Longitudinal fan-beam computed tomography dataset for head-and-neck squamous cell carcinoma patients

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Purpose: To describe in detail a dataset consisting of longitudinal fan-beam computed tomography (CT) imaging to visualize anatomical changes in head-and-neck squamous cell carcinoma (HNSCC) patients throughout radiotherapy (RT) treatment course.

Acquisition and validation methods: This dataset consists of CT images from 31 HNSCC patients who underwent volumetric modulated arc therapy (VMAT). Patients had three CT scans acquired throughout the duration of the radiation treatment course. Pretreatment planning CT scans with a median of 13 days before treatment (range: 2–27), mid-treatment CT at 22 days after start of treatment (range: 13–38), and post-treatment CT 65 days after start of treatment (range: 35–192). Patients received RT treatment to a total dose of 58–70 Gy, using daily 2.0–2.20 Gy, fractions for 30–35 fractions. The fan-beam CT images were acquired using a Siemens 16-slice CT scanner head protocol with 120 kV and current of 400 mAs. A helical scan with 1 rotation per second was used with a slice thickness of 2 mm and table increment of 1.2 mm. In addition to the imaging data, contours of anatomical structures for RT, demographic, and outcome measurements are provided.

Data format and usage notes: The dataset with DICOM files including images, RTSTRUCT files, and RTDOSE files can be found and publicly accessed in the Cancer Imaging Archive (TCIA, <http://www.cancerimagingarchive.net/>) as collection *Head-and-neck squamous cell carcinoma patients with CT taken during pretreatment, mid-treatment, and post-treatment (HNSCC-3DCT-RT)*.

Discussion: This is the first dataset to date in TCIA which provides a collection of multiple CT imaging studies (pretreatment, mid-treatment, and post-treatment) throughout the treatment course. The dataset can serve a wide array of research projects including (but not limited to): quantitative imaging assessment, investigation on anatomical changes with treatment progress, dosimetry of target volumes and/or normal structures due to anatomical changes occurring during treatment, investigation of RT toxicity, and concurrent chemotherapy and RT effects on head-and-neck patients. © 2019 American Association of Physicists in Medicine [<https://doi.org/10.1002/mp.13460>]

Key words: CT, fan-beam computed tomography, head-and-neck squamous cell carcinoma

1. INTRODUCTION

Cancer is a world-wide disease affecting an estimated 2 million new cases and approximately 610,000 deaths every year. Head-and-neck cancers [mostly squamous cell carcinoma (HNSCC)] consist of about 8% of new cases and comprise approximately 7% of total cancer deaths. It is estimated that 134,000 new cases of HNSCC are diagnosed in the United States each year resulting in more than 40,000 deaths yearly.¹

Approximately half of all cancer patients can benefit from radiation therapy (RT) in management of their disease.² This is also true for head-and-neck (HN) cancer patients. HN patients in particular may undergo significant anatomical changes over a 6- to 7-week course of radiation treatment.^{3–5} These anatomic changes can occur for a variety of reasons including decrease of tumor and lymph node volumes, weight loss due to poor oral intake, muscle mass alteration, fat distribution, and fluid shift in the body.^{3,4,6,7} Gross changes in anatomy can be noticed with simple visual inspection of the patient, motion in the immobilization device, inability to align on cone-beam CT, or more accurately with the acquisition of new computed tomography (CT) scans.^{6,8} It is

apparent that multiple CT images, acquired over the course of treatment, can facilitate the detection of these anatomy changes. Additionally, the use of CTs is fast, convenient, and it provides good contrast for visualization of these changes. Multiple CTs, however, contribute additional radiation dose to the patient, and as not being a standard of care, require additional efforts and resources. Nonetheless, close monitoring of visual changes (weight loss, loose immobilization, etc.), combined with CT imaging, can assist in treatment adaptation to potentially improve therapy outcome. To visualize the changes described above, HNSCC patient CTs were acquired at three time points — pre-, mid-, and post-treatment. This is the first HNSCC dataset in The Cancer Imaging Archive (TCIA) with CT images acquired throughout the course of RT, which also includes results of normal tissue toxicity.

The HNSCC data available in TCIA include variety of Magnetic Resonance, Positron Emission Tomography (PET), and CT imaging studies, acquired “when available” (according to the data publication) as standard of care or when ordered.^{9,10} The majority of that data include pre- and post-treatment PET/CT scans which is valuable for evaluating and/

or predicting tumor response,^{11–14} but does not illustrate anatomy changes during therapy. At this time, limited MRI data (only nine subjects) for pretreatment, mid-treatment, and post-treatment HNSCC patients are available in TCIA, which however does not provide RT dose as well as supporting clinical information as opposed to our dataset.¹⁵ The data presented herein could be used alongside this MRI data to provide validation of their findings. Overall, our data hold new information not present in the TCIA datasets, since we include well-annotated pre-, mid-, and post-treatment CT images, as well as outcomes for tumor control and normal tissue toxicity of HNSCC patients after completion of therapy. Our dataset allows researchers to compare/validate existing clinical outcomes, visualize anatomical changes, potentially create improved treatment adaptation techniques, and test research ideas where imaging, tumor control, and normal tissue toxicity are studied.

