



# **Role of Neck Imaging Reporting and Data System (NI-RADS) in the Prediction of local and Regional Recurrence of Head and Neck Squamous Cell Carcinoma by Cross Sectional Imaging Modalities**

*Thesis*

*Submitted for Partial Fulfillment of M.D. Degree in Radiology*

*Presented by*

**Manar Maamoun Mohamed Ashour**

*M.B., B. Ch., M. Sc.*

*Faculty of Medicine, Ain Shams University*

*Supervised By*

**Prof. Dr. Hanaa Abdel Kader Abdel Hameed**

*Professor of Radiodiagnosis*

*Faculty of Medicine - Ain Shams University*

**Prof. Dr. Zeinab Mohammed Abdel Hafeez**

*Professor of Clinical Oncology and Nuclear Medicine*

*Faculty of Medicine - Ain Shams University*

**Assistant Prof. Dr. Togan Taha Abdel Aziz**

*Assistant Professor of Radiodiagnosis*

*Faculty of Medicine - Ain Shams University*

**Dr. Ahmed Samy Abdelrahman**

*Lecturer of Radiodiagnosis*

*Faculty of Medicine - Ain Shams University*

*Faculty of Medicine  
Ain Shams University*

*2019*

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

# قَالَ

سُبْحَانَكَ لَا يَعْلمُ لَنَا  
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ  
الْعَلِيمُ الْعَظِيمُ

صدق الله العظيم

سورة البقرة الآية: ٣٢



## Acknowledgement

*First and foremost, thanks to Allah, the most Beneficent and Merciful.*

*Thanks to Prof. Dr. Hanaa Abdel Kader Abdel Hameed, Professor of Radiodiagnosis, Faculty of medicine-Ain Shams University, for giving me the honor to work under her supervision, judicious guidance and kind support at this study.*

*I wish to express my great thanks to Prof. Dr. Zeinab Mohammed Abdel Hafeez, Professor of clinical Oncology, Faculty of medicine-Ain Shams University, for her kind care, constant help and great assistance throughout this work,*

*My deep appreciation and thanks to Dr. Togan Taha Abdel Aziz, Assistant Prof. of Radiodiagnosis, Faculty of medicine-Ain Shams University, for suggesting this topic, and for her keen guidance, and continuous kind encouragement, which made the completion of this work possible.*

*My deep appreciation to Dr. Ahmad Samy Abdelrahman, Lecturer of Radiodiagnosis, Faculty of medicine-Ain Shams University, for his sincere guidance and effort during this study.*

*I am grateful to all my brave patients, for their kind acceptance to be included in this study.*

*I am indebted to my parents, my family, my friends and my colleagues for their endless and continuous help, support and prayers.*

---



*Manar Maamoun Ashour*

# *List of Contents*

Title	Page No.
List of Abbreviations .....	i
List of Tables .....	iv
List of Figures.....	ix
Introduction .....	1
Aim of the Work.....	21
Review of Literature	
▪ Anatomy of the Head and Neck .....	22
▪ Pathology of Head and Neck Squamous Cell Carcinoma .....	45
▪ Imaging Technique and Interpretation.....	66
Patients and Methods .....	95
Results .....	109
Illustrative Cases.....	125
Discussion.....	144
Recommendations .....	164
Summary .....	165
Conclusions .....	170
References .....	171
Arabic Summary .....	--

