shoulder. The CT simulation (preferably 2–3 mm slice thickness) scan should be acquired with IV contrast typically from vertex to 2 cm below the sternoclavicular joints. In centers that prefer to treat with a beam split technique with a low anterior neck AP or AP/PA fields (N0 patients), thicker slices can be obtained in the low neck.
- EBER status should be obtained from tissue biopsies to assist in the discussion of prognosis. When possible, one can obtain EBV DNA in a CLIA or equivalent certified laboratory.
- Target volumes include gross tumor volumes (GTV) and clinical target volumes (CTV). Accurate selection and delineation of the primary tumor CTV (i.e. CTV_{70}) and subclinical region ($CTV_{54–59.4}$) are of great importance when considering tumor progression and ease of tumor spread along neural pathways and foramina in the IMRT era for NPC. For more dosing options, can refer to NRG HN001 clinical trial. See Tables 1.1 and 1.2.
- Figures 1.1, 1.2, 1.3, 1.4, 1.5, and 1.6 demonstrate several examples of target delineation for different nasopharyngeal carcinoma cases.
- For additional dosing options, can refer to NRG HN001 clinical trial or the international consensus guidelines. Sequential no SIB techniques can also be done. The subclinical regional volume can receive 50–54 Gy with a sequential boost to the gross disease of 16–20 Gy to a total dose of 70 Gy.

Table 1.1 Suggested clinical target volumes at the gross disease region

Target volumes	Definition and description
GTV_{70}[a]	**Primary**: All gross disease on physical examination and imaging. Pre-treatment imaging should be carefully scrutinized for invasion of the skull base and perineural spread **Neck**: All nodes ≥1 cm in short axis, with necrotic center; any FDG PET avid nodes; given high likelihood of nodal involvement, contour the lymph node in doubt as GTV
CTV_{70}[a]	**Primary**: $CTV_{70}p = GTV_{70}p + 3–5$ mm [Please note that, at the discretion of the treating radiation oncologist, when there is complete certainty of the $GTV_{70}p$, then $GTV_{70}p$ can be equivalent to $CTV_{70}p$ **without any margin**. Therefore, in this situation, $GTV_{70}p$ is equivalent to $CTV_{70}p$] A 0 mm margin is also acceptable if tumor is in close proximity to critical OARs (i.e. brainstem, spinal cord) If tumor is near the ipsilateral optic nerve, informed discussion of risks and benefits is required. The authors favor coverage of the tumor, sacrificing the ipsilateral optic apparatus, but strictly constraining the contralateral optic nerve and optic chiasm **Neck**: $CTV_{70}n = GTV_{70}n + 3–5$ mm For nodes that are small (i.e. ~1 cm), lower doses of 63–66 Gy may be considered at the discretion of the treating physician [Please note that, at the discretion of the treating radiation oncologist, when there is complete certainty of the $GTV_{70}n$, then $GTV_{70}n$ can be equivalent to $CTV_{70}n$ **without any margin**. Therefore, in this situation, $GTV_{70}n$ is equivalent to $CTV_{70}n$]
PTV_{70}[a]	**Primary**: $PTV_{70}p = CTV_{70}p + 3–5$ mm, depending on daily patient positioning and on treatment imaging. If PTV overlaps with critical OARs (brainstem, spinal cord, brain), compromise of PTV must be accepted **Neck**: $PTV_{70}n = CTV_{70}n + 3$ mm Please note that when the radiation oncologist is certain of the $GTV_{70}p$ or $GTV_{70}n$, these can also be known as $CTV_{70}p$ or $CTV_{70}n$. In other words, $GTV_{70}p = CTV_{70}p$ (without margin) and $GTV_{70}n = CTV_{70}n$ without margin A 5 mm margin can then be added to the $CTV_{70}p$ to name this $PTV_{70}p$. But as stated above, when the target is near critical structures such as brain stem, chiasm, and spinal cord, the PTV margin can be 0 mm. A 3 mm margin can be added to the $CTV_{70}n$ to name this $PTV_{70}n$

[a] Suggested gross dose disease is 2–2.12 Gy/fraction to 69.96–70 Gy in 33–35 fractions

Table 1.2 Suggested clinical target volumes at the high-risk subclinical region

Target volumes	Definition and description
$CTV_{56–59.4}$[a]	**Primary**: $CTV_{56–59.4}p = GTV_{70}p$ + 10 mm (when possible) + whole nasopharynx. In addition, ensure adequate coverage of soft palate inferiorly, posterior nasal cavity (at least 5 mm from choana), posterior maxillary sinuses (ensuring coverage of pterygopalatine fossae where V2 resides), posterior ethmoid sinus when indicated, skull base (foramen ovale, rotundum, lacerum), cavernous sinus to Meckel's cave (if T3–T4; involved side only), pterygoid fossa/parapharyngeal spaces, sphenoid sinus (inferior half if T1–T2; whole if T3–T4), clivus (1/3 if no invasion; whole if invasion; when in doubt, whole clivus should be targeted) Importance of reviewing bone window while contouring on CT scan to ensure coverage of skull base foramina **Neck**: $CTV_{54.12-56}n$ = bilateral retropharyngeal nodes, levels IB, II, III, IV, and V Level IB can be omitted in the N0 neck Level IB can also be omitted in N+ neck at the discretion of the treating radiation oncologist after ensuring there are no suspicious IB lymph nodes Can consider omitting low neck for N0 neck
$PTV_{56–59.4}$[a]	**Primary**: $PTV_{56–59.4}p = CTV_{56–59.4}p$ + 3–5 mm, depending on daily patient positioning and on treatment imaging. When the target is near critical structures like brain stem, chiasm, and spinal cord, the PTV margin can be 0 mm **Neck**: $PTV_{54.12-56}n = CTV_{54.12-56}n$ + 3 mm

[a] High-risk subclinical dose: for 35 fractions: 1.6–1.7 Gy per day; for 33 fractions: 1.64–1.8 Gy per day

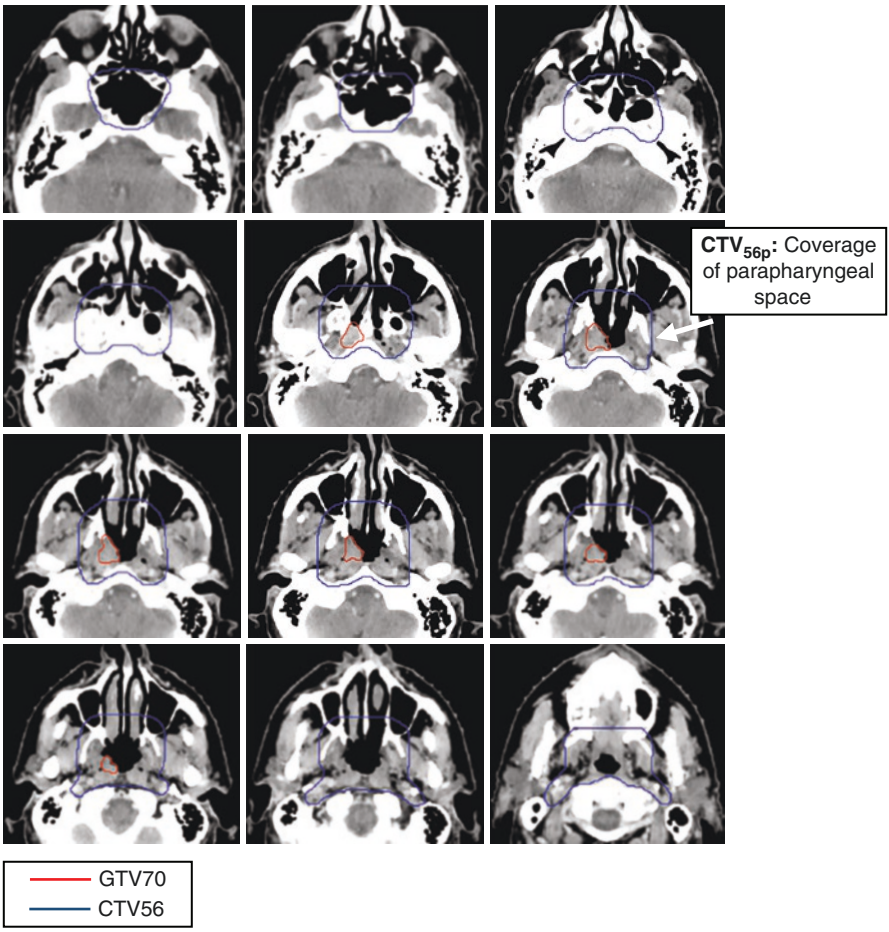
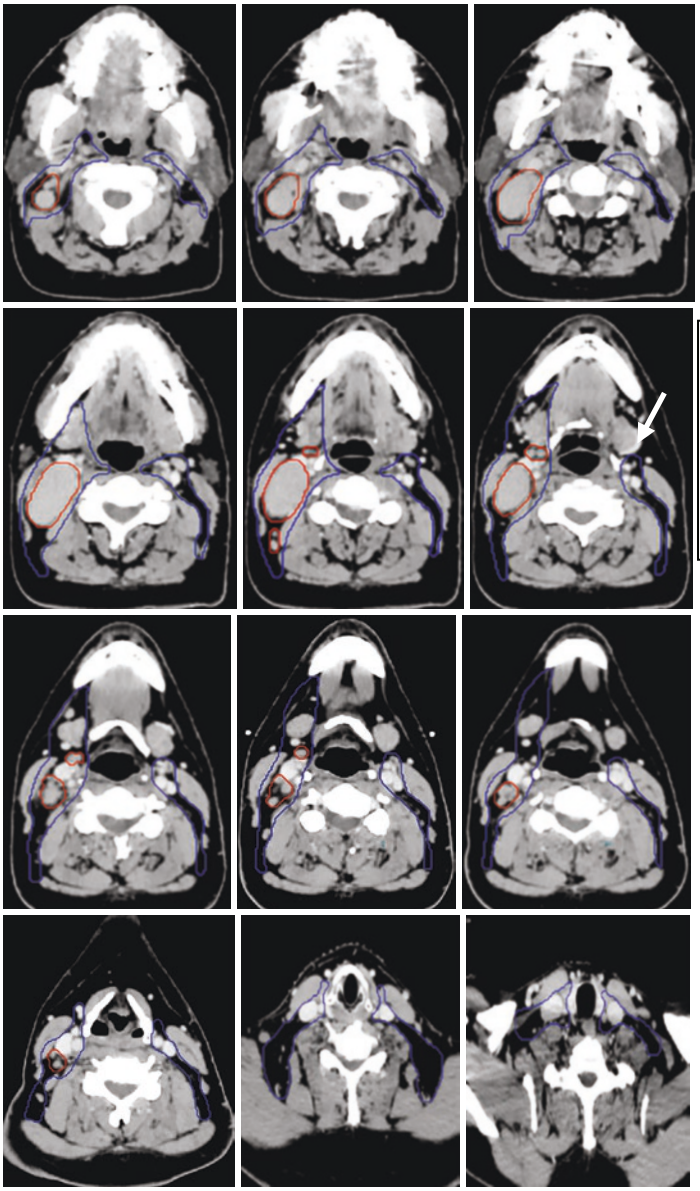


Fig. 1.1 A patient with T1N1 EBV positive nasopharyngeal carcinoma with right-sided level II and III nodes in a cranial to caudal direction. This patient was simulated with a planning MRI scan and PET/CT in the treatment position. Please note that these are representative slices and not all slices are included. The treating radiation oncologist can use the dosing according to institution or protocol guidelines