The purpose of this work was to describe in detail longitudinal fan-beam CT scans collected during pretreatment, mid-treatment, and post-treatment for 31 HNSCC patients and share this dataset with the community.

2. ACQUISITION AND VALIDATION METHODS

2.A. Overview of the dataset

The dataset consists of three CT scans, contours, doses, clinical variables, and outcome measures from 31 HNSCC patients who underwent volumetric arc therapy (VMAT) at our institution from 2011 to 2017. VMAT was chosen due to superior dose conformity and tissue sparing.^{16,17} All patients provided informed consent and were enrolled in an Institutional Review Board (IRB)-approved protocol.

The study dates should be used only to discriminate and chronologically trace when the imaging studies were performed. Those study dates have been changed from the actual acquisition dates in order to protect patient confidentiality and comply with Health Insurance Portability and Accountability Act requirements. Modification was done in such a way as to preserve the relative time between acquisitions. Table I shows the modified dates for pretreatment, mid-treatment, and post-treatment, acquisition time to treatment start time (days), mid-treatment fraction, and near-post fraction.

Pretreatment planning CT scans were performed with a median of 13 days before treatment (range: 2–27), mid-treatment CT was performed at 22 days after start of treatment (range: 13–38), and post-treatment CT 65 days after start of treatment (range: 35–192). Patient imaging data were stored with identifiers in the form HN_PXXX, where XXX is a number from 001 to 035. Each number represents a different patient. Figure 1 shows pretreatment, mid-treatment, and post-treatment CT images with planning target volume (PTV) contours of two patients. Each contour color represents a different PTV delineated by the attending physicians. Table I shows the days when CT imaging was acquired prior to treatment start first column, after treatment start (second column), and after completion of therapy (third column). The other

TABLE I. Computed tomography imaging information for pretreatment, mid-treatment, and post-treatment. The data contain days from acquisition time to treatment start, days from treatment start to mid-CT, and days from last treatment date to the post-treatment scan. Number of slices per CT image for pre-, mid-, and post-treatment are also included.

HN_P	Pre-Tx (Days)	Mid-Tx (Days)	Post-Tx (Days)	Number of slices per CT image		
				Pre-Tx	Mid-Tx	Post-Tx
001	14	33	47	196	209	198
002	12	21	35	193	186	196
003	7	17	37	174	204	229
004	24	22	36	235	226	207
005	27	17	37	207	206	217
007	12	22	36	220	217	158
008	12	18	38	207	189	197
009	10	38	52	191	200	197
010	13	23	38	191	185	194
011	7	23	38	200	206	205
012	14	23	36	178	168	193
013	11	24	44	180	182	201
014	20	15	37	215	189	223
015	5	23	49	222	216	227
016	13	23	38	181	199	209
017	8	29	41	189	183	198
018	12	20	41	209	192	196
019	2	31	107	180	179	172
020	14	23	90	225	182	175
022	13	30	102	181	168	188
023	12	25	86	206	179	192
024	19	24	79	179	221	219
026	13	28	97	194	171	165
027	13	20	94	219	228	218
028	14	21	91	228	178	190
029	12	16	86	244	236	195
030	14	16	105	196	230	218
032	14	14	56	216	221	205
033	12	23	91	193	221	193
034	8	21	68	192	206	185
035	13	13	192	202	234	213

three columns denote the corresponding of images per CT scan (pretreatment, mid-treatment, and post-treatment).

2.A.1. Inclusion/exclusion criteria

All patients were recruited according to the following criteria, specified in our IRB-approved prospective imaging acquisition protocol. Inclusion: (a) patients had histologically confirmed HN tumors, (b) patients were treated with definitive RT or concurrent chemoradiation therapy, (c) patients treated with postoperative RT, for whom the gross tumor volume (GTV) or the resection cavity were visible on CT, such that it could be delineated as a target for RT, (d) patients were informed of the investigational nature of this study and were able to understand and to sign a written

FIG. 1. Pretreatment (a), Mid-treatment (b), Post-treatment (c) CT images with planning target volume contours of two patients (1 and 2). The different colors represent the same type of planning target volume across the two patients. [Color figure can be viewed at wileyonlinelibrary.com]

TABLE II. Patient age, sex, tumor stage, tumor volume and location, prior surgery, performance status and chemotherapy medication.

