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ORIGINAL RESEARCH

Diagnostic Efficacy of Dynamic Maneuver in Contrast Enhanced Computed Tomography Compared to Conventional Contrast Enhanced Computed Tomography in the Imaging of Neck Region

Rubi P, MSc[1], Dinesh Sekar, MSc[2] and Ramiya R, MSc[3]*

[1]*Lecturer, Department of Radio-Diagnosis, Allied Health Sciences, Trichy SRM Medical College Hospital & Research Centre, Irungalur, Tiruchirapalli, Tamil Nadu, India*

[2]*Assistant Professor, Department of Radiology, Dhanalakshmi Srinivasan University, Samayapuram, Tiruchirapalli, Tamil Nadu, India*

[3]*Lecturer, Department of Radio Diagnosis, Panimalar College of Allied Health Sciences, Varadharajapuram, Poonamalle, Chennai, Tamil Nadu, India*

***Corresponding author:** Rubi P, MSc, Lecturer, Department of Radio-Diagnosis, Allied Health Sciences, Trichy SRM Medical College Hospital & Research Centre, Irungalur, Tiruchirapalli, Tamil Nadu, India, Tel: 9123523430*

Abstract

Introduction: Neck lesions encompass a variety of pathological conditions, including carcinomas, lymphadenopathy, and abscess and thyroid nodules. The advancements of Computed Tomography (CT) play major role in detecting neck pathologies. Injection of contrast media is primary while imaging neck region, So Contrast Enhanced Computed Tomography (CECT) is the best choice for this imaging. Though, CECT performed with dynamic maneuvers plays important role in assessing the lesion size, margins and relationship with other structures.

Methods: The retrospective observational crossover study included 50 patients who undergone for Contrast Enhanced Computed Tomography in department of Radio-Diagnosis. Patient demographics are analyzed. Chi- square test was used to perform statistical analysis for hypothesis.

Results: The study included 37 males and 13 females with mean age of 50 years. 86% of abnormalities were detected with Dynamic Maneuver and 14% were visualized without maneuver. The relationship between dynamic maneuver techniques used and region of interest were used in this study. There is a significant relation between the region of interest (anatomy) and technique.

Discussion: The use of dynamic maneuvers improves lesion detection, overcome blind spots and add value to the pretherapeutic evaluation of neck lesions, tumors and other pathologies during radiologic assessment. This study will be helpful to the technologist/radiographers and radiologists to select the appropriate technique in the imaging of neck based on the abnormalities.

Conclusion: The dynamic maneuver contrast enhanced CT and conventional contrast enhanced CT, both performs equal role in detecting pathologies in the neck region. Applying the correct useful technique in the region of interest helps to demonstrate the anatomical position and nature of the pathology.

Keywords

Dynamic maneuver, Contrast enhanced computed tomography, Neck lesions, Puff cheek, Phonation, Valsalva maneuver

Abbreviations

CT: Computed Tomography; CECT: Contrast Enhanced Computed Tomography; RFT: Renal Function Test; MDCT: Multi Detector Computed Tomography; SCC: Squamous Cell Carcinoma; MRI: Magnetic Resonance Imaging; CTDI: Computed Tomography Dose Index; CTDIvol: Computed Tomography Dose Index volume; DLP: Dose Length Product

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Introduction

The oral cavity spans between the oral fissure and the oropharyngeal isthmus. The oral cavity includes the lips, hard palate, retromolar trigone, front two third of the tongue, gingiva, buccal mucosa and floor of the mouth. Neck lesions encompass a variety of pathological conditions, including carcinomas, lymphadenopathy, and abscess and thyroid nodules [1].

Computed Tomography (CT) is a medical imaging modality used to obtain internal structures of the body, by using reconstruction techniques. Computed Tomography is the modality of choice for head and neck lesions. However, despite its improved capabilities, Computed Tomography does not always accurately depict the tumor nor demonstrate its margin. So, injection of contrast media can be standardized to achieve reproducible enhancements of the lesion.

In the case small tumor, apposition of the structures could almost hide the lesion. Moreover, during respiration, the true vocal cords & laryngeal ventricles are poorly visualized.

