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Original Research Article

Imaging Evaluation of Deep Neck Space Infections and Clinical Correlation

Dr. Sankha Subhra Roy[1], Dr. Patibandla Tharani[2], Dr. Partha Sarathi Ain[3], Dr. Insun Islam[4], Dr. Satkuri Shivakrishna[5]

[1]Senior Resident, Department of Radiodiagnosis, Prafulla Chandra Sen Government Medical College & Hospital, Hooghly, West Bengal, India.
[2]Junior Resident, Department of Radiodiagnosis, Burdwan Medical College &Hospital, Purba Bardhaman, West Bengal, India.
[3]Assistant Professor, Department of Anatomy, Raiganj Government Medical College & Hospital, Uttar Dinajpur, West Bengal, India.
[4]Junior Resident, Department of Radiodiagnosis, Burdwan Medical College & Hospital, Purba Bardhaman, West Bengal, India.
[5]Consultant, Department of Radiodiagnosis, Telangana, India.

Corresponding Author
Dr. Patibandla Tharani, Junior Resident, Department of Radiodiagnosis, Burdwan Medical College &Hospital, Purba Bardhaman, West Bengal, India.

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ABSTRACT

Background
Deep neck space infection is a serious infection with rapid progression and development of life-threatening complications with variable presentations. Clinical presentation of this infections may vary according to primary site of infections; extent of inflammation and infection; presence of abscess and local effects and associated comorbidity. More over several deep neck space infections may not be evident on palpation posing challenges for clinical diagnosis. Early identification of extent and patterns with help of imaging modalities will help in choosing appropriate management and provide an important role in reducing morbidity and complications and preventing mortality. Therefore, the study is being performed to determine the role of imaging modalities in evaluating the patterns of deep neck space infections.

Methods
This cross-sectional study was carried out in the Department of Radiodiagnosis collaborating with the Department of ENT in Burdwan Medical College & Hospital from April 2021 to September 2022. We studied 50 consecutive patients who were referred from ENT Out-Patient Department (OPD) and EMERGENCY having symptoms pertaining to deep neck space infections. The patients were evaluated by Computerised Tomography (CT) performed by Hitachi Scenaria Model No. G XL 8578 and then subjected to magnetic resonance imaging (MRI) performed by BRIVO MR355 1.5 Tesla GEHE Whole body MR scanner with other required accessories

Results
In this study we had a study population of 50 patients. Parapharyngeal and submandibular infections were most common. In our study, correlation between the ability of CT and MRI in the detection of Deep neck Space Infection showed good total agreement. Soft tissue

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inflammation, necrosis, lymphadenopathy, abscess formation in deep neck spaces, delineation of extent showed 100% agreement.

Conclusion

Both CT and MRI can accurately detect soft tissue inflammation, necrosis and abscess formation, Lymphadenopathy and delineation of extent. Employment of the imaging techniques help in early detection and delineation of deep space infections. Overall, there was a good agreement between CT and MRI in the assessment of Deep neck space infections.

Keywords: Deep neck space infection; CT and MRI

INTRODUCTION

Deep neck space infections refer to infection in the potential spaces and fascial Planes of neck either with abscess formation or cellulitis.[1] Deep neck infections are a serious but treatable group of infections affecting the deep cervical space and characterized by rapid progression and life-threatening complications.[2] Cervical fascia can be divided into superficial and deep cervical fascia. The superficial fascia comprises of skin, subcutaneous tissue and platysma while the deep fascia is further divided into superficial; middle and deep layers.

The superficial layer of Deep fascia covers the submandibular gland; the parotid gland as well as muscles deep to the platysma. The layer encloses the submandibular and masticator spaces which can be foci of submandibular and dental infections.

The middle layer encloses space between the vital parts of the neck including pharynx; larynx; trachea; upper esophagus; thyroid; para thyroid and are most often infected by infections of pharynx; larynx; tonsil; 2nd and 3rd Molar tooth.

The deep layer of deep cervical fascia (also known as pre vertebral fascia) covers the vertebral columns and muscles of the spine. An alar fascia is also present which forms the terminus of the retropharyngeal space. The Alar Fascia Lies between the middle layer of deep cervical fascia and pre vertebral fascia proper. The space between the alar fascia and the pre vertebral fascia is called the “Danger Space” as it is continuous with the mediastinum.