HN_P	Age	Sex	Cancer staging	Tumor location	Prior surgery	Performance status	Chemotherapy medication
001	64	M	IVA	Left base of the tongue and retromolar trigone	Biopsy was obtained from the left retromolar mass as well as another biopsy from the posterior oral tongue	ECOG 0–1	Cisplatin, Cetuximab
002	83	M	IVA	Right tonsil with cervical adenopathy	Cataract surgery (both eyes), corneal transplant (left eye), FNA biopsy of the bulky cervical adenopathy on the right side	ECOG 0–1	Carboplatin, Cetuximab
003	87	M	IVA	Left base of the tongue	Carpal tunnel release, elbow surgery, knee surgery, tonsillectomy and adenoidectomy, tongue biopsy	ECOG 0–1	Carboplatin, Cetuximab
004	66	M	IVA	Left base of the tongue	Total hip arthroplasty	ECOG 0–1	Erbix
005	55	M	IVA	Base of tongue	Hemorrhoid surgery	ECOG 0–1	Cisplatin
007	52	M	IVA	Left tonsil	Tonsil biopsy	ECOG 0–2	Cisplatin
008	71	M	III	Right tonsil with ipsilateral nodal disease.	Appendectomy, biopsy tonsil	ECOG 0–1	Cisplatin
009	59	M	IVA	Anterior floor of the mouth	Cholecystectomy, and history of thoracic surgery, tumor removal at floor of the mouth	ECOG 0–1	Cisplatin
010	59	F	III	Left lateral border of the tongue	Cesarean section, appendectomy, cholecystectomy, tongue surgery, lymph removal at neck	None	None
011	87	M	II	Left lateral oral tongue	Coronary angioplasty, Cataract removal (right), Prostatectomy, colonoscopy with or without biopsy	None	None
012	55	F	IIB	Right oral tongue	Right hemiglossectomy, right revision radical neck dissection, radial forearm free flap, tracheotomy, hysterectomy, tonsillectomy, laryngoscopy/bronchoscopy/esophagoscopy, glossectomy, tongue surgery	None	Cisplatin
013	45	M	IVA	Retromolar trigone	Neck surgery (retromolar trigone)	ECOG 0	Cisplatin
014	69	M	IVA	Left mandible	Tongue biopsy, tonsillectomy	None	Cisplatin

TABLE II. Continued.

HN_P	Age	Sex	Cancer staging	Tumor location	Prior surgery	Performance status	Chemotherapy medication
015	71	M	IVA	Lymph nodes of head, face, and neck	Umbilical hernia repair, Surgery of lip, cosmetic surgery, dissection neck	ECOG 0–1	Cisplatin
016	80	M	IVA	Left base of the tongue, both tonsils with extensive lymph node	Laryngectomy, inguinal hernia repair	ECOG 1	Cetuximab
017	84	M	IIA	Base of tongue	Appendectomy, hernia repair, prostate surgery, cardiac catheterization, cataract surgery	ECOG 0–3	None
018	67	M	IVA	Larynx	Tonsillectomy and the vocal cord biopsy, total laryngectomy, bilateral neck dissection, tracheoesophageal puncture	ECOG 0	None
019	70	F	IVA	Left parotid gland	Appendectomy, cholecystectomy, sinus surgery, and neck and ear surgery	None	None
020	59	M	III	Larynx (right true vocal cord)	Hemorrhoid surgery, colonoscopy	None	Cisplatin
022	43	F	III	Right tongue base	Tonsillectomy	ECOG 1	Cisplatin
023	71	M	III	Nasal cavity	Appendectomy, hernia repair, nasal endoscopy, and sinus surgery	None	None
024	66	M	IVA	Oropharynx	Vulva removal, knee surgery, myringotomy (right), tonsillectomy	None	Cisplatin (with Mannitol).
026	61	F	IVA	Larynx	Endoscopy, biopsy, total laryngectomy, cholecystectomy	ECOG 1–2	Cisplatin
027	65	M	III	Larynx- right TVC	Cholecystectomy, IR US biopsy thyroid (right)	ECOG 1	Carboplatin
028	68	M	III	Occipital scalp	Tumor excision in head, colonoscopy w/or w/o biopsy, upper gastrointestinal endoscopy, resect tumor soft tissue neck/anterior thorax, removal nodes, neck, cervical, tunneled venous port placement	None	Cisplatin
029	64	M	I	Right tonsil	Coronary angioplasty with stent placement, aorto-femoral bypass graft, cardiac defibrillator placement, pacemaker placement	None	None
030	80	M	IVA	Left hard palate	Cryoablation prostate transperineal, tonsillectomy, repair hernia inguinal	None	None
032	51	M	III	Paranasal sinus	Cardiac surgery, coronary angioplasty with stent placement, sinus surgery	None	None
033	45	F	IIA	Oral tongue	Tubal ligation	None	None
034	56	F	III	Nasal cavity	Cesarean section, cholecystectomy, nasal polyp removal, nasal endoscopy, removal part ethmoid, maxillary sinusotomy, upper jaw maxillectomy	None	None
035	41	F	I	Right true vocal cord, glottic larynx	larynx surgery, cesarean section	None	None

informed consent document. Exclusion: (a) pregnant or nursing women were not eligible to participate, (b) women of reproductive potential must have been offered a pretreatment pregnancy test and informed of the need to practice an effective contraceptive method, (c) patients younger than 18 years, (d) patients whose size and weight would not allow CT scanning, and (e) patients who did not finish the RT treatment course.

2.A.2. Patient demographics

Table II includes age, sex, tumor stage, tumor volume and location, prior surgery, performance status, and patient chemotherapy medication (if any). Performance status is a standard criteria used for measuring how the disease impacts patient's daily abilities. The Eastern Cooperative Oncology Group (ECOG) performance status is commonly used when

TABLE III. Hounsfield Unit-to-electron density conversion table.