In such cases, Dynamic maneuver provide detailed imaging in the visualisation of neck lesion with their size & margins. The Dynamic maneuver includes Puff-cheek, EEE-Phonation, mouth opened with tongue-out, Inspiration and modified Valsalva maneuver. These maneuver techniques with Contrast Enhanced Computed Tomography (CECT) provide information concerning lesion size, location, volume and relationship with surrounding structures [2-4].

In an effort to add to our knowledge of Dynamic maneuver Contrast Enhanced Computed Tomography, we conducted this study to compare its effectiveness with that of conventional Contrast Enhanced Computed Tomography in the evaluation of oral cavity pathologies.

The aim of this study was to assess the effectiveness and detection rate of Conventional CECT and Dynamic maneuver CECT in the neck lesions. In order to fulfil the aim of this study, the following objectives were set:

- To conduct a Retrospective study to compare the effectiveness of Conventional CECT and Dynamic maneuver CECT in detecting the presence and extension of oral cavity tumors, inflammation mass, and lymphadenopathy.

- To statistically analyse the data acquired from radiological findings of the patients with dynamic maneuver CECT and compare it with conventional CECT images.

- To compare the image quality and diagnostic accuracy of Conventional Contrast Enhanced Computed Tomography and Dynamic maneuver Contrast Enhanced Computed Tomography.

- Analyse patient outcomes and satisfaction with the use of Conventional CECT and Dynamic maneuver CECT in Neck Imaging.

Methods

Study design

This retrospective observational cross over study was conducted in the hospital with the study period of 6 months (August 2020-February 2021). The inclusion criteria for this study were patient with known case of oral cavity carcinomas, patient undergoing chemotherapy, and patient with lymphadenopathy and thyroid carcinoma. The exclusion criteria for this study were patient with allergic history to contrast media and elevated RFT (Renal Function Test) values.

Data collection procedure

This study was conducted with 50 patients, who referred for CECT Neck to the department of Radio-Diagnosis. All patients were undergone for both Dynamic maneuver Contrast Enhanced Computed Tomography and conventional Contrast Enhanced Computed Tomography in the equilibrium phases to increase the sensitivity and specificity of this study. Data collected by using preform a, which includes Age, Sex, Indication, Type of maneuver in Contrast Enhanced Computed Tomography Neck studies and findings in the studies. The Dynamic maneuver and Conventional Contrast Enhanced Computed Tomography radiographic images of each patient were analysed by two radiologists to find the diagnostic accuracy of these techniques.

Patient consent declaration

The authors certify that they have obtained all appropriate consent from all patients.

Ethical approval

Institutional Review Board approval is not required for this study.

Data analysis

Statistical analysis was performed using Statistical tests. Chi square tests were used in this study to prove the hypothesis. The P-value of less than 0.05 was considered statistically significant. Compared the sensitivity and specificity of conventional Contrast Enhanced Computed Tomography and Dynamic maneuver Contrast Enhanced Computed Tomography in the neck imaging. Analysed image quality, resolution and diagnostic accuracy to visualize size and extent of the pathologic conditions. Analysed patient outcomes and satisfaction with the use of Conventional Contrast Enhanced Computed Tomography and Dynamic maneuver Contrast Enhanced Computed Tomography in Neck Imaging.