# *List of Abbreviations*

Abb.	Full term
<b>2D</b> .....	Two dimensions
<b>3D</b> .....	Three dimensions
<b>ACR</b> .....	American College of Radiology
<b>ADC</b> .....	Apparent diffusion coefficient
<b>AJCC</b> .....	American Joint Committee on Cancer
<b>ALT FF</b> .....	Anterolateral thigh Fasciocutaneous flap
<b>ASL</b> .....	Arterial spin labelling
<b>BIRADS</b> .....	Breast Imaging Reporting and Data System
<b>BOLD</b> .....	Blood oxygen level-dependent
<b>C6</b> .....	The sixth cervical vertebra
<b>Cho</b> .....	Choline
<b>Cho-to-Cr</b> .....	Choline to creatine ratio
<b>CN IX</b> .....	Glossopharyngeal nerve
<b>CN V</b> .....	Trigeminal nerve
<b>CN VII</b> .....	Facial nerve
<b>CN X</b> .....	Vagus nerve
<b>CN XI</b> .....	Spinal accessory nerve
<b>CN XII</b> .....	Hypoglossal
<b>CNS</b> .....	Central nervous system
<b>COMMANDO</b> .....	Combined mandibulotomy and neck dissection operation
<b>Cr</b> .....	Creatine
<b>CRTH</b> .....	Chemo-radiotherapy
<b>CSs</b> .....	Carotid spaces
<b>CT</b> .....	Computed tomography
<b>D</b> .....	True diffusion coefficient
<b>D*</b> .....	Pseudo-diffusion coefficient
<b>DCE</b> .....	Dynamic contrast-enhanced
<b>EES</b> .....	Extracellular extravascular space receptor
<b>EGFR</b> .....	Epidermal growth factor receptor
<b>EORTC</b> .....	European Organization for Research and Treatment of Cancer
<b>f</b> .....	the vascularity volume fraction
<b>FDG</b> .....	<sup>18</sup> F-fluorodeoxyglucose

## *List of Abbreviations Cont...*

Abb.	Full term
<b>FFE</b> .....	Fast field echo
<b>FN</b> .....	False negative
<b>FOM</b> .....	Floor of mouth
<b>FOV</b> .....	Field of view
<b>FP</b> .....	False positive
<b>FSE</b> .....	Fast spin echo
<b>GFR</b> .....	Glomerular filtration rate
<b>Gln</b> .....	Glutamine
<b>Glu</b> .....	Glutamate
<b>H&amp;N</b> .....	Head and neck
<b>HGF</b> .....	Hepatocyte growth factor
<b>HNSCC</b> .....	Head and neck squamous cell carcinoma
<b>HPV</b> .....	Human papillomavirus
<b>IHN</b> .....	Infra-hyoid neck
<b>IVIM</b> .....	Intravoxel incoherent motion
<b>Kep</b> .....	The rate constant between EES and blood plasma
<b>Ktrans</b> .....	The volume transfer constant between blood plasma and EES
<b>LN</b> s .....	Lymph-nodes
<b>MET</b> .....	The receptor for hepatocyte growth factor
<b>MRI</b> .....	Magnetic resonance imaging
<b>MRS</b> .....	MR spectroscopy
<b>MS</b> .....	Masticator space
<b>NAA</b> .....	N-acetylaspartate
<b>NIRADS</b> .....	Neck Imaging Reporting and Data System
<b>NOTCH1</b> .....	A human gene encoding a single-pass transmembrane receptor
<b>NPC</b> .....	Nasopharyngeal carcinoma
<b>PACS</b> .....	Picture archiving and communication system
<b>PERCIST</b> .....	PET Response Evaluation Criteria in Solid Tumors criteria
<b>PET</b> .....	Positron emission tomography

## *List of Abbreviations Cont...*

Abb.	Full term
PET-CT .....	Positron emission tomography-computed tomography
PET-MRI .....	Positron emission tomography- magnetic resonance imaging
PMS .....	The pharyngeal mucosal space
PNS.....	Perineural spread
PPF .....	The pterygopalatine fossa
PPG.....	The pterygopalatine ganglion
PPM.....	Part per million
PPS .....	The parapharyngeal space
PRESS .....	Pointed-resolved spectroscopy
PS.....	Parotid space
PVS .....	Peri-vertebral space
R2* (1/T2).....	The rate of transverse relaxation
RB.....	The retinoblastoma pathway
RMT .....	Retromolar trigone
ROI .....	Region of interest
RPLN.....	Retropharyngeal lymph-node
RPS.....	Retropharyngeal space
RTH .....	Radiotherapy
SCC.....	Squamous cell carcinoma
SE.....	Spin echo
SHN.....	Supra-hyoid neck
SMS.....	Submandibular space