CT number	Density
0	0.000
179	0.190
499	0.459
936	0.952
976	0.976
999	1.000
1047	1.043
1054	1.052
1223	1.117
1900	1.512
5000	12.000

planning trials to study a new treatment method. ECOG 0 indicates fully active, able to carry on all pre-disease performance without restriction. ECOG 1 indicates restricted in physically

TABLE IV. Contoured structures organs at risk per patient in Original, Mid, and Post Images.

	HN_P	Cord	Rparotid	Lparotid	Brainstem	Esophagus	Larynx (GSL)	Mandible
<i>Original</i>	001	x	x	x	x			x
<i>Mid</i>		x	x	x				
<i>Near Post</i>		x	x	x	x			x
<i>Original</i>	002	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x				
<i>Original</i>	003	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x	x		x	x
<i>Original</i>	004	x	x	x	x	x	x	x
<i>Mid</i>		x	x	x	x	x	x	x
<i>Near Post</i>		x	x	x	x	x	x	x
<i>Original</i>	005	x	x	x	x	x	x	x
<i>Mid</i>		x	x	x	x	x	x	
<i>Near Post</i>		x	x	x	x	x	x	
<i>Original</i>	007	x	x	x	x	x	x	x
<i>Mid</i>		x	x	x	x	x	x	x
<i>Near Post</i>		x	x	x	x	x	x	x
<i>Original</i>	008	x	x	x	x			x
<i>Mid</i>		x	x	x	x			x
<i>Near Post</i>		x	x	x	x			x
<i>Original</i>	009	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x	x		x	x
<i>Original</i>	010	x	x	x	x		x	
<i>Mid</i>		x	x	x	x		x	
<i>Near Post</i>		x	x	x	x		x	
<i>Original</i>	011	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x	x		x	x
<i>Original</i>	012	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x	x		x	x
<i>Original</i>	013	x		x	x		x	x
<i>Mid</i>		x		x	x		x	x
<i>Near Post</i>		x		x	x		x	x
<i>Original</i>	014	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x	x		x	x
<i>Original</i>	015	x	x	x	x		x	
<i>Mid</i>		x	x	x	x		x	
<i>Near Post</i>		x	x	x	x		x	
<i>Original</i>	016	x	x	x	x			x
<i>Mid</i>		x	x	x	x			x
<i>Near Post</i>		x	x	x	x			x
<i>Original</i>	017	x	x	x	x		x	x
<i>Mid</i>		x	x	x	x		x	x
<i>Near Post</i>		x	x	x	x		x	x
<i>Original</i>	018	x	x	x	x			x
<i>Mid</i>		x	x	x	x			x
<i>Near Post</i>		x	x	x	x			x

TABLE IV. Continued.

	HN_P	Cord	Rparotid	Lparotid	Brainstem	Esophagus	Larynx (GSL)	Mandible
Original	019	x	x		x		x	x
Mid		x	x		x		x	x
Near Post		x	x		x		x	x
Original	020	x	x	x	x			x
Mid		x	x	x	x			x
Near Post		x	x	x	x			x
Original	022	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	023	x	x	x	x			?
Mid		x	x	x	x			?
Near Post		x	x	x	x			?
Original	024	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	026	x	x	x	x	x		x
Mid		x	x	x	x	x		x
Near Post		x	x	x	x	x		x
Original	027	x	x	x	x	x		x
Mid		x	x	x	x	x		x
Near Post			x	x	x	x		x
Original	028	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	029	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	030	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	032	x	x	x	x			x
Mid		x	x	x	x			x
Near Post		x	x	x	x			x
Original	033	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	034	x	x	x	x		x	x
Mid		x	x	x	x		x	x
Near Post		x	x	x	x		x	x
Original	035	x						
Mid		x						
Near Post		x						

strenuous activity but ambulatory and able to carry out work of a light or sedentary nature. ECOG 3 indicates capable of only limited self-care, confined to bed or chair more than 50% of waking hours. ECOG 4 indicates completely disabled, cannot carry on any self-care, totally confined to bed or chair. ECOG 5 denotes patient's death.¹⁸ All the information in Table II was obtained from the institutional electronic medical record (EMR) system (Epic Systems Corporation, Verona, WI, USA) and its publication has been IRB approved.

2.B. Acquisition

2.B.1. CT

In this work CT scan refers to a series of images, while an image represents a single frame of the CT scan. Longitudinal fan-beam CT scans were acquired using a Siemens 16-slice CT scanner with standard clinical HN protocol. The protocol utilized 120 kV potential and tube current of 400 mAs. A

TABLE V. Planning target volumes in Gy per patient.

HN_P	PTV1	PTV2	PTV3	PTV4
001	60	54		
002	70	60	54	
003	60	54		
004	70	60	54	
005	70	56	52.5	
007	70	60	54	
008	70	60	54	
009	64.5	60	54	
010	60	54		
011	60	54		
012	66	60	54	
013	66	54		
014	66	60	54	
015	66	60	54	
016	66	54		
017	70	66	63	56
018	60	54		
019	60	54		
020	70	60	54	
022	70	60	54	
023	60			
024	70	60	54	
026	66	60	54	
027	70	60	54	
028	60	54		
029	63			
030	60	54		
032	66	60		
033	60	54		
034	60			
035	66			

helical scan with 1 rotation per second was used with a slice thickness of 2 mm and table increment of 1.2 mm. The field of view was 50×50 cm, mapped to a slices of 512×512 pixels, with a pixel size of 0.0977×0.0977 cm².