Case Studies

Case 1

52-year-old man came with history of verrucous carcinoma of left alveolus, left palate and lower lip regions. For this patient, we performed plain study,
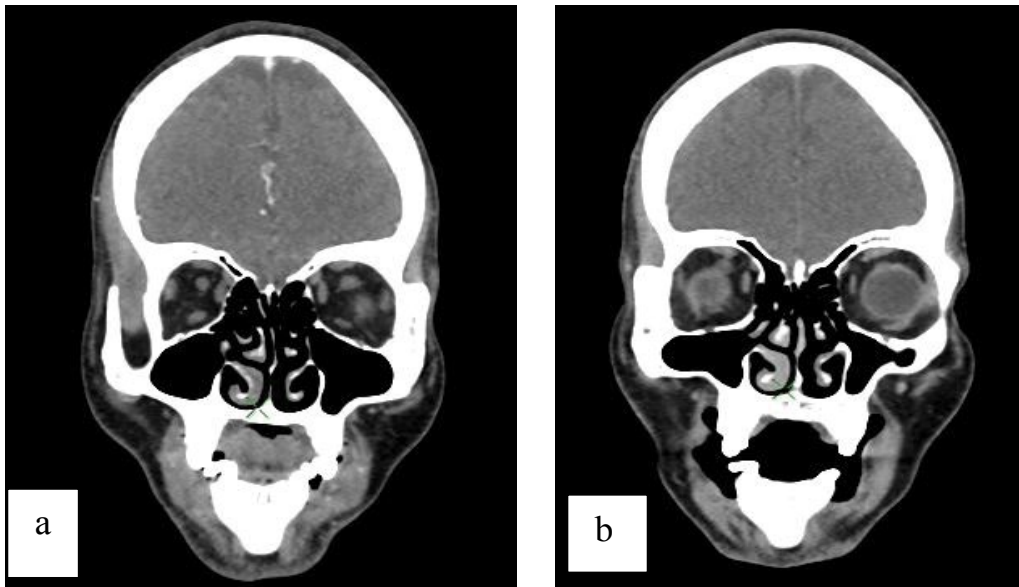
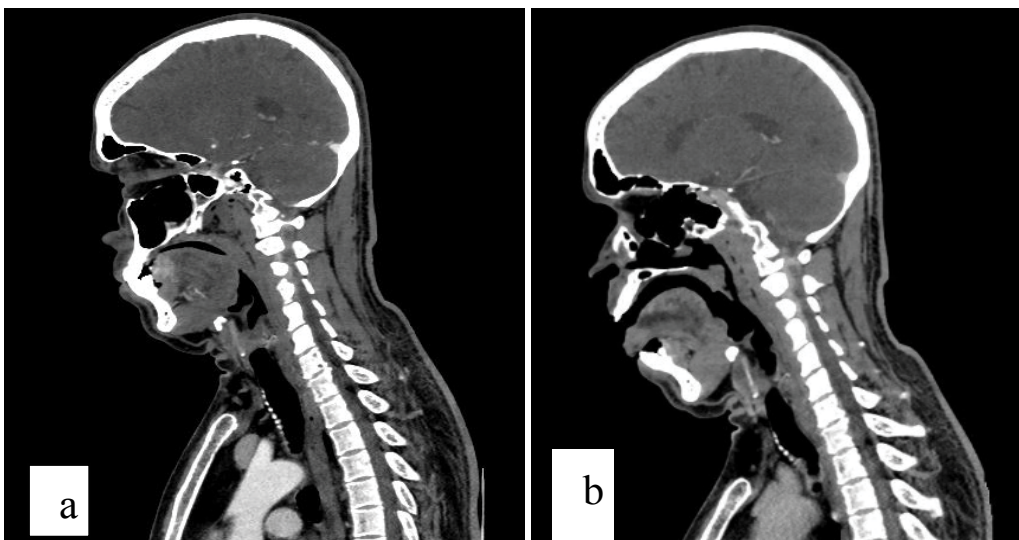**Figure 1:** (a) Case 1 (Arterial phase CECT); (b) Case 1 (Puff cheek maneuver CT).

Figure 2: (a) Case 2 (Without maneuver CECT); (b) Case 2 (Tongue-out maneuver CECT).

contrast enhanced arterial phase and puffed-cheek technique in venous phase.

Figure 1a shows Arterial phase CECT showed a fairly defined heterogeneously faintly enhancing lesion in left gingivobuccal space, left lower gingival, alveolus region and the retromolar trigone region.

Figure 1b shows Puff cheek maneuver-Extension-Anteriorly, it is limited by left lower 1st premolar along the buccal aspect; Posteriorly, seen extending to the retromolar trigone; Superiorly involving the mucosal plane medial to the left upper molar region.

Case 2

45-year-old man has known history of SCC of tongue.

For this patient, we performed plain CT, CECT arterial phase and tongue out in venous phase.

Figure 2a shows a fairly defined moderate heterogeneously enhancing ulcerative lesion is seen in the anterior 1/3rd of the left lateral border of the tongue.