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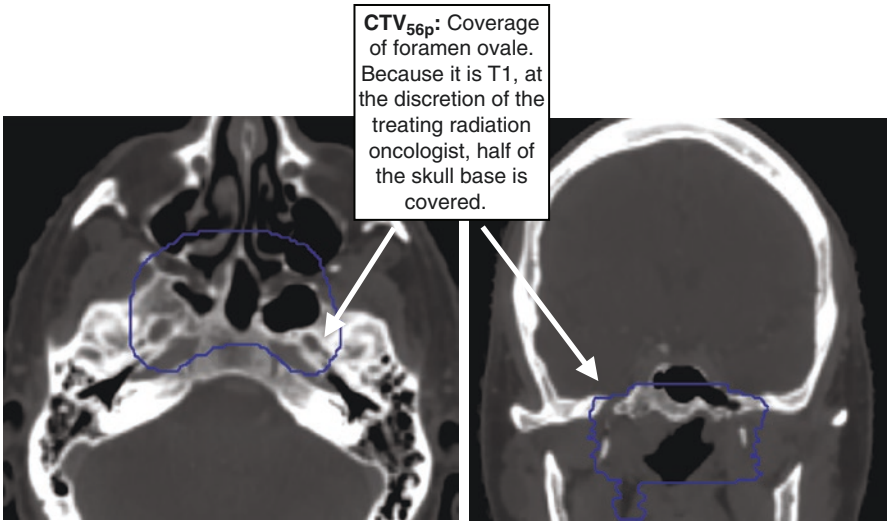

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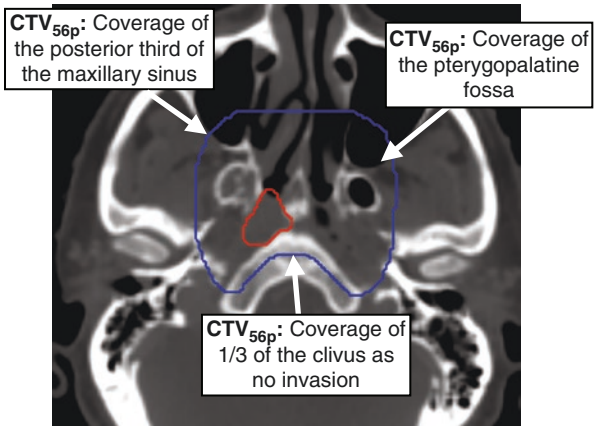


Fig. 1.2 Example of GTV and CTVs displayed on bone windows. The treating radiation oncologist can use the dosing according to institution or protocol guidelines

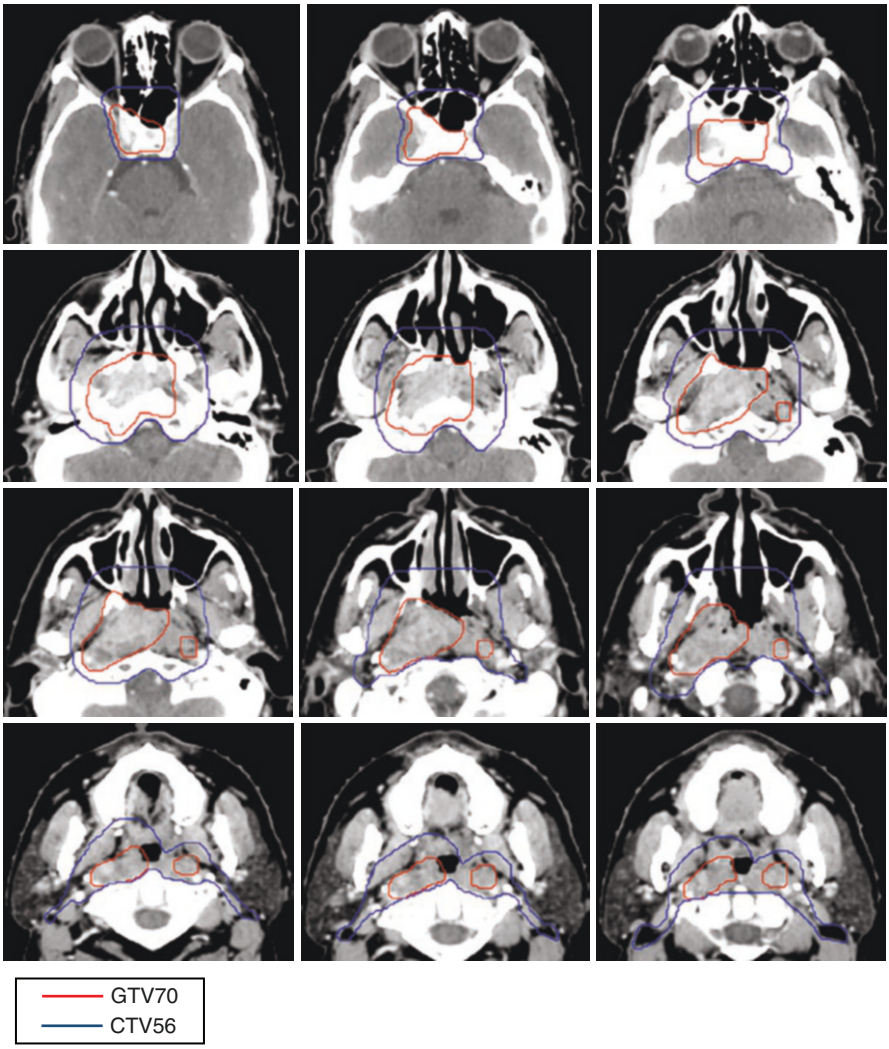
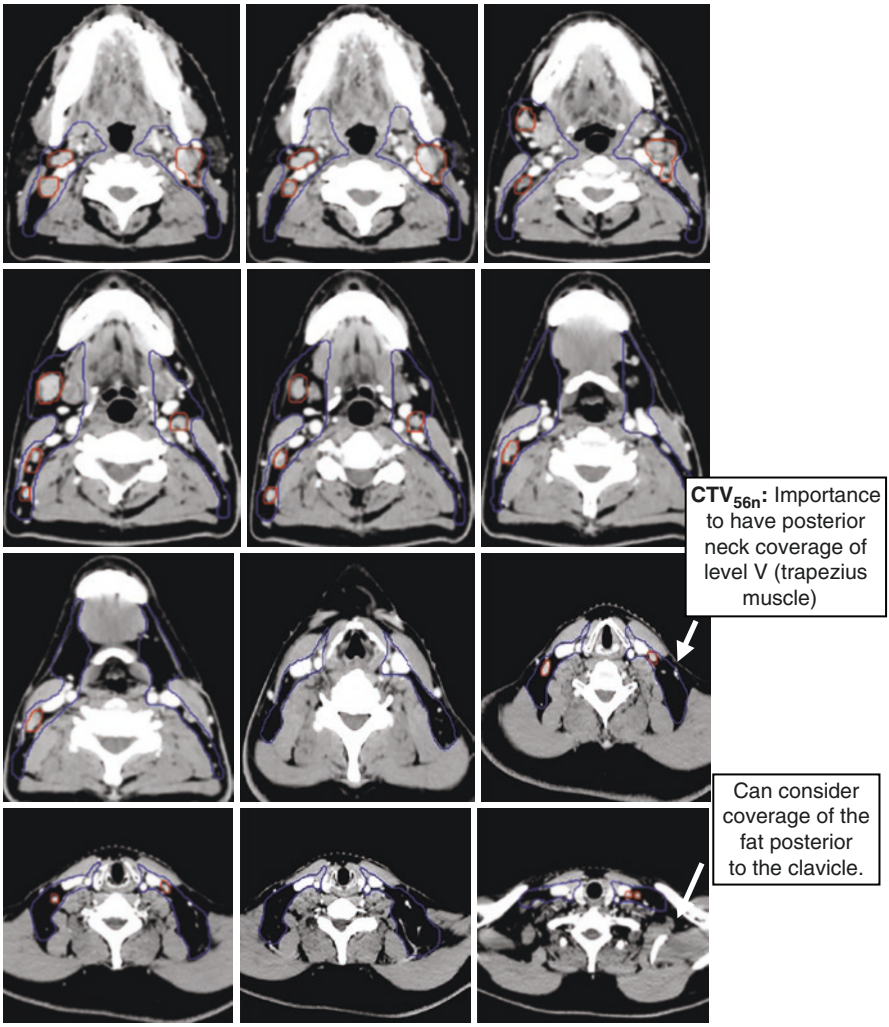


Fig. 1.3 A patient with T4N2 EBV positive nasopharyngeal carcinoma. The treating radiation oncologist can use the dosing according to institution or protocol guidelines



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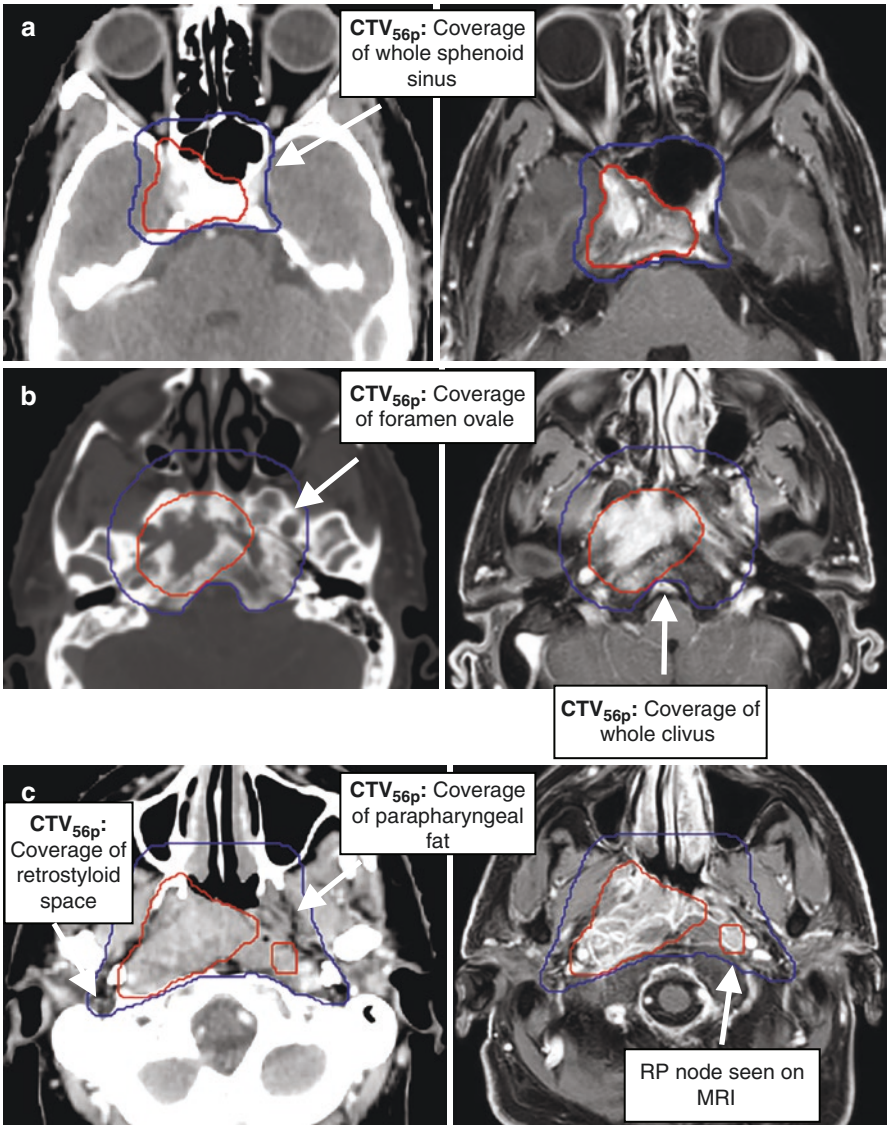