All CT scans were acquired on the same scanner, and a Hounsfield Unit-to-electron density calibration table reproduced from the clinical treatment planning system is listed in Table III for reference.

2.B.2. Segmentation

In addition to the imaging data, the dataset contains contours of anatomical structures for RT. The contours were outlined by the attending radiation oncologists for treatment planning purposes. The RT treatment plans were generated with Eclipse® (Varian Medical Systems, Inc., Palo Alto, CA, USA) treatment planning system. Table IV shows the organs at risk (OARs), where X denotes if the contour was present in the plan (different patients had different OARs outlined, depending on tumor location and clinician discretion). OARs include spinal cord, right

parotid gland, left parotid gland, brainstem, esophagus, larynx, and mandible. Table V includes the planning target volume (PTV) doses. OARs and PTV were included together because they are delineated by the physician prior to treatment planning and are used in the treatment plan optimization. Patients had several levels of prescription, and therefore several PTVs were outlined. The corresponding doses are listed in Table V. The clinical target volume to PTV contour expansions were generated on per-patient basis, depending on the individual therapeutic needs and clinician's decision. Figure 2 shows the OARs described above for three different patients for pretreatment CTs in axial, sagittal, and coronal views.

2.B.3. Clinical parameters

Table VI lists clinical treatment information for all subjects including prescription, dose per fraction, total number of fractions, PTV volume, VMAT arcs, and energy. Patients underwent RT treatment to a total dose of 58–70 Gy, using daily 2–2.20 Gy, fractions for 30–35 fractions. The reported PTV volumes are combination of all PTVs shown in Table V, since they represent the total treated volume.

2.B.4. Outcome information

Table VII includes treatment related toxicities for parotid glands and oral cavity. Table VIII includes patient weight change during the course of treatment and the net loss after the end of therapy. Grading for toxicity was measured using Common Terminology Criteria for Adverse events version 4. Most common toxicities were xerostomia and mucositis, which appear in our database on average from day 22 to 186 days post radiotherapy. All this information was obtained from the institutional EMR system and its publication has been approved by the IRB.

2.B.5. Known issues and limitations

There are a few known issues and limitations of this dataset. We have a limited number of HNSCC patients (31), therefore the conclusions derived from this dataset may not be representative of the general HNSCC population. Another limitation is the differences of the outlined anatomical structures across patients. All the structures were outlined at the discretion of the attending physicians and since different patient had different tumors, some of the OARs were not included for every patient (Table IV indicates which structures are present for each patient). In addition, PTV prescription doses and fractionation schemes are tailored to each individual and therefore they are not uniform across patients, as presented in Table V.

2.C. Data validation

As all the patients in this dataset were treated at our institution and images were acquired using the same CT scanner

FIG. 2. Organs at risk contours for three different patients outlined on the pretreatment CT images in axial, sagittal, and coronal views. Each organ at risk is represented in a different color. The different colors represent the same organ at risk across the three patients. [Color figure can be viewed at wileyonlinelibrary.com]

by licensed radiation therapists. The utilized reconstruction algorithm was consistent for all scans in the dataset. The transfer of the images to the treatment planning system followed the same institutional protocol. After image import in the treatment planning system, all images were reviewed by licensed dosimetrists and/or physicist for any artifact prior to performing any segmentation and treatment planning according to the guidelines from AAPM Task Group 66.¹⁹ CT quality assurance tests for mechanical and imaging performance were regularly performed on daily, monthly, and annual basis, thereby ensuring adequate, reliable, and reproducible SC scanner performance.

In order to verify the dataset, the DICOM files with the corresponding RTSTRUCT and RTDOSE were cross-checked with the original (non-anonymized) data. All patient data were then transferred from MIM (MIMCorp, Cleveland,

OH, USA) to Eclipse after anonymization to ensure compatibility with the treatment planning system.

3. DATA FORMAT AND USAGE NOTES

Data were exported from Eclipse in DICOM (images), DICOM-RTSTRUCT (structures), and DICOM-RTDOSE (doses) format and then imported into MIM. It should be noted that we have two DICOM-RTst per imaging set, one with series description MIM structures and another named ARIA Rad Onc Structure Sets. The RTst-MIM structures was renamed by us to remain consistent with Table V structures. On the other hand, RTst-ARIA Rad Onc Structure Sets were the original structures as part of treatment planning and delivery. Our recommendation is to use RTst-MIM structures so that the information on Table V is

TABLE VI. Treatment information: Total dose, number of fractions, dose per fraction, number of arcs (full arcs are a complete rotation while partial arcs are denoted by degrees of rotation), and beam energy.