Figure 2b shows Seen involving the adjacent intrinsic muscles of tongue. Not crossing the midline. No evidence of extension into extrinsic muscles of tongue.

Case 3

48-year-old man with squamous cell carcinoma of the supraglottic larynx. CT was acquired during "eee" phonation. The pyriform sinuses are distended with air, the margins of the tumor are clearly delineated. Because tumor involved under surface of the high left pyriform sinus wall. The thin arrow marks the laryngeal ventricle, which is distended with air during "eee" phonation (Figure 3).

Case 4

24-year-old woman with history of histopathologically

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Figure 3: Case 3 (Phonation maneuver performed CECT Neck).

Figure 4: Case 4 (Arterial phase CECT).

proven case of suspicious papillary carcinoma.

For this patient; plain study, contrast enhanced arterial phase and venous phase because the pathology is diagnosed without any maneuver in this anatomic region (Figure 4).

Thyroid gland homogeneously enlarged in size and mildly attenuating and on postcontrast shows diffuse mild increased vascularity.

Case 5

59-year-old woman with known case of neck abscess.

Supra-hyoid, and infra-hyoid, focal uni-loculated ill-defined non-enhancing collection seen in the right upper, lower posterior cervical space; central homogenous and peripheral mild enhancing thin-walled margin. Supero-posteriorly and infero-posteriorly abutting right para-vertebral muscles. Infero-medially with mild displacement of internal jugular vein and common carotid artery (Figure 5).

For this case, dynamic maneuver not performed because the diagnostic pathology is well visualized without maneuver in this region of interest.
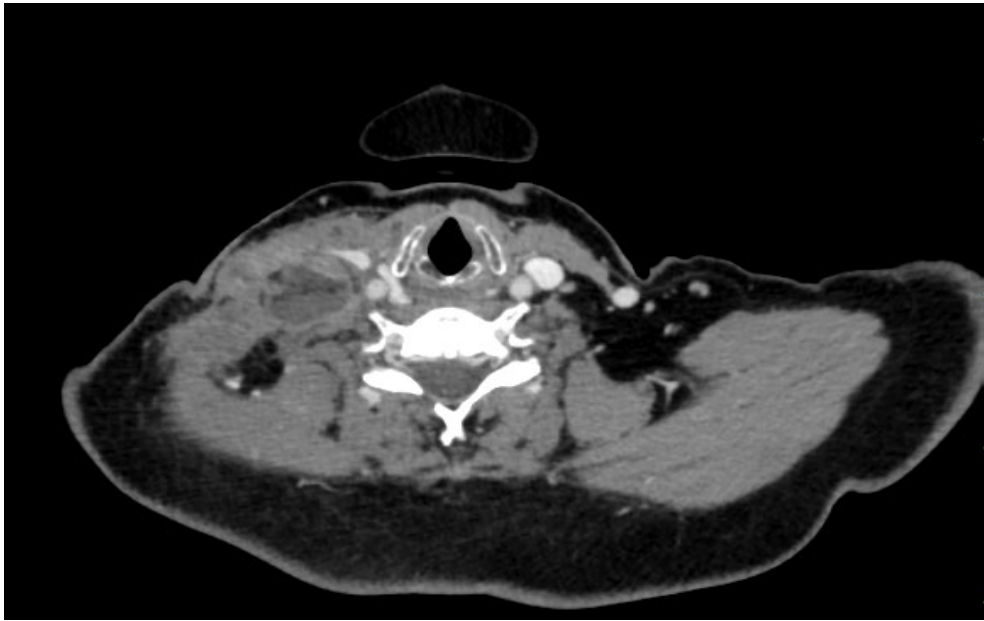
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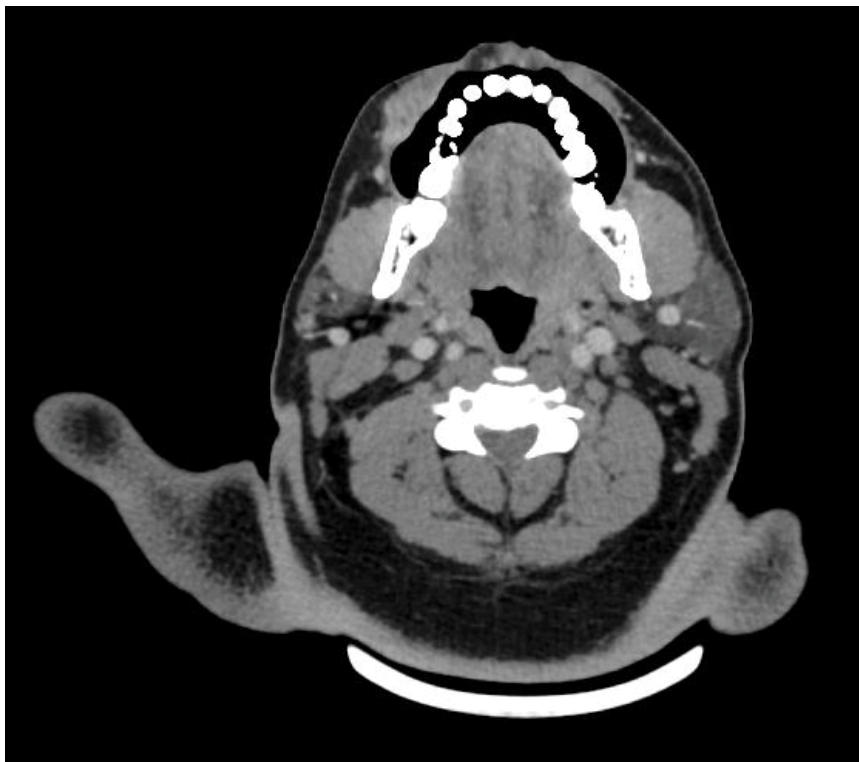**Figure 5:** Case 5 (CECT Neck without maneuver).