Fig. 1.4 Example of GTV and CTVs displayed on: (**a**) soft tissue window and MRI T1 + GAD, (**b**) bone window and MRI T1 + GAD, (**c**) soft tissue window and MRI + T1 + GAD. The treating radiation oncologist can use the dosing according to institution or protocol guidelines

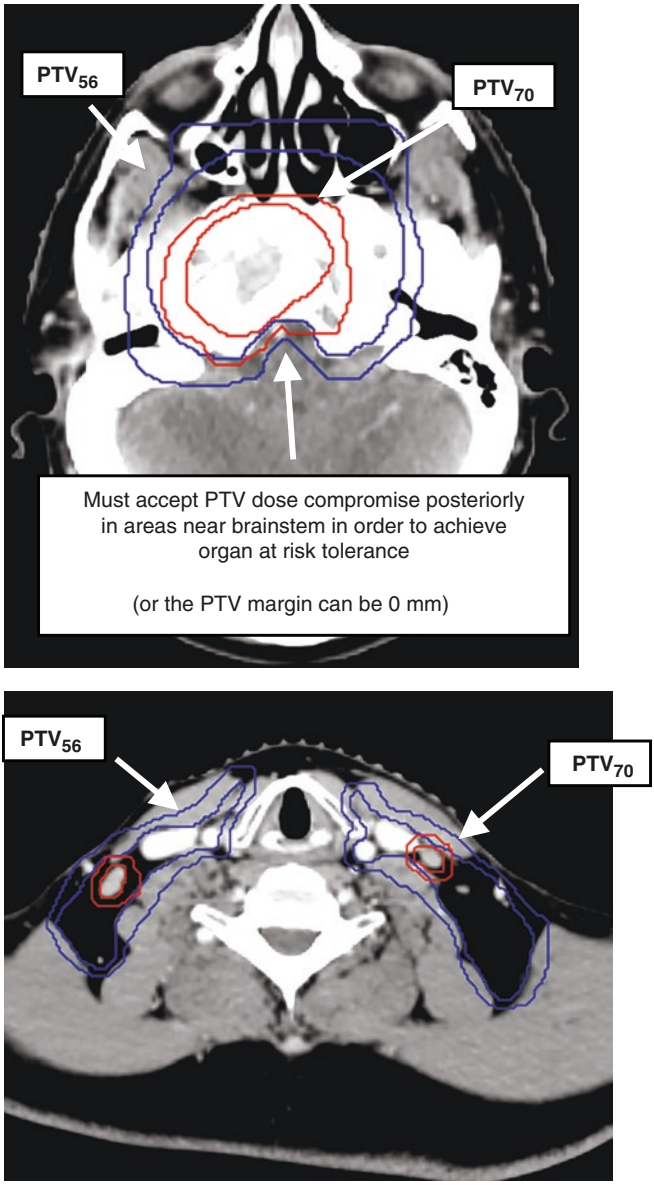

Fig. 1.5 Example of the final 3-mm PTV images. The treating radiation oncologist can use the dosing according to institution or protocol guidelines

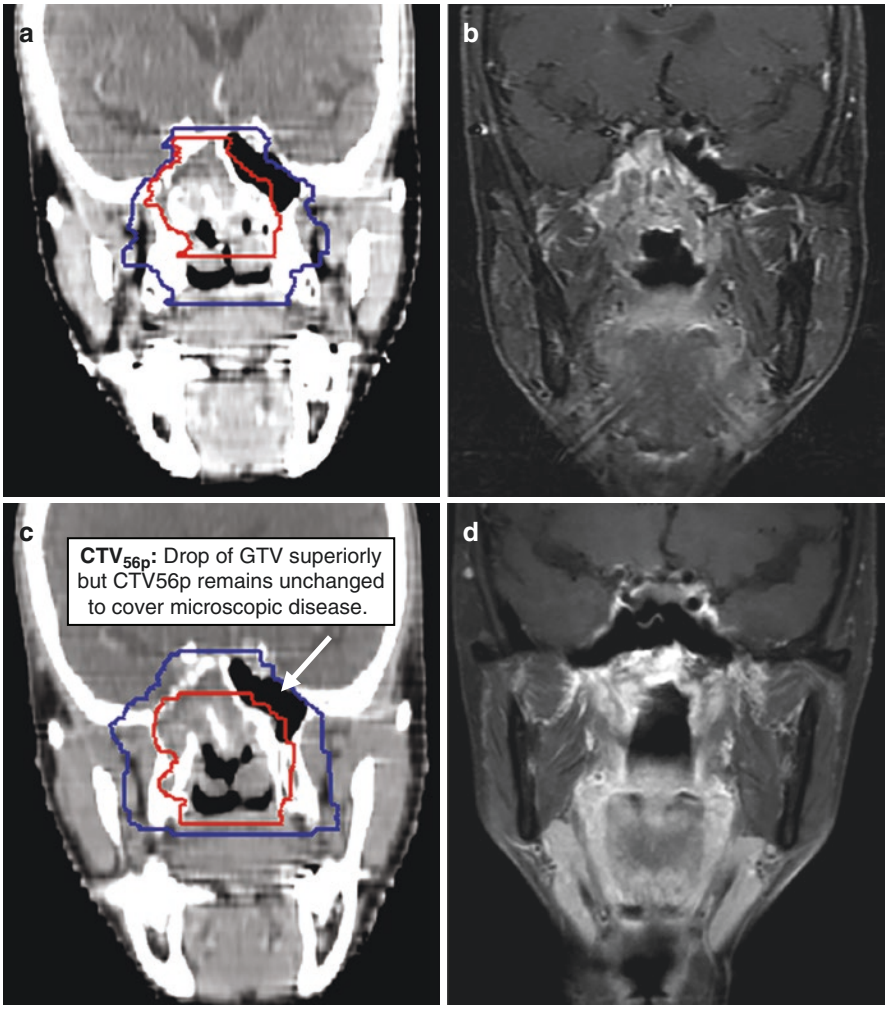

Fig. 1.6 Example of an adaptive nasopharyngeal plan. Patient with cT3N2 NPC who underwent mid-treatment adaptive replanning with MRI simulation showing shrinkage of disease superiorly allowing for reduction of the GTV away from the optic chiasm, and improvement in coverage: (**a**) Phase 1 GTV in red and CTV_{56p} in blue on original CT sim and (**b**) Phase 1 MRI sim T1 post GAD, (**c**) Phase 2 GTV in red and CTV_{56p} in blue on original CT sim, and (**d**) Phase 2 MRI sim T1 post GAD. The treating radiation oncologist can use the dosing according to institution or protocol guidelines

Further Reading

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NRG HN001 Clinical Trial Protocol.

Oropharyngeal Carcinoma

2

Zain A. Husain, Jung Julie Kang, Nancy Y. Lee, and Ian Poon

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2.1 Introduction

Oropharyngeal carcinoma comprises primary tumors involving the tonsils, base of tongue, soft palate, or posterior pharyngeal wall. The vast majority of oropharyngeal cancers are squamous cell carcinomas, most of which are associated with the human papillomavirus (HPV). HPV-unrelated cancers are commonly associated with tobacco or alcohol use. HPV-associated head and neck cancers have superior prognosis [1, 2]. Since the last edition of this book, the American Joint Committee

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on Cancer revised staging for oropharyngeal cancer, dividing it into two different systems for HPV-positive and HPV-negative oropharyngeal cancers. Given the prognostic importance of HPV status, viral testing should be performed in all oropharyngeal carcinoma patients. However, de-escalation of therapy based on HPV status should not be performed outside of a clinical trial [3–5]. In this chapter, we outline radiotherapy target delineations with careful consideration of microscopic mucosal spread of the primary tumor as well as knowledge of cervical nodal drainage patterns.

2.2 General Principles of Anatomy and Patterns of Spread

- The oropharynx is a cuboidal space bordered by the oral cavity anteriorly, the nasopharynx superiorly, and the larynx and hypopharynx inferiorly.
- It consists of four subsites: the tonsils, base of tongue, soft palate, and the pharyngeal wall, with the majority of cases arising in the tonsils and tongue base.
- The oropharynx is equipped with a rich lymphatic drainage and lymph nodes are commonly involved.

2.3 Diagnostic Workup Relevant for Target Delineation

- Gross tumor volume delineation of the primary site is best identified by a combination of imaging and physical examination.
- The mucosal and superficial extents of disease are best accessed by visual inspection, palpation, and fiberoptic endoscopic examination. Photographic documentation of disease at the time of consult or simulation is helpful in order to document mucosal extension of disease that may be poorly seen on imaging (Fig. 2.1).

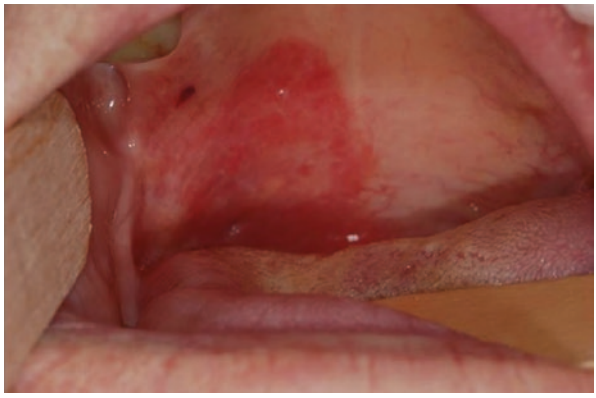

Fig. 2.1 Direct visualization helps demonstrate involvement of the soft palate and evidence of the tumor crossing midline

- While contrast-enhanced CT scans remain the mainstay of diagnostic imaging for this disease, both MRI and PET/CT have well-defined roles.
  - T1-weighted pre-contrast MRI sequences are ideal for the evaluation of fat planes and bone marrow signals.
  - T1-weighted contrast-enhanced MRI sequences may be critical for delineation of the anterior extension of base of tongue tumors and for the assessment of perineural invasion.
  - T2-weighted fat-saturated sequences offer utility for the evaluation of RP nodes and soft tissue extent in the parapharyngeal and pre-epiglottic spaces.
  - FDG-PET provides metabolic information that complements both CT and MRI, and may identify tumor extent missed by CT or MRI.
  - Limitations of FDG-PET include poor spatial resolution and low sensitivity for small-volume lymph node metastases. Thus, the absence of FDG uptake in an otherwise suspicious lymph node should not necessarily be considered reassuring.

2.4 Simulation and Daily Localization

- The patient should be set up in the supine position with head rest with the neck extended. The customized immobilization device (5-point Aquaplast mask) should provide adequate head, neck, and shoulder immobilization. A bite-block and/or mouth guard may be inserted. Patients are instructed not to swallow during scans or during treatment.
- CT simulation with IV contrast using $\leq$3 mm slice thickness encompassing the entire vertex of the skull down through the carina.
- The isocenter is typically placed at the arytenoid cartilages. A low anterior conventional AP neck field can be matched to the IMRT fields.
- MRI and PET images may be registered or fused to the CT simulation scan. The use of immobilization mask during PET scan improves the fusion accuracy, but the use of immobilization mask during the MRI may preclude the use of a dedicated head and neck coil.
- At MSKCC, image guidance is achieved with daily linear accelerator-mounted 2D kV imaging and daily kV and conebeam CT. Conebeam CT can also be used weekly, with daily KV imaging as an alternative strategy. Alternative methods for image guidance may include orthogonal kV imaging (“ExacTrac”) or linear accelerator-mounted MV CT images (“TomoTherapy”).