HN_P	Total dose (Gy)	Number of fx	Dose/fx (Gy)	PTV vol (cm ³)	VMAT arcs	Energy (MV)
001	69.96	33	2.12	650.37	2 full	6
002	69.96	33	2.12	561.63	2 full	6
003	69.96	33	2.12	471.64	2 full	6
004	70	35	2.00	744.30	2 full	6
005	70	35	2.00	481.63	2 full	6
007	69.96	33	2.12	629.86	2 full	6
008	69.96	33	2.12	573.82	2 full	6
009	65	30	2.15	604.77	2 full	6
010	60	30	2.00	351.96	2 full	6
011	60	30	2.00	581.63	2 full	6
012	66	30	2.20	524.45	2 full	6
013	66	33	2.00	816.94	2 full, 1 arc :330–30 ^a	6
014	66	30	2.20	602.99	2 full	6
015	66	33	2.00	602.29	2 full	6
016	66	33	2.00	486.86	2 full	6
017	70	35	2.00	724.45	2 full	6
018	60	30	2.00	595.22	2 full	6
019	60	30	2.00	267.13	3 full	6
020	69.96	33	2.12	440.64	2 full	6
022	69.96	33	2.12	447.25	3 full	6
023	60	30	2.00	170.57	3 arcs: 208–152 ^a , 1 arc: 320–20 ^a	6
024	69.96	33	2.12	538.83	3 full	6
026	66	33	2.00	676.72	3 full	6
027	69.96	33	2.12	668.63	3 full	6
028	60	30	2.00	537.14	3 full	6
029	63.6	30	2.12	63.22	2 full	6
030	60	30	2.00	360.14	3 arcs: 200–160 ^a	6
032	60	30	2.00	139.24	3 full	6
033	60	30	2.00	494.93	3 full	6
034	60	30	2.00	140.96	3 full	6
035	66	33	2.00	42.56	2 full	6

^aIEC coordinate system.

helpful. Data were then imported into TCIA at the National Institutes of Health for storage, where it was additionally post-processed to ensure protection of potentially confidential information.²⁰

HN_PXXX is consistent among all tables and TCIA data. The PatientID DICOM tag has a similar identification. Images can be identified by the DICOM study date, as mentioned previously, but the study dates are offset to protect identification while remain consistent with relative to time between scans. DICOM series description contains patient identifier, patient ID, and study ID. The patient name is HN_PXXX, while patient ID and study ID are ANONXXX. ANONXXX was a randomized name created by MIM

software to de-identify the patients. DICOM tags related to acquisition such as the technique, image orientation, and spacing were preserved during de-identification and anonymization.

The dataset of HNSCC patients with multiple CT acquired during the course of therapy can be found at the TCIA website <http://www.cancerimagingarchive.net/>. Alternatively, the dataset can be accessed by digital object identifier (DOI) <https://doi.org/10.7937/k9/tcia.2018.13upr2xf>.

The total size of the dataset is 14.4 GB, with 372 individual DICOM files consisting of 93 images containing 18906 individual slices, 186 RTSTRUCT files, and 93 RTDOSE files. DICOM and DICOM-RT compatibility have been tested with Eclipse and MIM (MIM Software, Cleveland, OH, USA).

The DOI link above points directly to the dataset. To download the data, the user needs to select the download button under Data Access. A TCIA Download Manager will appear where a directory to save the data can be selected. Once downloaded, the data will appear in separate folders titled HN_PXXX, representing different patients. Each folder contains the pretreatment, mid-treatment, and post-treatment folders, and within each of these are imaging data, a RTSTRUCT, and RTDOSE. In order to view these data, a DICOM accessible software such as standard RT treatment planning system, MIM, Velocity, or an alternative DICOM viewer (such as DicomBrowser at <http://nrg.wustl.edu/software/dicom-browser>) will be required.

4. DISCUSSION

This dataset included imaging information, contours of tumors and normal tissues, demographics, and outcomes for tumor control and normal tissue complications. This information will allow researchers to measure gross tumor changes, validate their existing data, and potentially create new measures to treatment adaptation. In the future, this dataset can be used for contouring purposes where automated or semiautomated algorithms can be trained or validated on the data. Furthermore, the data can be used in radiomics studies for predictions of tumor control and/or normal tissue complications. The dataset can also be utilized for training and/or validation in delta-radiomics studies. Another venue for application of this data might be in proton studies, where plan robustness can be tested on changing patient anatomy.

The HNSCC data available in TCIA include a variety of MRI, PET, and CT imaging studies with unclear dates and timelines creating difficulty in seeing anatomical changes during radiation treatment and success of such treatment. Majority of the available data only include pretreatment and post-treatment PET/CT scans which does not illustrate anatomy changes during treatment. Our dataset adds to the collective HNSCC data in TCIA and it can be used in conjunction with pretreatment and post-treatment PET/CT and MRI for pretreatment, mid-treatment, and post-treatment HNSCC data found in the repository.

TABLE VII. Patient toxicities associated with the pretreatment, mid-treatment, and post-treatment time points.