# *List of Tables*

Table No.	Title	Page No.
<b>Table (1):</b>	Deep neck spaces relations and contents. ....	24
<b>Table (2):</b>	Clinical and epidemiological differences between HPV positive and HPV negative head and neck cancer patients.....	52
<b>Table (3):</b>	Pathologic N staging for non-viral related head and neck cancer and non-viral unknown primary-cervical lymphnodes.....	54
<b>Table (4):</b>	Pathologic T staging of cancer of the Oral Cavity, AJCC 8th edition .....	55
<b>Table (5):</b>	Pathologic T staging of cancer larynx, AJCC 8th edition.....	39
<b>Table (6):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for Laryngeal cancer.....	57
<b>Table (7):</b>	Changes of the T and N categories in the 8 <sup>th</sup> edition compared to 7 <sup>th</sup> edition TNM classification for nasopharyngeal cancer .....	41
<b>Table (8):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for nasopharyngeal carcinoma.....	60
<b>Table (9):</b>	Pathologic T staging of non-viral related oropharyngeal carcinoma of the head and neck, AJCC 8th edition.....	43
<b>Table (10):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for the non-viral mediated oropharyngeal cancer.....	61
<b>Table (11):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for the HPV-mediated oropharyngeal cancer .....	44
<b>Table (12):</b>	Pathologic T staging of hypopharyngeal carcinoma, AJCC 8th edition. ....	62
<b>Table (13):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for hypopharyngeal carcinoma. ....	62



## *List of Tables Cont...*

Table No.	Title	Page No.
<b>Table (14):</b>	Pathologic T staging of maxillary sinus carcinoma, AJCC 8th edition. ....	63
<b>Table (15):</b>	Pathologic T staging for nasal cavity and ethmoid sinus carcinoma, AJCC 8th edition.....	63
<b>Table (16):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for maxillary sinus, nasal cavity and ethmoid sinus carcinoma. ....	47
<b>Table (17):</b>	Pathologic T staging of cutaneous carcinoma of the head and neck, AJCC 8th edition.....	64
<b>Table (18):</b>	Pathologic T staging of major salivary gland carcinoma, AJCC 8th edition.....	48
<b>Table (19):</b>	The 8 <sup>th</sup> edition pathologic TNM classification for major salivary gland carcinoma. ....	65
<b>Table (20):</b>	The suitable imaging modalities for different anatomical subsites of the H&N.....	72
<b>Table (21):</b>	Neck Imaging Reporting and Data System descriptor table for primary tumor site .....	101
<b>Table (22):</b>	Neck Imaging Reporting and Data System descriptor table neck lymph-nodes .....	102
<b>Table (23):</b>	Patients demographics and clinical status.....	110
<b>Table (24):</b>	Treatment modalities received by the study patients. ....	111
<b>Table (25):</b>	Characteristics of the included scans.....	112
<b>Table (26):</b>	Tumor recurrence rate for primary tumor site.....	113

## *List of Tables Cont...*

Table No.	Title	Page No.
<b>Table (27):</b>	Tumor recurrence rate for neck lymph-nodes .....	113
<b>Table (28):</b>	Accuracy of the CT NI-RADS template in the detection of residual/ recurrent tumor at primary tumor site .....	114
<b>Table (29):</b>	Accuracy of the CT NI-RADS template in the detection of residual/ recurrent tumor at neck lymph-nodes.....	114
<b>Table (30):</b>	Accuracy of the PET CT NI-RADS template in the detection of residual/ recurrent tumor at primary tumor site .....	115
<b>Table (31):</b>	Accuracy of the PET CT NI-RADS template in the assessment of residual/ recurrent tumor at neck lymph-nodes .....	115
<b>Table (32):</b>	Accuracy of the MRI NI-RADS template in the detection of residual/ recurrent tumor at the primary tumor site .....	116
<b>Table (33):</b>	Accuracy of the MRI NI-RADS template in the in the detection of residual/ recurrent tumor at neck lymph-nodes.....	116
<b>Table (34):</b>	Statistical correlation between the described patterns of lymph nodes according to the NI-RADS lexicon and the outcome.....	118
<b>Table (35):</b>	Statistical correlation between the patterns of soft tissue changes at the primary site according to the NI-RADS lexicon and the outcome.....	119