2.5 Target Volume Delineation and Treatment Planning

2.5.1 Selected IMRT Dose and Fractionation Schemes

- There are many different treatment approaches. At MSKCC, the preferred approach is a sequential technique. Total dose to the gross disease is 70 Gy. For

HPV related tumors, the subclinical regions receive 30 Gy in 2 Gy per fraction followed by a cone down to the gross disease receiving 40 Gy in 2 Gy per fraction. The subclinical region is scrutinized heavily to ensure no gross disease with MRI, CT with contrast, and PET/CT scans. Please refer to our publication, Tsai et al. [6]. For HPV unrelated disease, the initial phase is 60 Gy in 2 Gy per fraction to the gross disease while simultaneously treat 54 Gy in 1.8 Gy per fraction to all subclinical regions. This is followed by a cone down of 10 Gy in 2 Gy per fraction to the gross disease. If a low anterior neck AP field is matched to the IMRT fields, HPV related tumors receive 30 Gy in 2 Gy per fraction to the low neck while the HPV unrelated tumors receive 50 Gy in 2 Gy per fraction to the low neck. Reduced elective doses should only be considered when treating with concurrent cisplatin-based chemotherapy

- Another commonly used radiation technique is the simultaneous integrated boost. Gross disease dose: 70 Gy (2 Gy/fx), high-risk subclinical dose: 56 Gy (1.6 Gy/fx), and low-risk subclinical dose: 50–52.5 Gy (1.43–1.5 Gy/fx). This technique should only be considered when using concurrent chemotherapy.
- Another fractionation schemes such as but not limited to RTOG 0022 [7] or RTOG 1016 [3].

2.5.2 Suggested Target Volumes

- Suggested target volumes for gross disease (Table 2.1) and for subclinical disease (Table 2.2) are presented in the following.

Table 2.1 Suggested target volumes for gross disease

Target volumes	Definition and description
GTV_{70}	Primary: All gross disease as defined by clinical exam and imaging Nodes: all suspicious (>1 cm, necrotic, enhancing, or FDG-avid) lymph nodes. Borderline suspicious nodes can be given less than 70 Gy, i.e. 60–66 Gy for example
CTV_{70}	In areas of excellent visualization GTV_{70} can equal CTV_{70} (no added margin). In situations where there is uncertainty of tumor extent $CTV_{70} = GTV_{70} + 3–5$ mm
PTV_{70}	$CTV_{70} + 3–5$ mm depending on daily set up accuracy and the availability of image guidance

Table 2.2 Suggested target volumes for subclinical disease

Target volumes	Definition and description
General guidelines	As a useful guideline, the primary site $CTV_{subclinical}$ should encompass the GTV_{70} + 1 cm (shaved off of anatomic barriers to spread such as air, bone, and skin)
Tonsil primary, $CTV_{subclinical}$	Ensure adequate margin to the primary tumor ~1 cm. Highly recommend inclusion of pterygoid plates with advanced primary disease (Fig. 2.2). Consider inclusion of the ipsilateral retromolar trigone if tumor spread anterolaterally along the pharyngeal constrictor is suspected
Base of tongue primary, $CTV_{subclinical}$	Glossotonsillar sulcus, vallecula, and the pre-epiglottic space (Fig. 2.3). Ensure a mucosal margin of at least 1.0 cm around the base of tongue primary tumor; anteriorly, this may extend into the oral tongue. MRI is very helpful to ensure accurate delineation of anterior extension of the tumor (Figs. 2.4 and 2.5)
Soft palate primary, $CTV_{subclinical}$	Entire soft palate, superior aspect of tonsillar pillars + fossa, adjacent nasopharynx superiorly to the pterygoid plate. For advanced primaries, consider inclusion of the pterygopalatine fossa. If the pterygopalatine fossa is involved, assessment of the base of skull with MRI is required. Ensure adequate coverage anteriorly, which may require coverage of a portion of the hard palate
Pharyngeal wall primary, $CTV_{subclinical}$	Generous superior and inferior margins given the possibility of skip lesions. In patients with advanced primary tumors, consider extending CTV cranially to include the nasopharynx and caudally to include the hypopharynx
Elective neck nodes, $CTV_{subclinical}$	The nodal regions can be treated to microscopic doses of 54 Gy in 1.8 Gy fractions, 54.12 Gy in 1.64 Gy fractions, 56 Gy in 1.6 Gy fractions, or 59.4 Gy in 1.8 Gy fractions depending on whether these regions are high risk or low risk In node-negative cases, at risk areas include bilateral levels II-IV and lateral retropharyngeal nodes. At MSKCC, we do not routinely treat levels IB or V, unless grossly involved (Figs. 2.5 and 2.6). The exception would be with gross oral cavity extension of disease, in which case IB nodes may be considered at risk (Figs. 2.2 and 2.4) In node-positive cases, the retropharyngeal nodes and retrostyloid nodes should be covered superiorly to the skull base (Fig. 2.4). If there is gross involvement of low-lying nodes, consider coverage of the supraclavicular space (Fig. 2.5) For T1–2, N0–N1 well-lateralized tonsil cancers (at least 1 cm lateral from midline) with no extension to the base of tongue or soft palate, ipsilateral neck treatment is acceptable (Fig. 2.6). The superior extent of coverage for the node-negative neck may begin at the transverse process of C1 or when the posterior belly of the digastric just starts to cross over the internal jugular vein (Fig. 2.6)

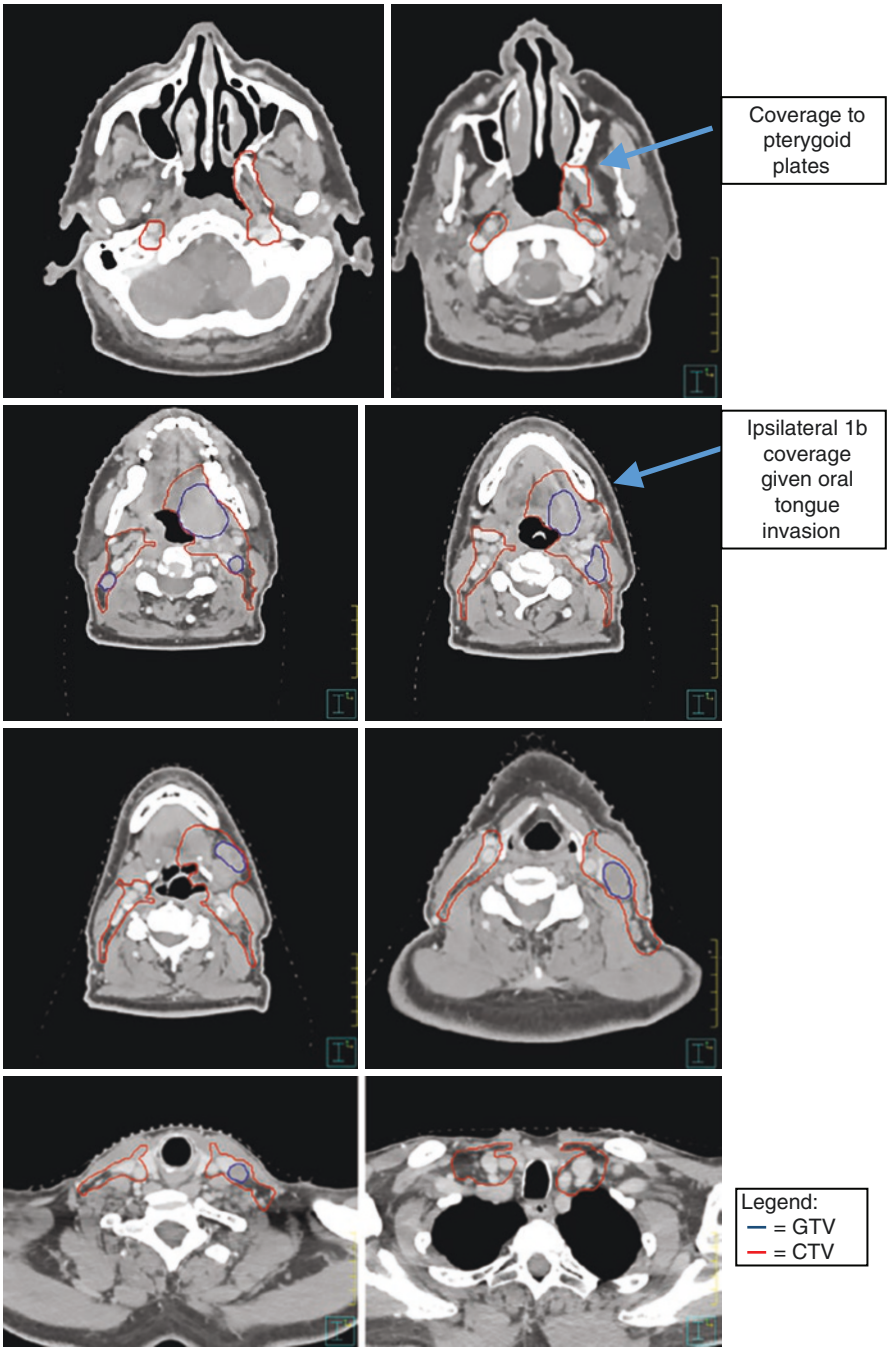

Fig. 2.2 Representative axial slices from a contrast-enhanced CT simulation for a patient with HPV-negative cT4N2 squamous cell carcinoma of the left tonsil

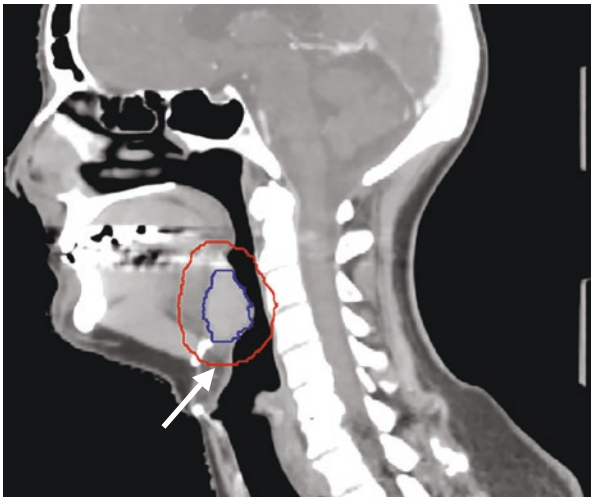

Fig. 2.3 Coverage of the pre-epiglottic space in base of tongue tumors (GTV: blue, CTV: red)