Figure 6: Case 6 (Puff-cheek maneuver performed CECT).

Case 6

38-year-old men with k/c/o right buccal carcinoma. Supra-hyoid homogeneous enhancing soft density/ lesion seen in the buccal space (buccal mucosa), central homogeneous, peripheral irregular to ill-defined margins. Lesion extending-laterally with invasion of right buccinators and zygomaticus major muscles. Postero-medially with invasion of lower gingivo-buccal sulcus. Medially with lower gingivo-buccal mucosa (Figure 6).

Case 7

50-year-old man came with history of ulcerative lesion in right border of tongue. We performed plain study, contrast enhanced arterial phase, tongue out in venous phase, puff-cheek in another immediate venous phase (Figure 7a, Figure 7b and Figure 7c).

Patient diagnosed with fairly defined heterogeneously enhancing soft tissue density epicentered in anterior 2/3rd of right half of tongue extending along the posterior
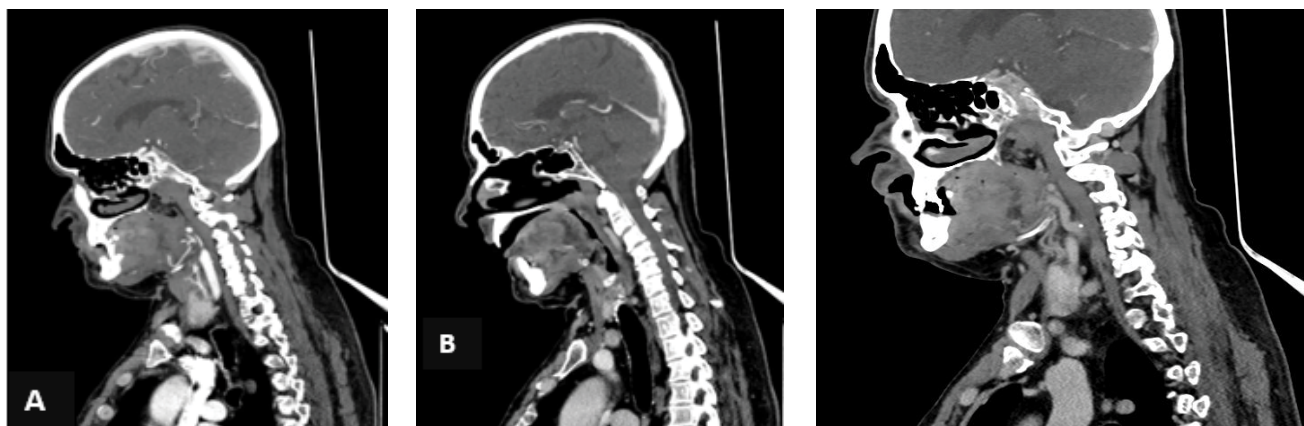
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Figure 7: (a) Case 7 (Arterial phase CECT Neck); (b) Case 7 (Venous phase CECT Neck with tongue-out maneuver); (c) Figure 7c: Case 7 (Venous phase CECT Neck with puff-cheek maneuver).