## *List of Tables Cont...*

Table No.	Title	Page No.
<b>Table (36):</b>	Statistical correlation between the enhancement patterns and the outcome at the primary site .....	121
<b>Table (37):</b>	Statistical correlation between the diffusion criteria at the primary tumor site and the outcome at the primary site.....	123
<b>Table (38):</b>	Diagnostic performance of the FDG uptake at the primary tumor site in the detection of disease residual/recurrence .....	124
<b>Table (39):</b>	Diagnostic performance of the FDG uptake at the lymph-nodes in the detection of nodal disease residual/recurrence. ....	124
<b>Table (40):</b>	Illustrative case (1) pre and post therapy scans in case of cancer larynx, with NI-RADS staging and linked management. ....	126
<b>Table (41):</b>	Illustrative case (2); initial post treatment follow up CE MRI scan after RTH for cancer tongue, with NI-RADS reporting template.....	128
<b>Table (42):</b>	Illustrative case (2); PET-CT scan for further assessment of the suspicious residual mass.....	129
<b>Table (43):</b>	Illustrative case (3); initial post treatment follow up CE MRI scan after surgery and RTH for hard palate cancer, with NI-RADS reporting template:.....	131
<b>Table (44):</b>	Illustrative case (4); initial, second and third post-treatment follow up CE CT scans reported using NI-RADS template in case of cancer larynx, received RTH.....	133

## *List of Tables Cont...*

Table No.	Title	Page No.
<b>Table (45):</b>	Initial, second and third post- treatment follow up CE MRI scans reported using NI-RADS template in case of cancer tongue, subjected to surgical excision and RTH. ....	134
<b>Table (46):</b>	Illustrative case (6); initial, second and third post-treatment follow up CE CT scans reported using NI-RADS template in case of cancer larynx, received RTH. ....	137
<b>Table (47):</b>	Illustrative case (7) Initial post treatment follow up sca in case with glottic cancer, with NI-RADS reporting template. ....	139
<b>Table (48):</b>	Illustrative case (8) Initial and second post treatment follow up scans in case with cancer tongue, subjected to surgical excision, with NI-RADS reporting template. ....	140
<b>Table (49):</b>	Illustrative case (9) Initial post treatment follow up scan in case with alveolar SCC subjected to surgical excision, with NI-RADS reporting template. ....	143
<b>Table (50):</b>	Guidelines for follow- up intervals for head and neck cancers .....	162