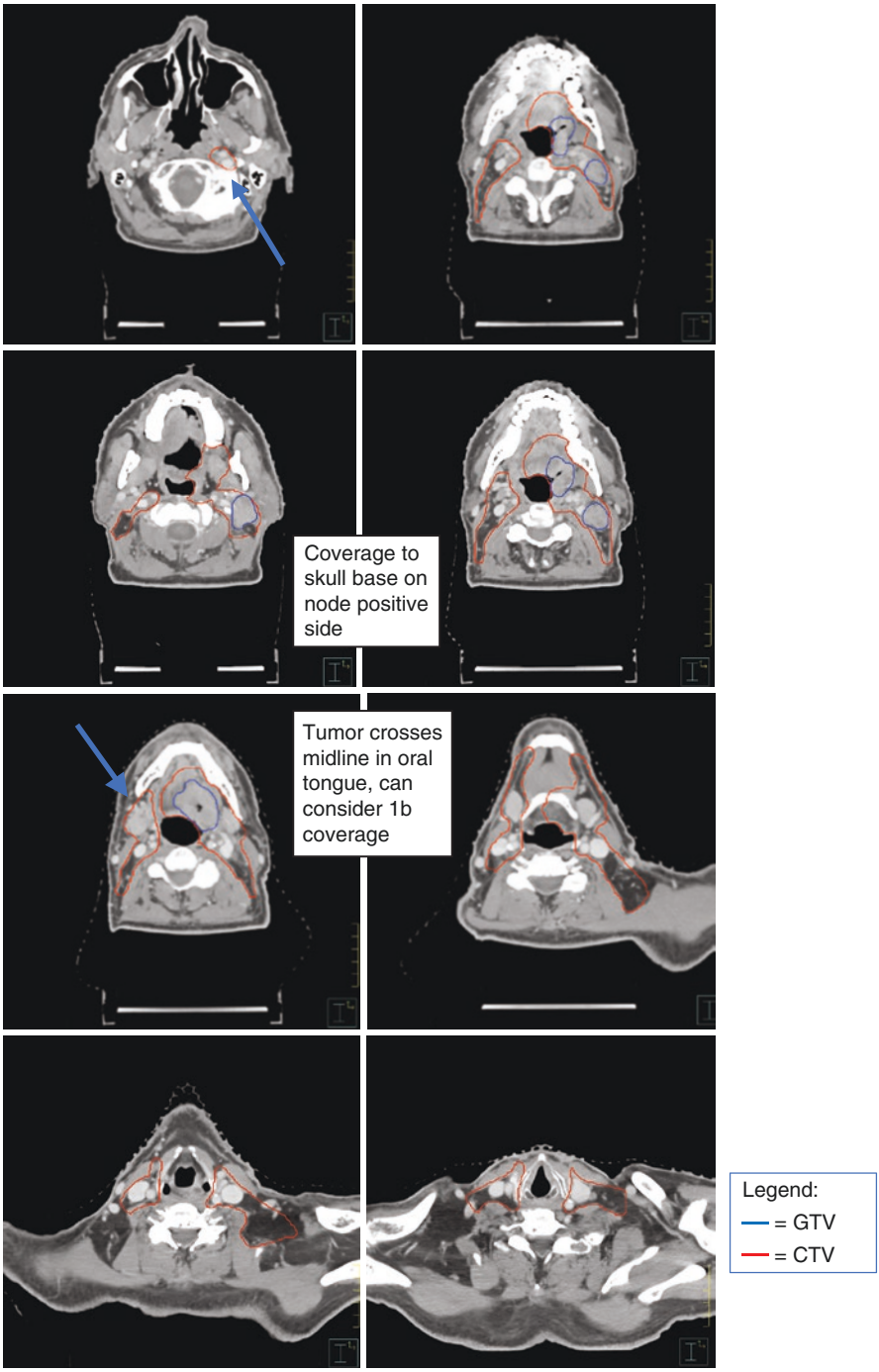

Fig. 2.4 Representative axial slices from a contrast-enhanced CT simulation for a patient with P16-positive, HPV-associated cT4N1 squamous cell carcinoma of the left base of tongue

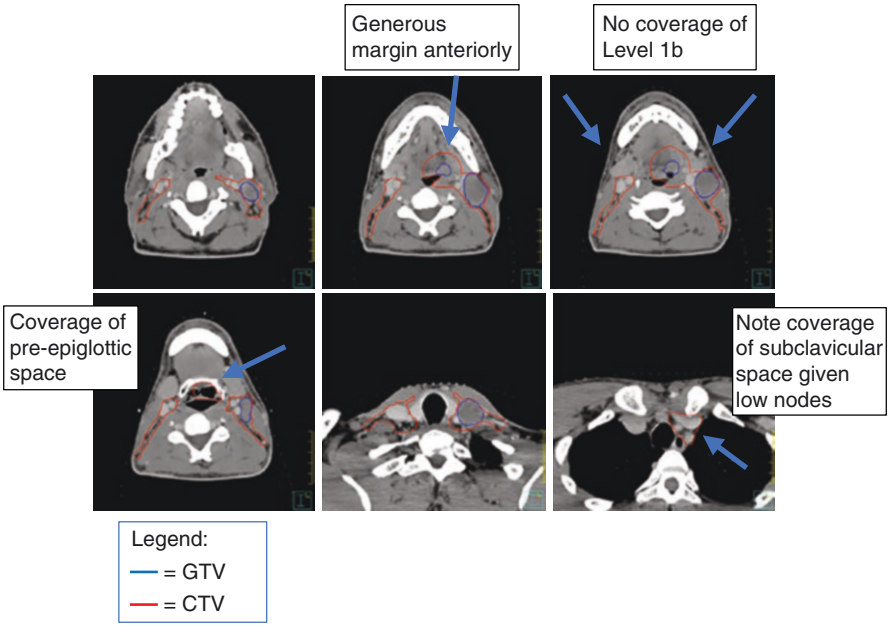

Fig. 2.5 Representative axial slices from a contrast-enhanced CT simulation for a patient with P16-positive, HPV-associated cT1N1 squamous cell carcinoma of the left base of tongue

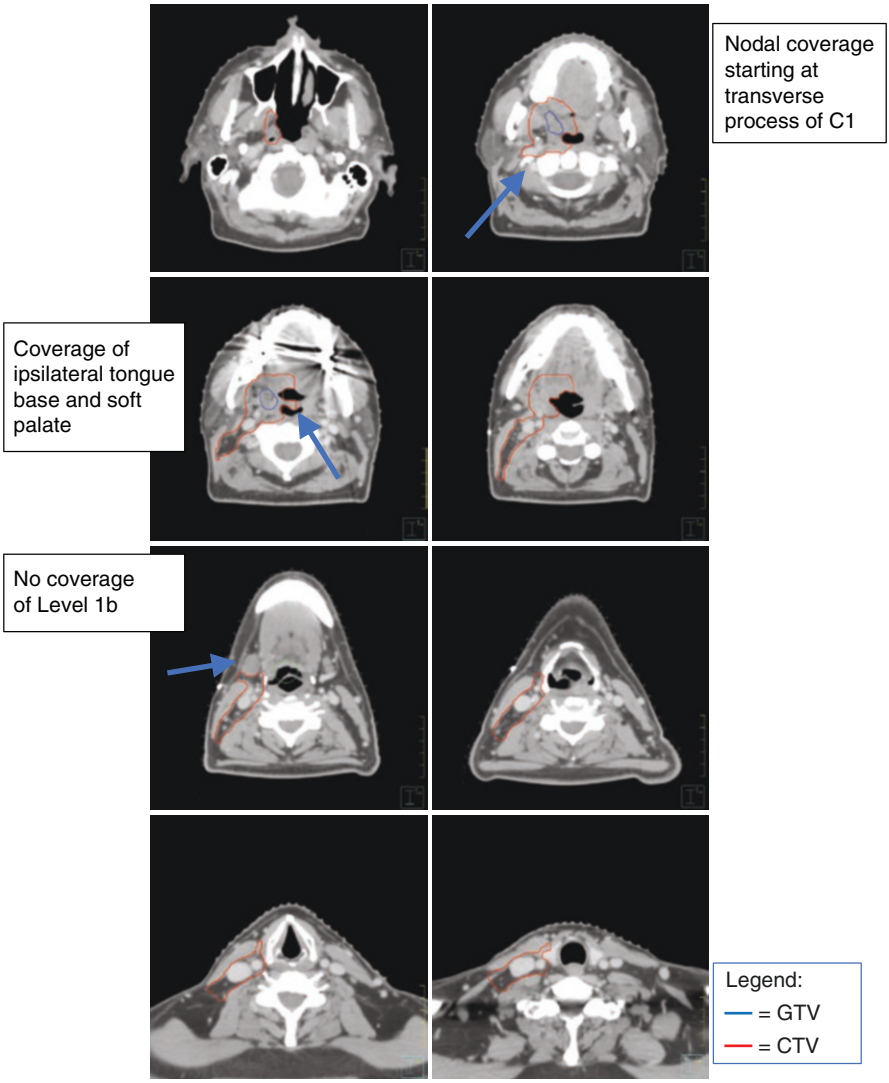

Fig. 2.6 Representative axial slices from a contrast-enhanced CT simulation for a patient with P16-positive, HPV-associated cT2N0 squamous cell carcinoma of the right tonsil (with no evidence of base of tongue or soft palate invasion) to be treated with unilateral radiation. At MSKCC, for tonsil cancers regardless of stage, the ipsilateral subclinical region almost always extend superiorly to include coverage of the ipsilateral pterygoid plate

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Stereotactic Body Radiotherapy for Cancers of the Head and Neck Cancer

3

Dana Keilty, Irene Karam, Nancy Y. Lee, and Ian Poon

Contents

- Advanced Head and Neck Cancer (HNC) is commonly a disease of the elderly and associated with a poor outcomes despite aggressive multi-modality treatments. Select fit elderly patients, despite the expectation of a poor outcome, may choose to undergo radical high-dose radiation to maximize cancer control but with higher rates of toxicity and morbidity. In frail patients, the decision against a prolonged RT course may be based on multiple factors: patient preference (Fig. 3.1), tumor factors (expected morbidity of tumor progression versus the morbidity/mortality risk of treatment and probability of a successful outcome [Figs. 3.2, 3.3, 3.4, 3.5, and 3.6]), life expectancy (influence of age and comorbid conditions [Figs. 3.1, 3.3, 3.4, 3.6, 3.7, 3.8, and 3.9]), tolerance of aggressive

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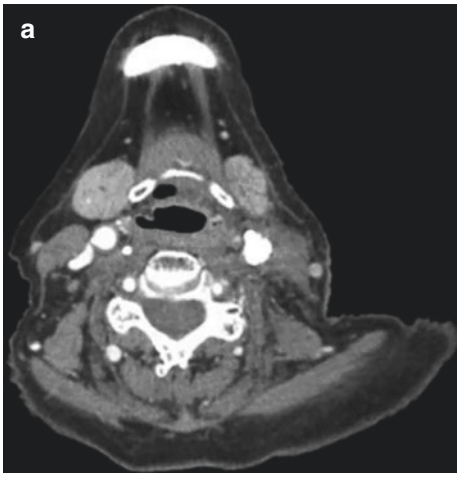
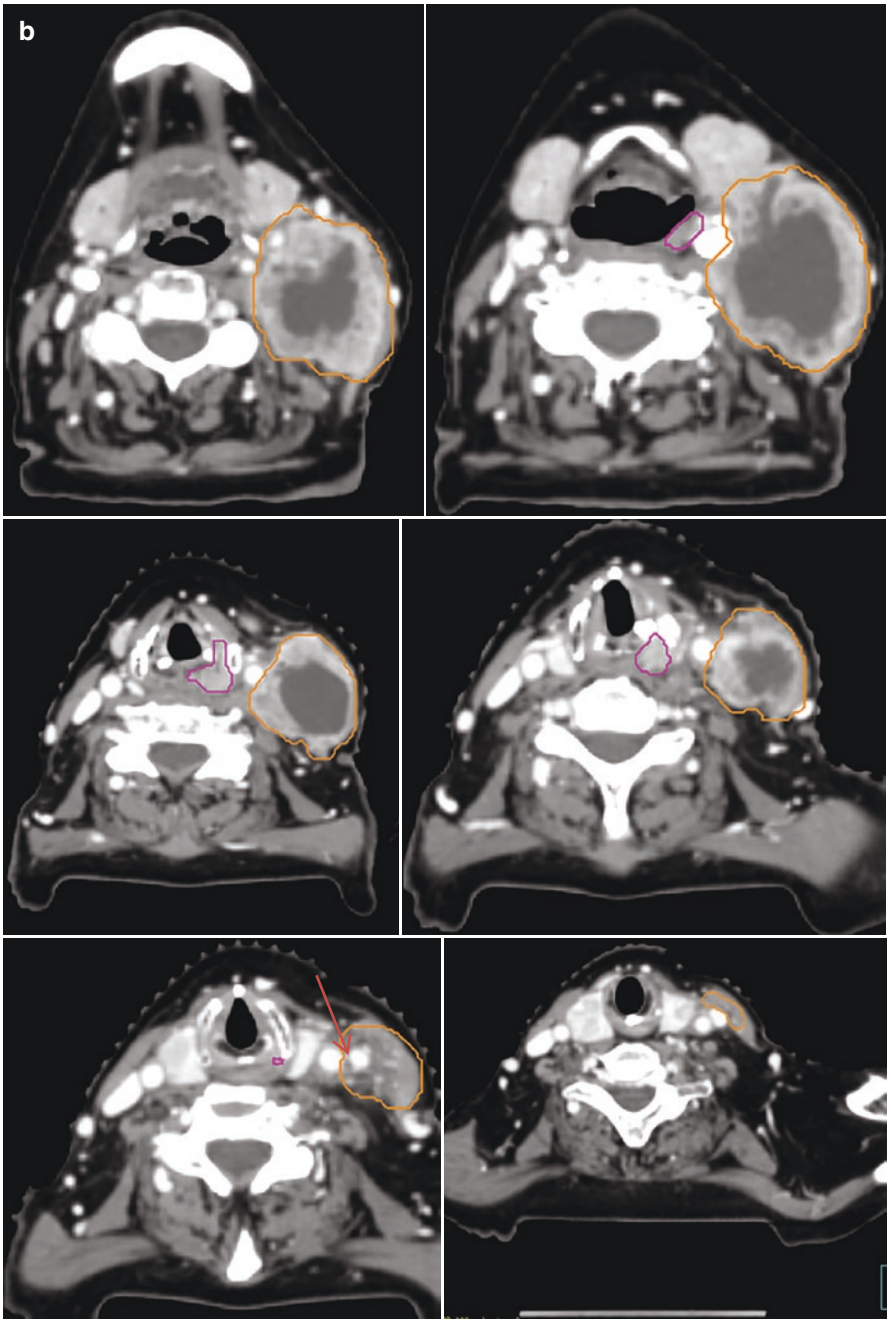


