Utilizing IG-IMRT for the Treatment of Head and Neck Cancer

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INTRODUCTION

Nasopharyngeal cancer (NPC) occurs in an anatomical site that is poorly accessible to surgeons, and is often advanced at presentation.[1] The standard of care includes concurrent cisplatin-based chemotherapy and radiotherapy.[2] The overall survival rate is 65% after five years.[1] Due to the close proximity of nasopharyngeal tumors and affected structures to critical organs, NPC presents a challenge for radiation therapy planning.

Intensity-modulated radiation therapy (IMRT) demonstrates a superior dosimetric advantage displayed by steep dose gradient distribution.[3] This makes IMRT an ideal modality for the treatment of NPC. However, patient setup reproducibility, immobilization, and daily irradiated fields are all important and should be closely monitored.

CASE REPORT

A 48-year-old Caucasian female presented with nasal stuffiness and decreased hearing on her right side. A nasal endoscopy was performed, and a large, left-sided nasopharyngeal mass completely obstructing the left eustachian tube was identified. An MRI showed a left-sided nasopharyngeal mass with perineural extension into the skull base extending into the inferior margin of the left cavernous sinus. A biopsy of the nasopharyngeal mass confirmed a diagnosis of undifferentiated nasopharyngeal carcinoma. Based on these findings, she was staged at IVA.

Treatment

The type of tumor (undifferentiated nasopharyngeal carcinoma) made this patient an ideal candidate for concurrent radiation and chemotherapy. The radiation therapy plan devised for the patient consisted of a sliding-window IMRT treatment of the upper head and neck in conjunction with an anterior 3D conformal field to treat the lower neck. These treatment plans were based on the patient's MRI, PET, and CT studies (figure 1). A thermoplastic mask was utilized to help with patient immobilization.

The patient also received concurrent cisplatin (75 mg/m2) and fluorouracil chemotherapy (4,000 mg/m2), in addition to amifostine to help with salivary gland function.

A dose of 59.4 Gy (1.8 Gy per fraction) was delivered to the nasopharynx and adjacent affected areas over seven weeks with the IMRT technique. A simultaneous boost was delivered to the primary tumor site for a dose of 70 Gy (2.12 Gy per fraction). In addition, the bilateral upper neck received a dose of 56 Gy (1.7 Gy per fraction) utilizing the same IMRT treatment fields. The lower neck received a dose of 50 Gy (2 Gy per fraction) over five weeks. The RTOG protocol 0225 guidelines were utilized to provide dose constraints to organs at risk.

The Varian Eclipse™ treatment planning system was utilized in conjunction with a CT simulation to create the image-guided IMRT plan (figure 2). The patient's sliding-window IMRT treatment plan was delivered with a Varian Clinac® iX linear accelerator with an On-Board Imager® kV imaging system.

On the first day of treatment, portal images were acquired for each treatment field to ensure that the planned and treated fields were aligned as demonstrated in figure 3. In addition, the On-Board Imager system was used to take daily kV-kV images and match them to digitally reconstructed radiographs (DRRs) from the patient's initial CT scan (figure 4). Verification of proper alignment was done twice, once by the therapists at the machine using the On-Board Imager system and then again in offline review by the physician. Figure 4 is an offline review image.

A graph of the shifts between the initial patient setup and the kV-kV image matching results is presented in figure 5. Note the large vertical shift present on day one. The patient was initially positioned for treatment using her external set-up marks. However, images taken with the On-Board Imager system and matched to the patient's radiographs showed a significant shift, requiring a large vertical adjustment of the table. After a physicist and physician confirmed accurate patient positioning, according to the policy of the Zangmeister Center, the set-up marks were repositioned. Following this adjustment, the daily vertical shifts were within the 1-cm shift tolerance used at the Zangmeister Center.