Table 1: Demographics of patients.

Demographics	Dynamic Maneuver Cect & Conventional Cect (n = 50)
Age (Mean + SD)	50 ± 15
Gender (Male)	37
Gender (Female)	13

Table 2: Techniques.

Technique	No. of Patients	Percentage
With maneuver	43	86%
Without maneuver	07	14%
Total	50	100%

Table 3: With maneuver techniques.

Technique	No. of Patients	Percentage
Puff	15	35%
Phonation	17	39%
Tongue Out	2	5%
Dual (puff-cheek and tongue out)	9	21%
Total	43	100%

$1/3^{rd}$ of right lateral hemi tongue to base of the tongue.

Results

In this study, the age presentation varied widely from 20 years to 80 years with the mean age of 50 years. Out of 50 patients selected for the study, 74% of the patients were male & 26% of them were female.

Table 1 and Figure 8 present patient demographic characteristics in this study, which includes gender and age.

Table 2, presents the detection rate of pathologies size and its margin by using Dynamic Maneuver techniques and neutral conventional techniques. In the study, 86% of abnormalities were detected with Dynamic Maneuver and 14% were visualized without maneuver.

Table 3 and Figure 9 present the varies Dynamic Maneuver used in this study. In this study Phonation technique plays major role in major role in many patients shown in the chart 3.

Table 4 shows the relation between dynamic maneuver techniques used and region of interest which were used in this study.

This section investigates the significant relation between the region of interest (anatomy) and technique with respect to chi-square values. 50 subjects were investigated. Chi-square test is used & the results shown in the following Table 5.

Table 5 shows the chi-square value is 116.47; that indicates hypothesis is satisfied at 5% level. This shows that there is significant relation between the region of interest and techniques.

Where, significant level = 0.05

Degree of freedom = 20

P = 0.00001

The result is significant at < 0.05

Patient dose data (1 scan phase for each patient) from dose information shows the mean value of DLP (Dose Length Product) was 589.66 mGy cm, mean value of CTDIvol (CTDI volume) was 6.91 mGy for 50 patients [5]. Lead aprons are used to reduce the radiation dose to the reproductive organs (pelvic region) [6]. Instead of separate acquisition for Dynamic Maneuver after venous phase, we did Dynamic Maneuver techniques in equilibrium phase to reduce radiation dose to the patient.