# *List of Figures*

Fig. No.	Title	Page No.
<b>Figure (1):</b>	Deep neck spaces illustrated in axial T2 WIs at the supra-hyoid neck (a) and the infrahyoid neck (b) (1) pharyngeal mucosal space, (2) parapharyngeal space, (3) masticator space, (4) parotid space, (5) carotid, (6) retropharyngeal space, (7) perivertebral space, and (8) visceral space .....	23
<b>Figure (2):</b>	Masticator space .....	28
<b>Figure (3):</b>	Oral cavity subsites.....	29
<b>Figure (4):</b>	Sagittal reformatted CT neck showing the boundary between the oral cavity and the oropharynx as a circle extending from junction between the hard palate and soft palate (asterix) along the anterior tonsillar pillar on both sides to the tongue .....	30
<b>Figure (5):</b>	Oral cavity structures and spaces.....	32
<b>Figure (6):</b>	Lingual septum and tongue root .....	33
<b>Figure (7):</b>	RMT anatomy': schematic diagram showing the RMT mucosa .....	34
<b>Figure (8):</b>	Photographic image of the retromolar trigone area .....	34
<b>Figure (9):</b>	Supra-glottic laryngeal anatomy .....	37
<b>Figure (10):</b>	Glottic laryngeal anatomy .....	37
<b>Figure (11):</b>	Axial T1-weighted post contrast MR image at the level of the nasopharynx.....	39
<b>Figure (12):</b>	Levels of cervical lymph nodes: Graphic illustration of cervical lymph nodes.....	42
<b>Figure (13):</b>	Levels of cervical lymph nodes; axial contrast-enhanced CT image at level of the hyoid bone (Hy) .....	26

## *List of Figures Cont...*

Fig. No.	Title	Page No.
<b>Figure (14):</b>	Levels of cervical lymph nodes; axial contrast-enhanced CT image of suprahyoid neck .....	43
<b>Figure (15):</b>	Levels of cervical lymph nodes; axial contrast-enhanced CT image at the infrahyoid neck shows level IV, V, and VI lymph node groups, defined by medial boundary of common carotid artery (A) and oblique line from the posterior border of sternocleidomastoid muscle (asterisk) to the lateral border of the scalene muscle (Sc) .....	27
<b>Figure (16):</b>	Levels of cervical lymph node; coronal CE CT image shows LNs levels II, III, and IV .....	44
<b>Figure (17):</b>	<b>(A)</b> A well differentiated conventional type HNSCC with keratinization (hematoxylin-eosin, 100×). <b>(B)</b> HPV-associated poorly differentiated HNSCC (hematoxylin-eosin, 200×) .....	46
<b>Figure (18):</b>	Papillary squamous cell carcinoma with numerous papillary fronds (hematoxylin-eosin, magnification x 100).....	47
<b>Figure (19):</b>	Adenosquamous carcinomas having abundant intracellular mucus.....	48
<b>Figure (20):</b>	Axial CE CT scan soft tissue (A) and bone window (B) at the level of the oropharynx.....	38
<b>Figure (21):</b>	Axial CECT showing right vocal cord enhancing exophytic mass.....	75
<b>Figure (22):</b>	A case of right glottic carcinoma .....	76
<b>Figure (23):</b>	Invasion of the mandible by left submandibular gland tumor in Conventional MRI sequences.....	77

## *List of Figures Cont...*

Fig. No.	Title	Page No.
<b>Figure (24):</b>	Invasion of the mandible by left submandibular gland tumor .....	78
<b>Figure (25):</b>	Perineural tumor spread along the right mandibular nerve shown in Coronal CE T1WI in the form of enlarged and enhancing mandibular nerve passing the right foramen ovale (multiple arrows), with normal appearance of contralateral mandibular nerve (large arrow) .....	79
<b>Figure (26):</b>	Perineural tumor spread shown in axial CECT in the form of widening of the right Pterygopalatine fossa (PPF) (thin black arrow) with soft tissue density and loss of normal fat density compared to the normal contralateral one containing fat and vessels .....	79
<b>Figure (27):</b>	Perineural tumor spread along the right hypoglossal nerve shown in coronal CE T1 WI .....	81
<b>Figure (28):</b>	Perineural spread along the mandibular nerve shown in sagittal CE CT neck .....	80
<b>Figure (29):</b>	Malignant necrotic level II lymphnode in axial CECT neck showing a peripherally enhancing left level II lymphnode in a clinically occult lingual tonsil SCCExtra capsular nodal spread demonstrated in axial .....	82
<b>Figure (30):</b>	CECT neck showing a rounded, low-density and rim enhancing Delphian (prelaryngeal node) in the anterior midline of low neck with ill-defined margins suggesting extracapsular spread .....	82