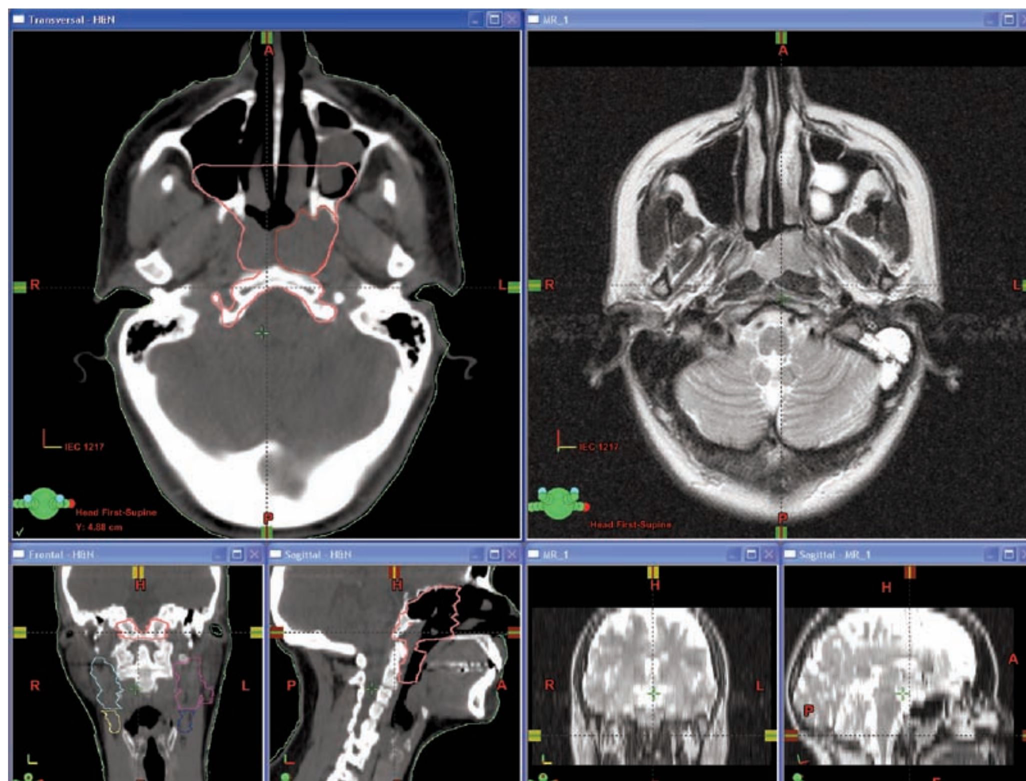


Figure 1. Axial CT image (upper left) with contours of the PTV 70 Gy (red) and the PTV 59.4 Gy (pink). The coronal and sagittal CT images (lower and middle left) also show the affected lymph nodes outlined in blue, purple, yellow, and green. A registered MRI scan of the patient is presented on the right.

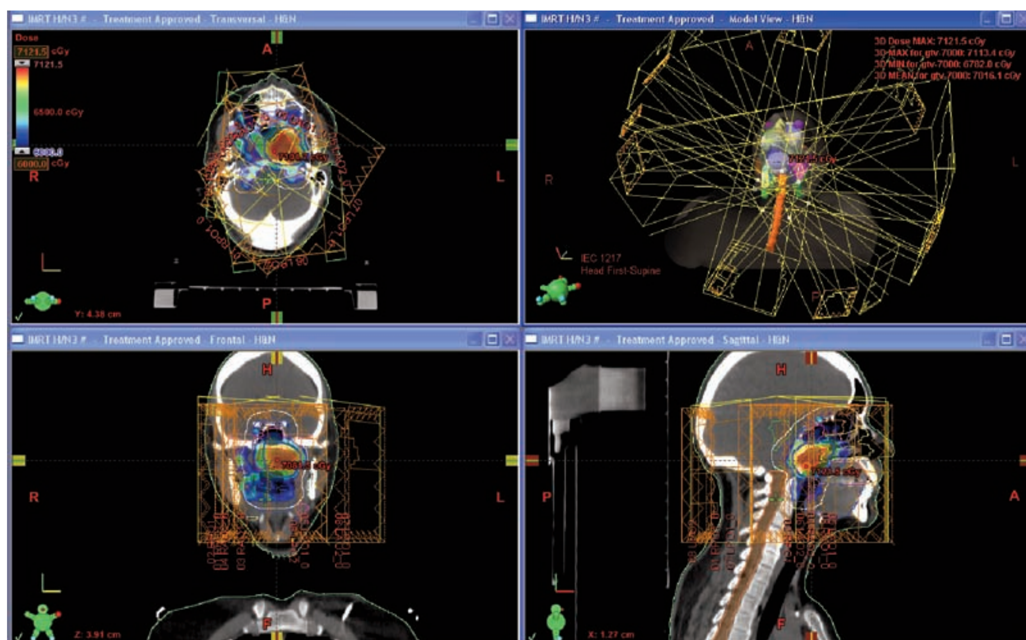


Figure 2. Axial (upper left), coronal (lower left), and sagittal (lower right) views of the patient's isodose distribution in color wash are presented. The upper right image demonstrates the arrangement of the treatment fields.