The result of this study indicates that the Dynamic Maneuver Contrast Enhanced Computed Tomography & Conventional Contrast Enhanced Computed Tomography, both performs major role in detecting
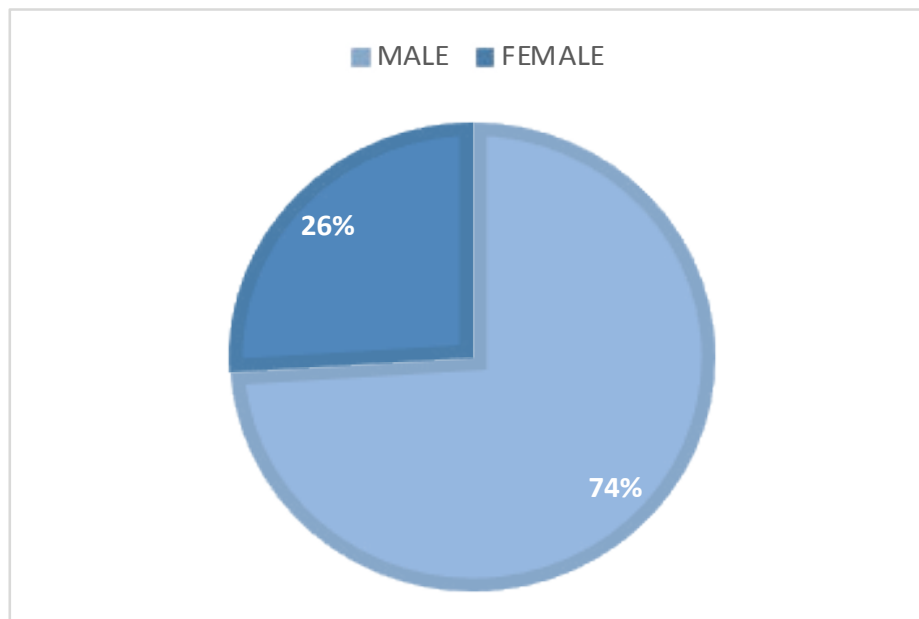
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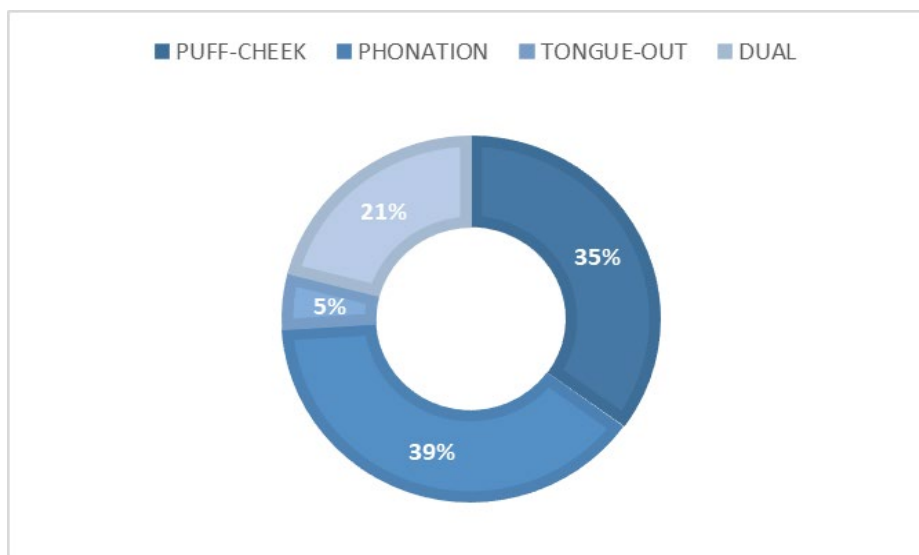**Figure 8:** Gender distribution of patients.

Figure 9: With maneuver techniques.

Table 4: Region of pathologies.

Area of Interest	Without Manoeuver	Puff-Cheek	Phonation	Tongue Out	No. of Cases
Buccal Region	1	13	0	0	14
Pharynx	1	1	6	0	8
Larynx	0	0	8	0	8
Tongue	0	9	0	11	11
Thyroid	3	0	0	0	3
Other Cervical Regions	2	1	3	0	6
Total	-	-	-	-	50

path in the neck region, with the knowledge of correct useful techniques in the region of interest.

Discussion

Arterial phase is mainly for visualization of vessels. If we do dynamic maneuver in arterial phase, it may have chance of doubling or missing of vessels due to the patient motion. And in arterial phase the enhancement pattern of the pathology will be less as compared to the venous phase. In the venous phase, the enhancement

Table 5: Observed values.

Area of Interest	Without Maneuver	Puff-Cheek	Phonation	Tongue-Out	Dual (puff-cheek & tongue-out)	Total No. of Cases
Buccal region	1	13	0	0	0	**14**
Pharynx	1	1	6	0	0	**8**
Larynx	0	0	8	0	0	**8**
Tongue	0	0	0	2	9	**11**
Thyroid	3	0	0	0	0	**3**
Other cervical regions	2	1	3	0	0	**6**
Total	**7**	**15**	**17**	**2**	**9**	**50**

of pathology is high and it's easy to delineate the outline and extent of the pathology. So, the equilibrium phase is better to diagnose pathologies by using dynamic maneuver [7,8].