Fig. 3.1 Unresectable piriform sinus tumor. A 73-year-old lady was diagnosed with a T1 N3 squamous cell carcinoma of the left piriform sinus compressing the internal jugular vein. She elected against a protracted radiation course. (**a**) 50 Gy in five fractions, two fractions per week, was prescribed to the GTVn (orange) and 40 Gy in five fractions, two fractions per week, was prescribed to the GTVp (red). Target coverage was not compromised in an attempt to spare the carotid artery (arrow). (**b**) No evidence of disease at 2 years



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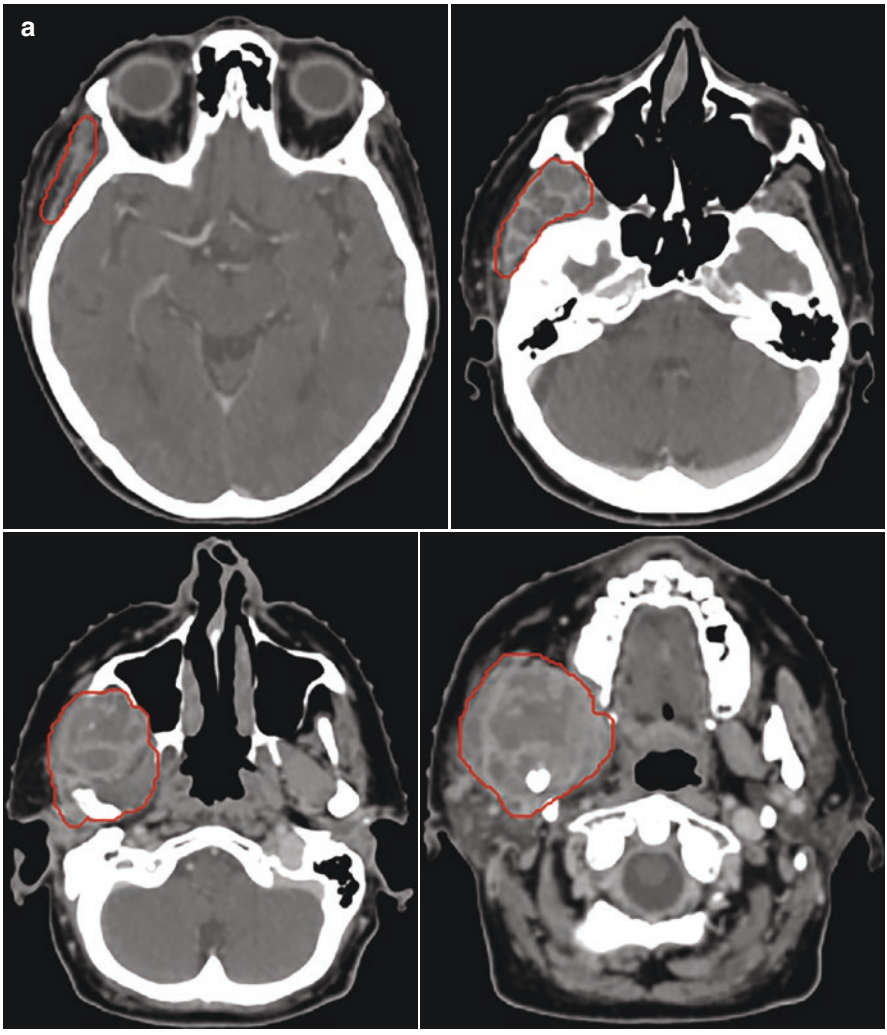
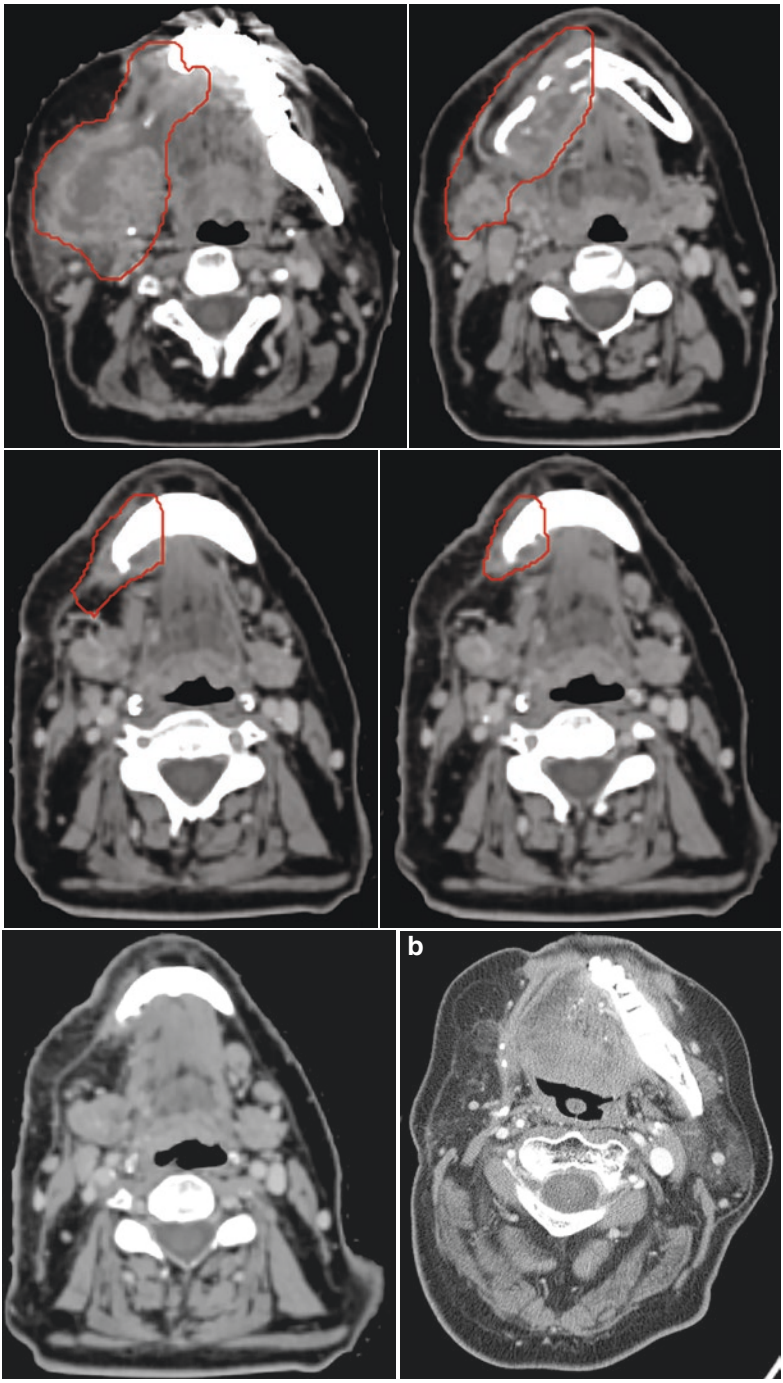


Fig. 3.2 Extensive HNC. A 65-year-old female presented with a painful squamous cell carcinoma of the oral cavity, measuring 6.9 by 4.0 cm, extending from the base of the skull along the infratemporal fossa into the masticator space and the right mandible, causing pathologic fracture and trismus with a mouth opening of 1.5 cm. She received 45 Gy in five fractions, two fractions per week. (**a**) $GTVp_{45}$ is delineated in red. (**b**) Four years later, she can open her mouth 4 cm and remains disease-free