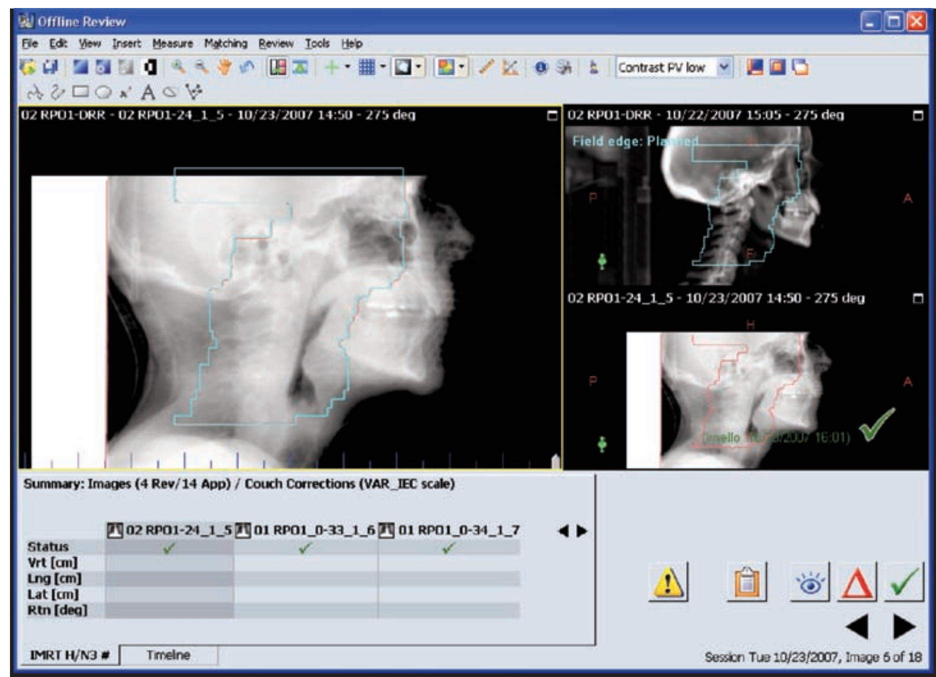


Figure 3. Planned (upper right) and delivered (lower right) port film images for an IMRT treatment field. The image on the left shows an overlay of the planned and treated fields.