Recurrent parotid gland swelling can have various etiologies. In suspected sialolithiasis, ultrasound is usually the modality used. Plain radiographs have little role, because the majority of parotid sialoliths have been reported to be radiolucent. CT is very sensitive in detecting even small deposits of calcium and can demonstrate coexisting diseases [9,10]. However, artifacts due to dental fillings may obscure small, semi calcified or distally located stones. When assessing sialolithiasis of the Stensen duct are the status of the parotid gland, size of the sialolith, and the distance between the sialolith and ductal orifice. Advanced damage to the parotid gland may require removal of the gland. The size and location of the sialolith determines the treatment options [11,12].

The puffed-cheek technique is useful in detecting small, distally located sialoliths. Even stones lucent to standard radiography contain a minimal number of calcific deposits that can be successfully imaged with CTs obtained by using this technique. The visualization of small sialoliths can be further improved by hyperflexion of the neck, which eliminates artifacts due to dental restorations. This technique is effective in the radiologic diagnosis of pneumoparotitis [13]. The modified Valsalva maneuver is also suited for this purpose. The modified Valsalva maneuver causes a greater increase in intraoral pressure. The increase of pressure in the oral vestibule facilitates retrograde passage of air into the Stensen duct [14].

Inspiration causes the true and false vocal cords to be abducted against the laryngeal wall. Abduction of the true cords, by eliminating any excessive soft tissue, causes clear demarcation of the anterior commissure. Assessment of anteroposterior and craniocaudal extensions of mucosa-based lesions is improved [15].

This study also indicates that "eee" phonation can be performed without increased patient motion. This advance is only possible because of the speed of a 64-detector MDCT scanner- which allows an entire scan to be acquired in less than 8 seconds [16].

Dr. Erdogan Bulbul, et al. reported that, the patients in their series were able to perform puff cheek and the maneuver helps to diagnose the extent and location of SCC (Squamous Cell Carcinoma) [17].

Allred, et al. reported that "E" phonation was used only as a supplemental technique. They also reported that the radiation exposure to patients will decrease when supplemental scanning is curtailed [16]. In our study, subjects were asked to do maneuver during primary scanning to minimize radiation dose and maximize our diagnostic capabilities and all were able to comply.

MRI is more useful than CT. For lesion near the skull base, a head coil is used and for lesions lower in the neck, neck coil is used [18]; disadvantage of combination of coils is the change in the recipient field characteristics at the crossover between two coils and also the scan time is too long, it costs high and the dynamic maneuver technique not possible to perform in the MRI study. So, we better go with Contrast Enhanced Computed Tomography Neck studies with helpful maneuver.

However, this study has some limitations. The sample size was small, which may limit the applicability of the findings. Prospective study with larger sample size is required to confirm these results and provide adequate diagnostic efficacy of Dynamic Maneuver techniques and conventional techniques. In this regard, we believe that our study provides useful information into the radiographers and radiologists' knowledge about the dynamic maneuvers techniques and conventional contrast enhanced computed tomography, which can guide future research and studies.

Overall, the results underscore that the Dynamic Maneuver Contrast Enhanced Computed Tomography provides more detailed imaging in neck studies. Moreover, Conventional Contrast Enhanced Computed Tomography also provides good details without maneuvers in some regions. So, it indicates that the region of interest is more important when we select maneuver techniques.

Conclusion

The use of dynamic maneuvers, which are Valsalva

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and modified Valsalva maneuvers, puff-cheek technique, phonation and inspiration, improves lesion detection, which overcome blind spots, and add value to the pretherapeutic evaluation of neck lesions, tumors and other pathologies during radiologic assessment. "EEE" phonation does not increase motion in the neck compared with the breath-hold technique when scanned with 64- detector Multi-Detector Computed Tomography. This is an early step toward a single acquisition with dynamic breathing maneuvers, which could streamline Multi-Detector Computed Tomography imaging of the neck.

The Dynamic Maneuver Contrast Enhanced Computed Tomography and Conventional Contrast Enhanced Computed Tomography, both performs major role in detecting pathologies in the neck region. Applying the correct useful technique in the region of interest helps to demonstrate the anatomical, physiological and nature of the pathology.

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Author Contributions

All authors have equally contributed for this study and agreed to be accountable for all aspects of the work.

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