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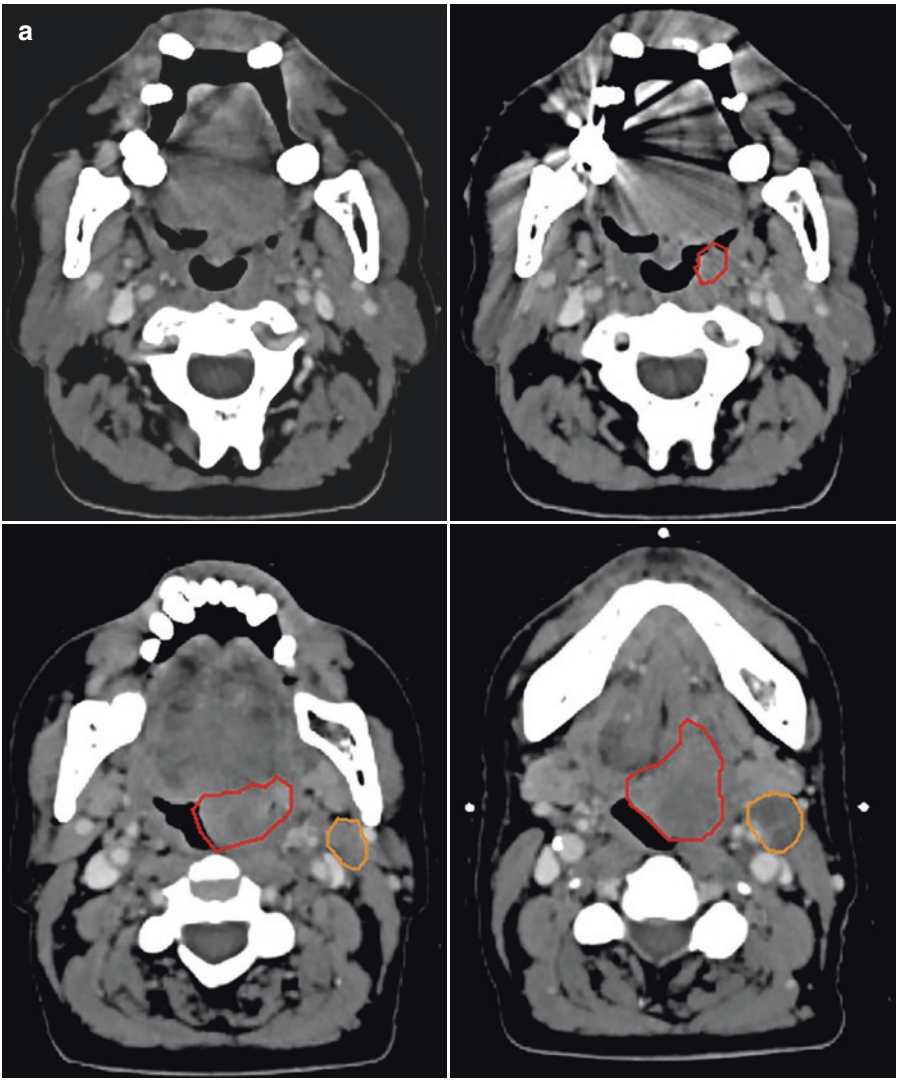
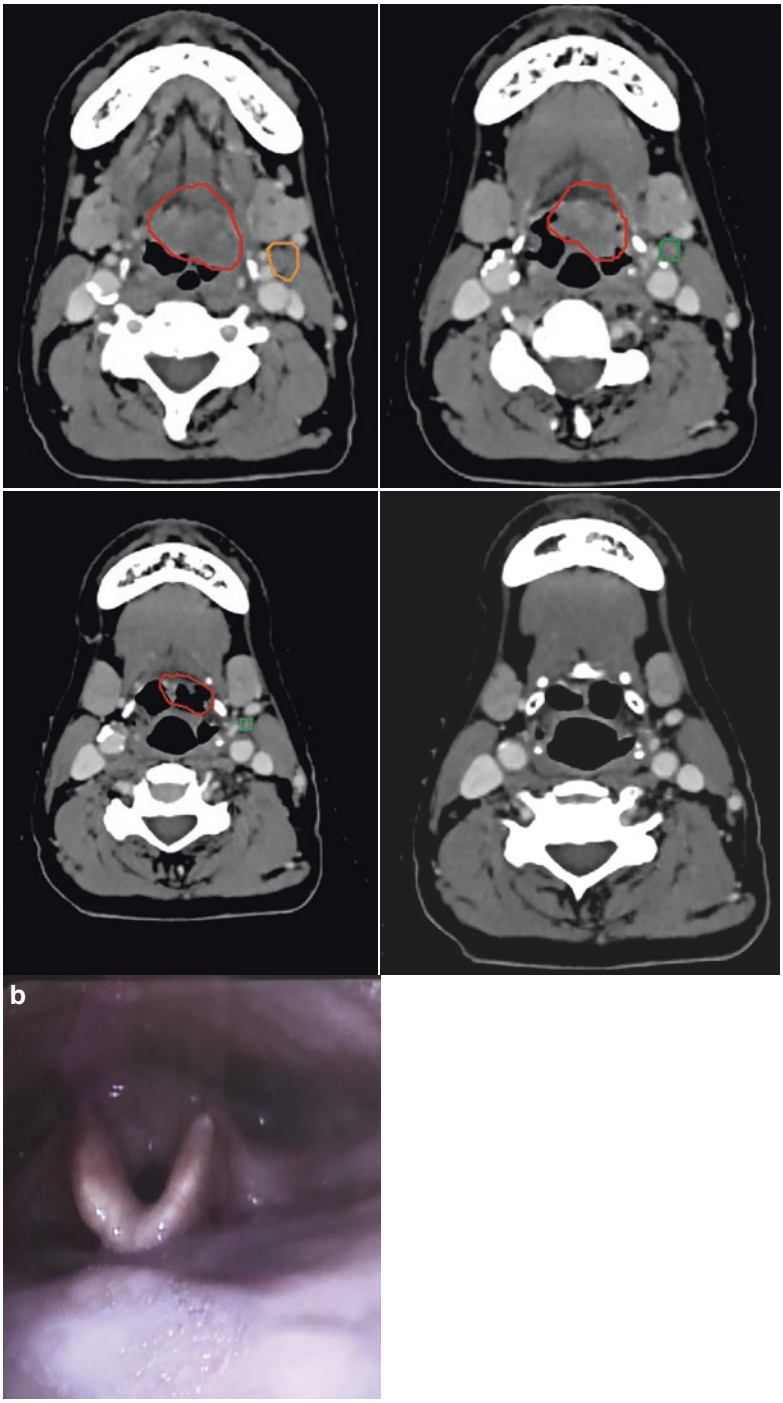


Fig. 3.3 HNC with concurrent life-threatening cancer. A 66-year-old gentleman presented with superior vena cava obstruction from a 10-cm non-small cell lung mass. Palliative radiation and chemotherapy rendered his disease stable for 18 months. Imaging to investigate painful dysphagia showed a 3-cm mass at the left base of tongue crossing the midline and a 3.3-cm left level II lymph node. Flexible nasopharyngoscopy showed the mass extended into the vallecula, displacing the epiglottis. This T2N1 base of tongue cancer was treated with 45 Gy in five fractions, two fractions per week, after which he started second-line lung systemic therapy. (**a**) $GTVp_{45}$ is delineated in red; $GTVn_{45}$ is delineated in orange; $GTVn_{40}$ is delineated in green. (**b**) There is no evidence of disease at 18 months, and he is tolerating all food textures without pain



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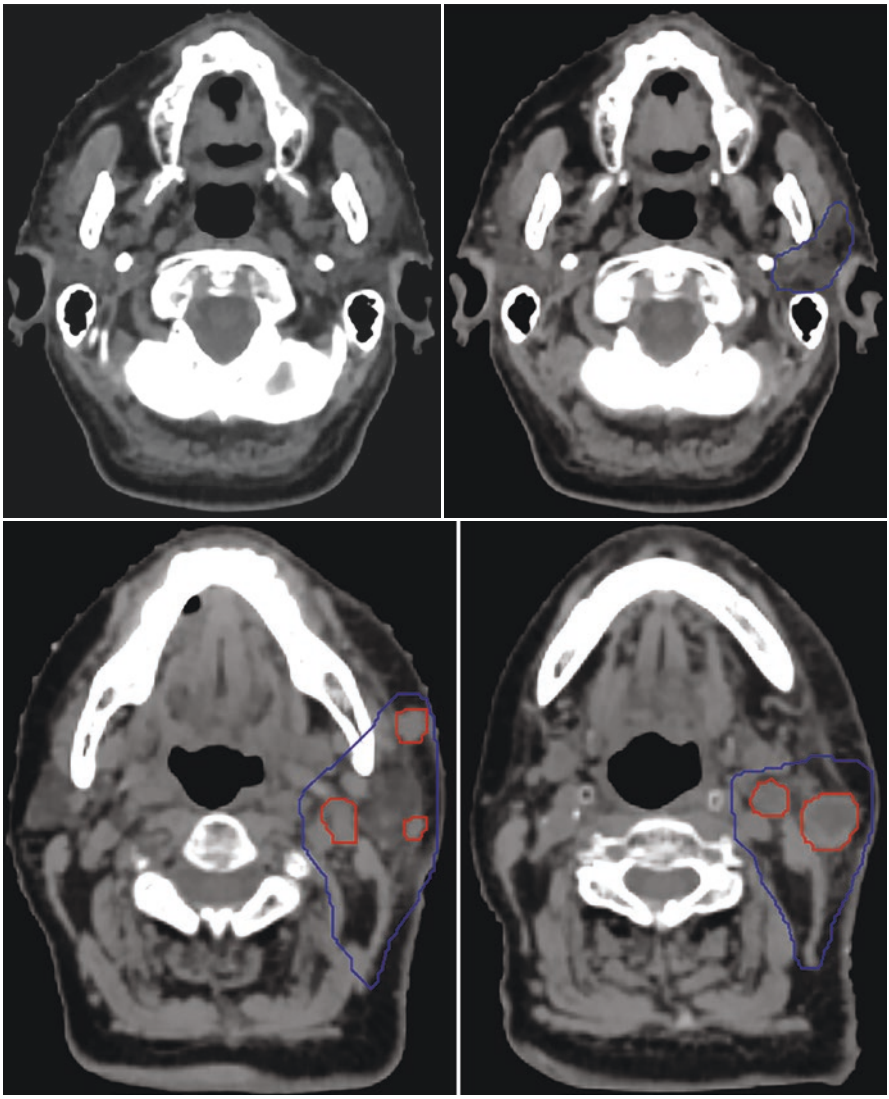
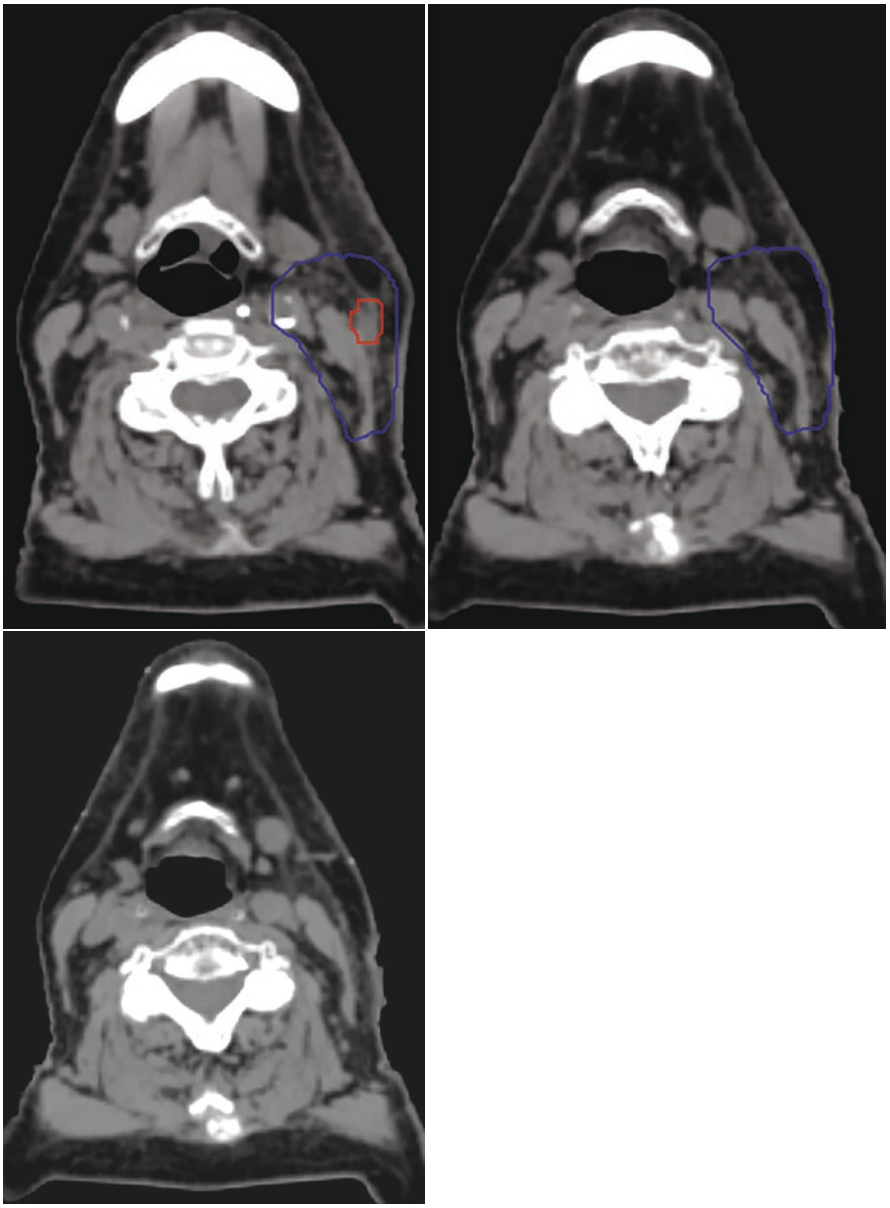