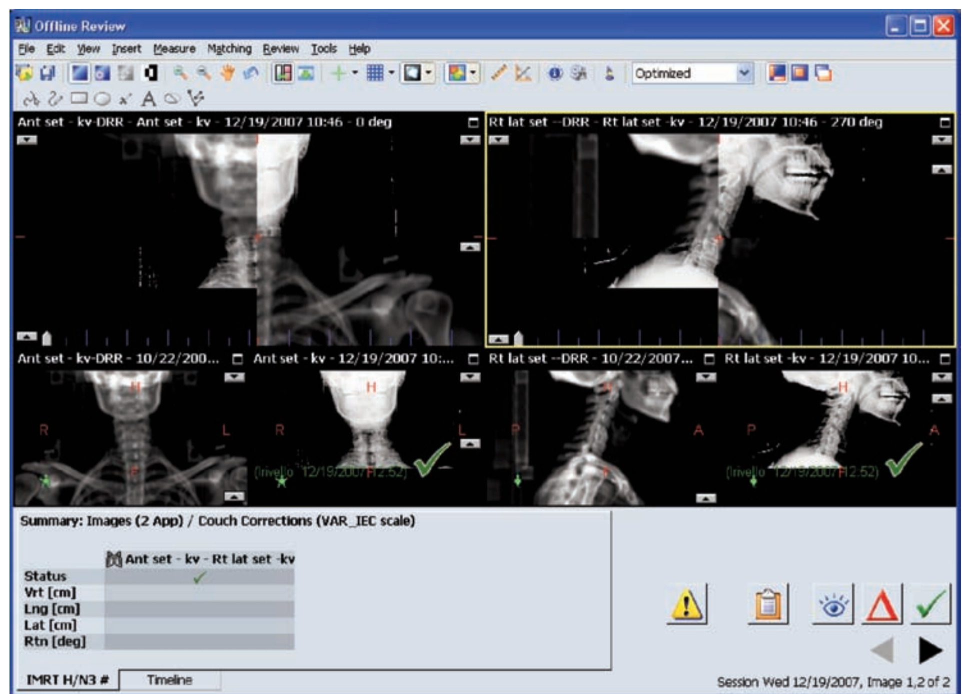
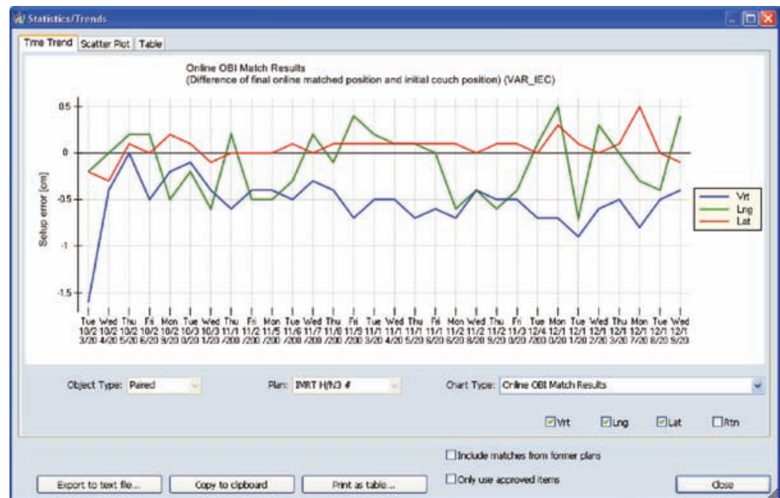


Figure 4. Split window view of anterior (upper left) and lateral (upper right) matched daily kV-kV and DRR images. The lower windows show the unmatched anterior (left) and lateral (right) images, respectively. Patient position was verified at the machine using the On-Board Imager system and in offline review by the physician and physicist.

Figure 5. Graph of table shifts before treatment as a result of daily kV-kV image matching. These shifts were made in the vertical (blue), longitudinal (green), and lateral (red) directions.



Results

By utilizing the On-Board Imager system, it was possible to localize the patient's position with a high degree of accuracy on a daily basis. Without the On-Board Imager system, the difference between the patient's set-up marks and the patient's internal anatomy might not have been corrected before the first day of treatment. This example demonstrates why the Zangmeister Center utilizes the On-Board Imager system with patients on a daily basis.

The primary adverse effects experienced by the patient were nausea and vomiting related to the amifostine, which was discontinued after four weeks of treatment. The patient also experienced dry mouth and slight skin erythema. The nausea and vomiting had lessened significantly by her one-month follow-up and completely cleared up by her three-month follow-up. Her skin erythema had also cleared up at that time.

IGRT AT THE ZANGMEISTER CENTER

During the first half of 2008, Zangmeister Center radiation oncologists treated approximately 300 patients with IGRT using Varian Trilogy® and Clinac accelerators with the On-Board Imager system. Patients were treated for cancer of the pelvis, head and neck, brain, spine, prostate, lung, breast, and pancreas as well as bone metastases. With IGRT, clinicians are able to deliver higher doses of radiation to control tumors near sensitive tissues and organs, and to deliver radiation more effectively to tumors in areas prone to movement.

CONCLUSIONS

An IG-IMRT treatment plan was developed to treat a patient with undifferentiated nasopharyngeal carcinoma based on CT, MRI, and PET studies. The IMRT field was matched with an anterior treatment field for the lower neck. In addition, the patient received concurrent chemotherapy according to the nasopharyngeal standard of care. The patient had three separate PTVs contoured, allowing a simultaneous in-field boost to be delivered. This helped to shorten the overall treatment time for the patient. The On-Board Imager device allowed daily kV-kV images to be acquired and matched to DRRs. The image-guidance system helped eliminate much of the variability initially present in this patient's setup.

References

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3. Kam, MKM, et al. Intensity-modulated radiotherapy in nasopharyngeal carcinoma: dosimetric advantage over conventional plans and feasibility of dose escalation. *Int J Radiat Oncol Biol Phys*. 2003;56:145–157.

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