HN_P	Outcome mid-treatment (tx)	Outcome near end treatment (tx)	Outcome 3–6 months post
001	Grade 2 xerostomia, Grade 3 mucositis	Grade 3 mucositis involving the Left oral tongue, facial arch	No palpable adenopathy of the head, neck or supraclavicular regions. Oral cavity and oropharynx are without suspicious lesions. Palpation of the oral tongue, floor of mouth, tongue base and tonsils bilaterally is negative. Significant mucositis and edema, mild xerostomia
002	Grade 2 mucositis involving the soft palate, Grade 1 mucositis involving the bilateral lateral tongue	Grade 3 mucositis involving the right oral tongue laterally and Grade 2 involving the left soft palate and left oral tongue	No masses are seen in the upper aerodigestive tract. Mucosal lining of the pharynx and larynx shows post-treatment changes. Superficial small ulcers on the posterior pharyngeal wall without any obviously suspicious lesions. Both vocal cords have normal aspect and range of motion, airway is patent. Significant xerostomia, odynophagia
003	Grade 1 xerostomia, Grade 1 mucositis of the left buccal mucosa and left lower gingiva	Grade 2 mucositis in the left lateral aspect of the base of tongue, Grade 3 mucositis on the soft palate	Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. No edema. Voice was normal. Xerostomia present
004	Grade 1 oral mucositis	Grade 2 oral mucositis	Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. Minimal bilateral arytenoid edema. Voice was normal. Xerostomia present
005	No toxicity	Grade 2 dermatitis over the treated area, Grade 1 mucositis over the left posterior pharyngeal wall	Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. No edema. Voice was normal
007	Grade 3 mucositis, Grade 2 mucositis over the soft palate and posterior oropharyngeal wall	Grade 3 mucositis over the soft palate and posterior oropharyngeal wall, with areas of Grade 2 along the lateral aspects of the tongue	Presents with dysphagia related to reduced base of tongue retraction. Presents with modest narrowing at the cricopharyngeal area that reduces bolus flow at this level. Persistent mucositis accompanied by taste change, dry mouth, reduced appetite and weight loss
008	Grade 1 mucositis over the hard and soft palate	Grade 3 mucositis of soft palate and tongue	No lesions or suspicious masses in the upper airway. Both vocal cords were mobile bilaterally and the airway was adequate. Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Significant blunting of the epiglottis. Vocal cords were mobile and met in midline. No edema. Voice was normal. Xerostomia present
009	No toxicity	Grade 3 mucositis in the floor of mouth, with Grade 2 in the tonsillar pillars	Significant for mild-to-moderate degree of mucositis and mouth sores as a postradiation change. Moderate degree of dry xerostomia. No lesions or suspicious masses in the upper airway. Both vocal cords were mobile bilaterally and the airway was adequate
010	Grade 1 mucositis of the oral cavity except the left lateral tongue which is Grade 2, Grade 1 xerostomia	Grade 3 confluent mucositis of the left oropharynx and left lateral tongue	No palpable adenopathy of the head, neck, or supraclavicular regions. Oral cavity and oropharynx are without suspicious lesions. Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. No edema. Voice was normal
011	Grade 3 mucositis in mouth (buccal mucosa, vestibule of mouth left tongue)	Grade 3 mucositis in mouth (buccal mucosa, vestibule of mouth left tongue)	Dry mouth as the only side effect. Oral cavity, oropharynx, hypopharynx, larynx, nasopharynx, nose and necks, including the use of a fiber optic scope shows no evidence of recurrence
012	Grade 2 mucositis	Grade 3 mucositis in oral cavity is limited to the left side	CT of the neck failed to show tumor recurrence and CT of the chest was normal. Rash noted. No masses are palpable in the neck
013	No toxicity	Grade 2 mucositis on the right ventrolateral aspect of the tongue and on the inner lip, Grade 2 mucositis on the right ventrolateral aspect of the tongue and on the inner lip	Developed a rapid recurrence in the right temporal region on the margin of the radiation field and completed chemo and re-irradiation. Increased thickening of the epiglottis and supraglottic larynx, could be related to post-treatment changes. No palpable adenopathy of the head, neck, or supraclavicular regions. Oral cavity and oropharynx are without suspicious lesions. Moderate thrush in the oral cavity. Mild xerostomia
014	Grade 1/2 mucositis limited to the oropharynx	Grade 2 mucositis of the soft palate	No toxicity
015	Grade 2 mucositis at underside of tongue and mucosal aspect of the lower lip	Grade 2 mucositis over the lip and tongue	Lymph nodes in mediastinum, lung nodule, and hypermetabolic upper abdominal preaortic lymphadenopathy 5. Mild hepatomegaly and evidence of splenomegaly. Transbronchial biopsy of right and left hilar lymph nodes and both positive for cancer

TABLE VII. Continued.