At least 11 deep spaces are a part of complex structure and based on their relationship with the hyoid bone deep spaces may be classified as follows:

1. **Spaces above Hyoid level:**
   a) Peritonsillar
   b) Submandibular
   c) Parapharyngeal
   d) Buccal
   e) Parotid
   e) Masticatory

2. **Spaces involving entire circumference of neck**
   a) Retropharyngeal
   b) Danger space
   c) Pre vertebral
   d) Carotid

3. **Spaces below the hyoid bone**
   a) Pre tracheal
   b) Visceral space

Even in era of wide spread antibiotic usage; deep neck space infection continues to be a serious but treatable group of infections affecting the deep cervical space and characterized by rapid

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progression and life-threatening complications. The infections most frequently arise from the local extension of infection from tonsils; parotid glands; cervical lymph nodes; and odontogenic structures. Symptoms are related to local pressure effects and the particular deep neck spaces which are involved. Most patients present with fever and neck pain. Associated symptoms such as dysphagia; stridor; dysphonia; trismus.

Pain on movement of neck may be present and can provide clues regarding affected fascial plane. On examination patients may be febrile and toxic with asymmetric redness and swelling over neck with regional lymphadenitis.

Deep neck space infections are almost typically polymicrobial in nature, reflecting the normal resident upper aerodigestive tract flora.[3,4] Odontogenic and periodontal infections are among the most common leading risk factors of deep neck space infections. The second most common source is tonsillopharyngitis.[5]

Streptococcus viridans, Peptostreptococcus species, Staphylococcus aureus, Klebsiella, and anaerobes are the most encountered microorganisms from DNSI that represent pathological overgrowth of the endogenous flora of the mouth and upper respiratory tract.[6] while actinomyces; mycobacterium; fungi are potential causes but rarer.

Presence of risk factors such as immunocompromised state; diabetes; iv drug abuse; steroid therapy; recent neck surgery or Radiations; predisposes individuals towards development of deep neck space infections and development of fatal outcomes. Mortalities after DNSIs are usually attributed to sepsis, pre-existing organ failure, and airway embarrassment.[7]

Although plain radiography and ultrasonography may provide a clue to the diagnosis of deep neck space infections. Computed Tomography is the most used imaging modality for assessing primary site of infection, extent of disease and local complications.[8] Also, MRI has the potential to be a good non radiation omitting options but its use limited due to lower patient tolerance; contraindications with implant and economic constraints.

AIM OF THE STUDY

To perform imaging evaluation of deep neck space infection and correlation of clinical outcomes.

OBJECTIVES OF THE STUDY

1. To estimate the pattern and extension of Deep neck space infection (CT and MRI) in clinically suspected cases of deep neck space infection.
2. To estimate clinical outcomes and determine their association with imaging findings.

MATERIALS AND METHODS

The present Cross sectional and prospective study was conducted in the Department of Radio-diagnosis & Imaging, Burdwan Medical College & Hospital from 1st April 2021 to 30th September 2022.

Study Population

The study will be done on patients clinically suspected to be deep neck space infection refered from the Department of ENT and Department of General Surgery Burdwan Medical College and Hospital, they will be subjected to CT and MRI within 24 hours and their clinical outomes will be followed

Sample Size

Sample size calculated using the formula

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$$n = \frac{(Z_\alpha)^2 P(1-P)}{d^2}$$

Where **n** is the sample size; **Z_α -** is the standard normal variate at 95 % confidence level and alpha 0.05 that is 1.96; **P** is the proportion of probable prevalence and **d** is the absolute precision. The incidence of the deep neck space infection was found to be about 3.2% from hospital records of previous two years which is in accordance to various study findings showing an incidence varying from 1% to 10% in different settings, Hence P is taken as 3.5% and d is taken as 5%. Using the above formula sample size appears to be approximately 50.

Method of Data Collection

1. Detailed history taking
2. Clinical examination
3. CT and MRI of the neck
4. Correlation with clinical outcome
5. Correlation and comparison of CT and MRI findings

First two steps will be performed at the ENT and General Surgery; Indoor; Emergency; Outdoor patients referred for imaging will subsequently undergo CT and MRI within 24 Hours.

Inclusion Criteria

- Patients with clinical suspicion of deep neck space infection.
- Patients >12 years of age and < 60 years of age.
- Patient of both sexes will be considered.

Exclusion Criteria

- Patient with known neck malignancies
- Patient who have already underwent surgical intervention / drainage
- Patients having an electrically / magnetically or mechanically activated implants or surgical prosthesis
- Patient not giving valid and informed consent
- Patient having severe respiratory distress and stridor

Study Tools & Imaging Protocols:

1. Collection of Demographic Data
2. MRI

a) Equipment: BRIVO MR355 1.5 Tesla GEHE Whole body MR scanner with other required accessories.

b) Protocol: To be done with patient in supine positon and neck in extended and neutral positions and applying appropriate sequences

T1W in axial coronal and sagital planes.
T2W in axial, coronal and sagittal planes.
STIR in axial, coronal and sagittal planes.
PDFS sequence in coronal and sagittal planes.
DWI in axial planes.
Contrast T1 FAT SAT sequence in axial and coronal planes.