Fig. 3.4 HNC recurrence in centenarian. A 100-year-old female with squamous cell carcinoma of the skin recurred at the parotid and neck nodes. $CTVn_{25}$ (blue) encompasses the nodal basin at high risk of relapse. GTV_{45} is delineated in red. She remained well for 6 months and then recurred regionally, both inside and outside the low-dose field



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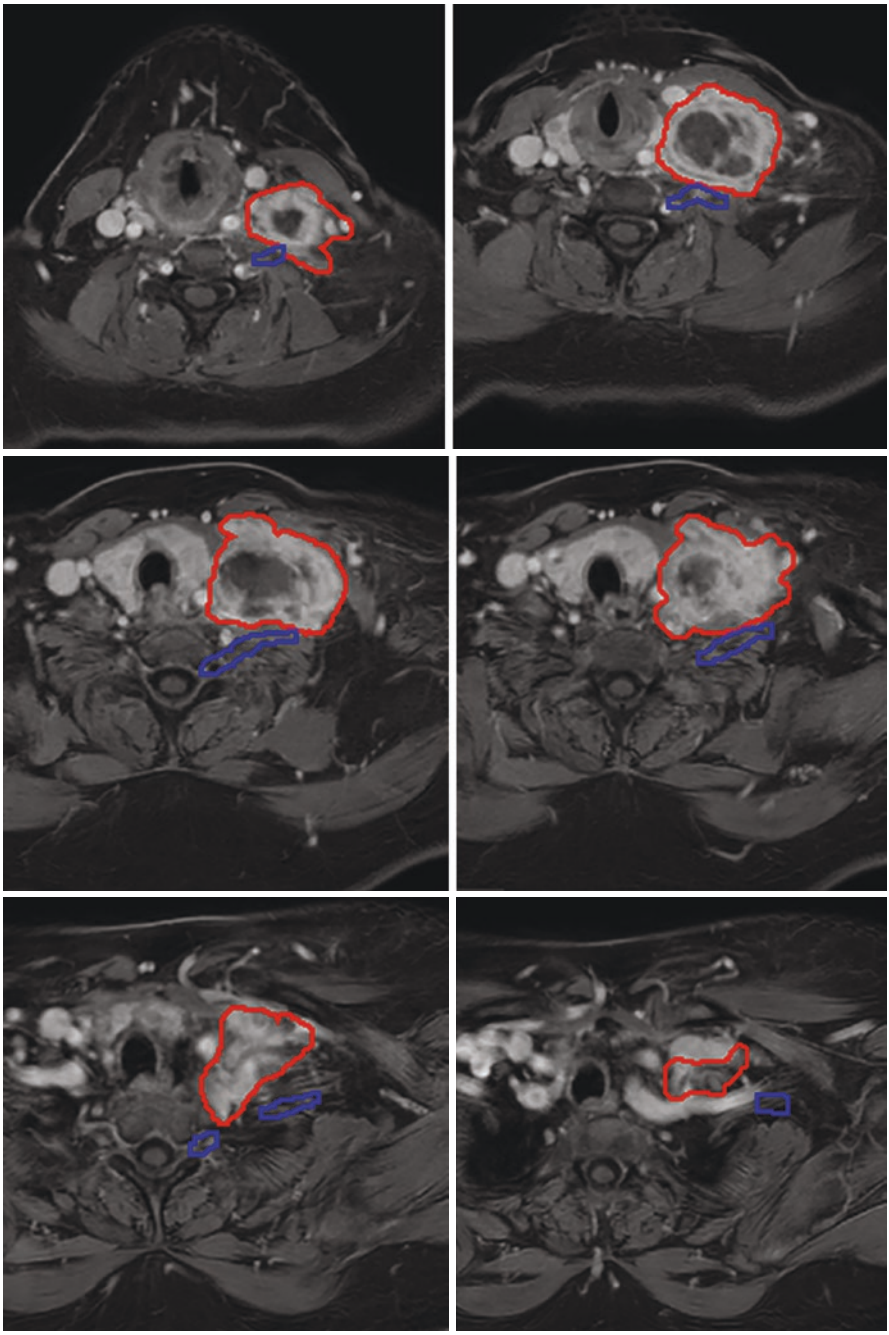


Fig. 3.5 Oligometastatic disease adjacent to brachial plexus. A 55-year-old female presented with an unresectable solitary oligometastatic colorectal cancer at the supraclavicular fossa. This 6-cm node was treated with 45 Gy in five fractions, two fractions per week. The radiation plan was created with MRI simulation to differentiate the GTV (red) from the brachial plexus (blue). The mass recurred 3 years later in the left neck

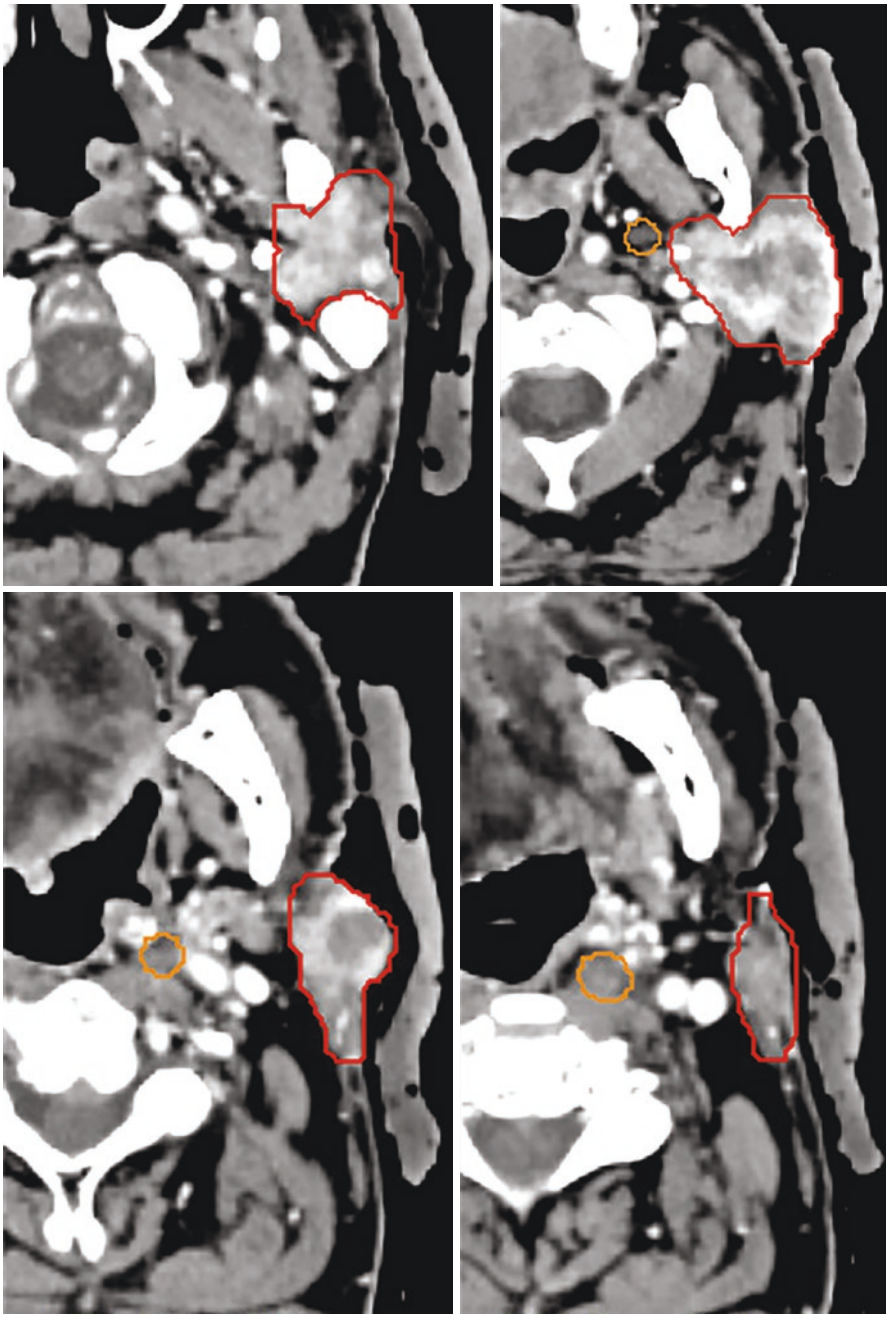
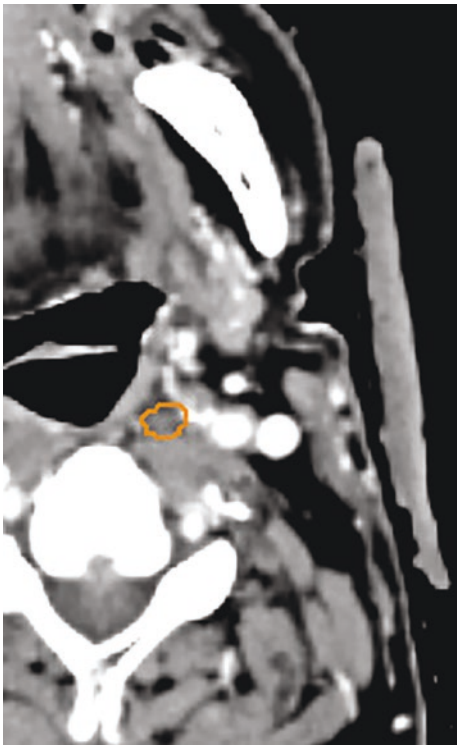


Fig. 3.6 Primary parotid tumor. A 91-year-old gentleman presented with facial nerve palsy secondary to a poorly-differentiated carcinoma in the left parotid (red) with two retropharyngeal nodes (orange). He received 50 Gy in five fractions, two fractions per week. He achieved a complete clinical response and facial nerve function returned. A minor paralytic ectropion of the eye will be treated with canthotomy and canthopexy. There is no evidence of disease at 6 months



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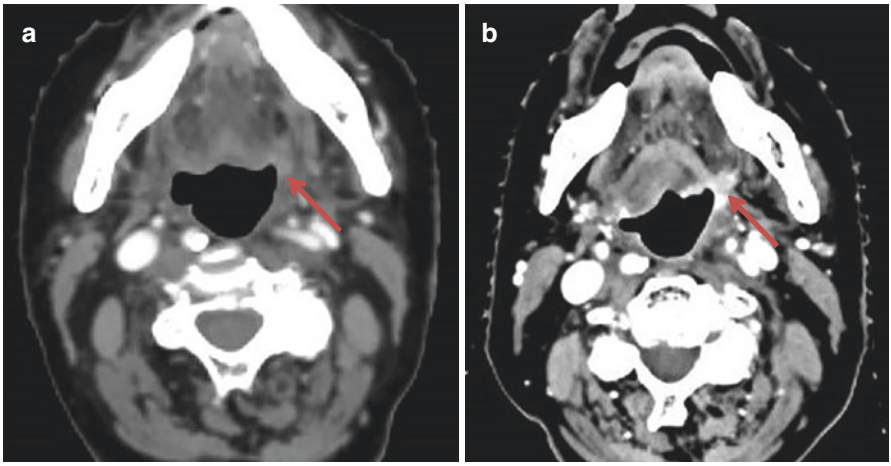

Fig. 3.7 Double-contrast simulation CT when MRI is not available. A 79-year-old lady with a T1N1 squamous cell carcinoma of the base of tongue had single-contrast (80 mL) CT simulation (**a**) that did not adequately visualize the GTV (arrow). (**b**) Double-contrast (160 mL) CT simulation allowed for excellent GTV (arrow) definition