HN_P	Outcome mid-treatment (tx)	Outcome near end treatment (tx)	Outcome 3–6 months post
016	Grade 1 mucositis of oral cavity	Grade 2 mucositis	Complete stenosis of the distal hypopharynx. Oral cavity, oropharynx, nasal cavity, nasopharynx, new hypopharynx, neck, and stoma are without evidence of recurrence. Dysphagia — receiving PEG tube feedings, but likely getting too little calories based on nutritional assessment. Weight loss, intermittent diarrhea
017	Grade 1 mucositis	Grade 2 xerostomia, Grade 2 mucositis of the right roof of mouth	Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. No edema. Voice was normal. Grade 2 xerostomia
018	No toxicity	No toxicity	Mucosal excoriations and sloughing extending circumferentially to about 2–3 cm from the stomal opening. No extensive crusting or bleeding. Trachea to the carina within normal. Both vocal cords were mobile bilaterally and the airway was adequate. Later examination revealed significant edema of mucosa in the nasopharynx
019	Grade 3 mucositis of left posterior buccal mucosa	No toxicity	Left parotid adenocarcinoma post-surgery and radiation. Left mixed hearing loss and tinnitus. Left facial/auricular discomfort — likely left TMJ dysfunction (TMJ capsule removed from tumor involvement)
020	No toxicity	No toxicity	Occasional odynophagia when swallows. Minimal xerostomia. No masses are seen in the upper aerodigestive tract. Mucosal lining of the pharynx and larynx is normal except for post-treatment changes. Both vocal cords have relatively normal aspect and the right cord has slightly reduced range of motion. Airway is patent. No evidence of persistent disease and no evidence of progression of chondronecrosis
022	Grade 2 mucositis involving the right soft palate, right lateral oral tongue and right buccal surface, Grade 2 xerostomia	No toxicity	Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Blunting of the epiglottis and bilateral arytenoid edema. Vocal cords were mobile and met in midline. Voice was normal
023	No toxicity.	No toxicity.	Nasal crusts at floor of nasal cavity and lateral nasal wall removed. Sinuses all patent. Few granulations suctioned away central skull base with normal ASB otherwise.
024	Grade 2 xerostomia, Grade 1 mucositis involving the soft palate and lateral tongue	Grade 2 xerostomia	No adenopathy in the neck. Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Left arytenoid edema was noted. Vocal cords were mobile and met in midline. No edema. Voice was normal
026	No toxicity	No toxicity	Airway is patent. Mucosa shows post-treatment changes. Cavities are widely patent and clean including maxillary, frontal, and sphenoid sinuses. Skull base is covered with relatively normal mucosa and the right inferior turbinate flap appears healthy. No lesions, polyps, or secretions are seen
027	Grade 1 mucositis posteriorly in pharynx, Grade 2 mucositis of right lateral tongue, Grade 3 laryngeal mucositis	Grade 1 mucositis posteriorly in pharynx, Grade 2 mucositis of right lateral tongue, Grade 3 laryngeal mucositis	Nasal cavities, nasopharynx, oropharynx, hypopharynx, and larynx shows no abnormality. Both vocal cords are fully mobile. Pyriform sinuses, post cricoid area, and vallecula are normal. No lesions seen
028	No toxicity	No toxicity	Large occipital mass excised from the occipital scalp was a squamous cell carcinoma by an outside surgeon. A new lesion was seen near the original site. He underwent a left posterior neck dissection, levels 2 through 4, and level 5 with adjacent tissue transfer and trapezius flap
029	Grade 2 mucositis of the right retrimolar trigone and anterior tonsillar pillar, and right lateral tongue base	No toxicity	Patient complains about pain in the throat, neck, and posterior cervical spine for which he is requesting pain medications. Nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. No edema. Voice was normal
030	No toxicity	Grade 1 xerostomia	No toxicity
032	No toxicity	No toxicity	Heavy growth of <i>Staphylococcus aureus</i> . Crusting after radiation — stable amount
033	Grade 2 mucositis in the flap and the tongue, Grade 2 xerostomia	Grade 1 mucositis	No toxicity
034	No toxicity	Grade 1 mucositis, Grade 2 mucositis of right nares	Right side has normal mucosa. Left side has mild contracture. No lesions seen. Ethmoid cavity normal. Crusts filling mega anrostomy cavity. Patchy area of exposed bone in maxillary sinus. Nasal secretions discolored secretions left. Nasal septum mild right deviation and no perforation appreciated, synechia formation between the inferior turbinates and septum
035	No toxicity	No toxicity	Supraglottic structures demonstrate mild postradiation edema. The airway is widely patent, and nasal cavity, nasopharynx, oropharynx, supraglottic laryngeal structures, pyriform sinuses, and glottic larynx were without suspicious lesions. Vocal cords were mobile and met in midline. No edema. Voice slightly raspy

TABLE VIII. Patient weight change during radiotherapy, and net weight loss (lbs) after treatment completion.

HN_P	Pre-tx weight	Mid-tx weight	Post-tx weight	Net weight loss
001	138	138	131	7
002	164	164	157	7
003	210	210	195	15
004	201	201	194	7
005	187	187	181	6
007	216	216	207	9
008	159	159	148	11
009	172	172	163	9
010	155	155	145	10
011	188	188	188	0
012	137	137	127	10
013	214	214	207	7
014	141	141	125	16
015	227	227	218	9
016	84	84	84	0
017	146	146	138	8
018	150	150	148	2
019	124	124	118	6
020	123	123	113	10
022	163	163	132	31
023	165	165	168	-3
024	175	175	172	3
026	147	147	128	19
027	205	205	170	35
028	200	200	180	20
029	134	134	138	-4
030	161	161	143	18
032	199	199	196	3
033	162	162	158	4
034	188	188	188	0
035	149	146	147	2

5. CONCLUSION

The purpose of this manuscript was to describe in detail longitudinal fan-beam CT scans collected during pre-, mid-, and post-treatment for 31 HNSCC patients and to share these data with the community. Despite being relatively small, this dataset adds more information to the already existing imaging archive in the TCIA, and thereby contributes to the Big Data paradigm.

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