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c) Interpretation of MRI Data
MRI Diagnosis

3. CT
a) Equipment: Hitachiscenaria MODEL NO: G XL 85078
b) Protocol: To be done with patient in supine position and neck in extended and neutral positions with proper reconstructions and review in appropriate windows I.e mediastinum window ;laryngeal window and bone window
c) Interpretation of CT data

CT Diagnosis
Interpretation of CT and MRI data includes assessment of
1. Site and Size
2. Extent (Space involved)
3. Soft Tissue Inflammation
4. Necrosis
5. Abscess
6. Regional Lymphadenopathy
7. Venous thrombosis
8. Bony involvement

Associated Findings

Correlation of the Findings
The CT findings were then compared to MRI findings. Accordingly, we used statistical analysis of the data to estimate the sensitivity and specificity of CT and MRI in our study setting.

Statistical Analysis Plan
A master sheet of meticulously collected data was prepared in Microsoft Excel sheet. The appropriate statistical analysis was done using MS Excel and SPSS 22. Data was presented inthe form of table. Interobserver agreement was determined by calculating a weighted kappa (Kw) statistic. The K statistic (Kw) reflects that the agreement is beyond chance. Landis and Koch proposed that a kappa in the range of 0.21-0.40 be considered ‘fair’ agreement, kappa=0.41-0.60 be considered ‘moderate’ agreement, kappa=0.61-0.80 be considered ‘substantial’ agreement, and kappa >0.81 as almost perfect agreement.

RESULTS
Among the 50 participants of the study, Maximum number of patients (10) were in the age bracket of 49-54 yr (25%) whereas minimum (3) was in the age bracket of 19-24 yr (6%) and 25-30 yr (6%). Lowest age of patient was 13 yr and highest was 59yr. Around 70% (35) of the population were male and the rest were female.32 % (16) of the population had right sided pathologies; 36 % (18) of the population had left sided pathologies ; 16 % (8) of the population had midline or paramedian pathologies ;while 16% (8) had bilateral pathologies.

54% of the population had comorbidities while 42% did not have any known comorbidities. 40% of the population had diabetes; 10 % were on immunosuppressant therapies of some kind; 4 % of them were iv drug abusers. Around 78% (39) of the population were having complaints from 5-10 days, 12% (6) were having them for less than 5 days and 10% (5) were having them for over 10 days.

Fever was the commonest symptom in our study (94%) followed by neck pain (90%), dysphagia (84%), odynophagia (80%) and Neck swelling (80%), trismus (4%), torticollis(2%).

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Inference of Chart 1: Overall submandibular space (38%) was the most common space involved followed by Peritonsillar space (18%) and Parapharyngeal space (14%)

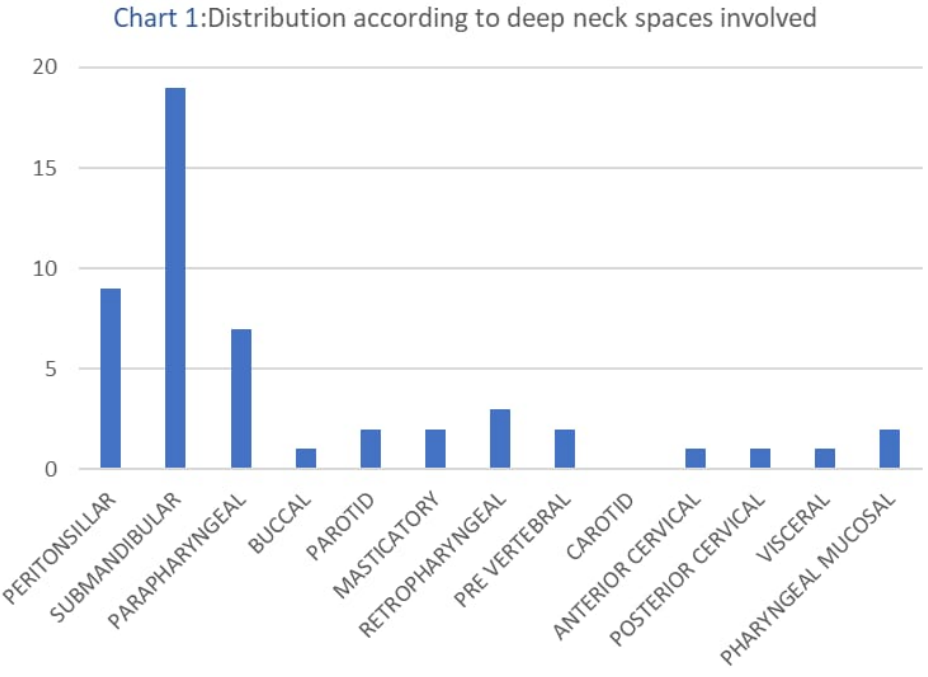

Chart 1

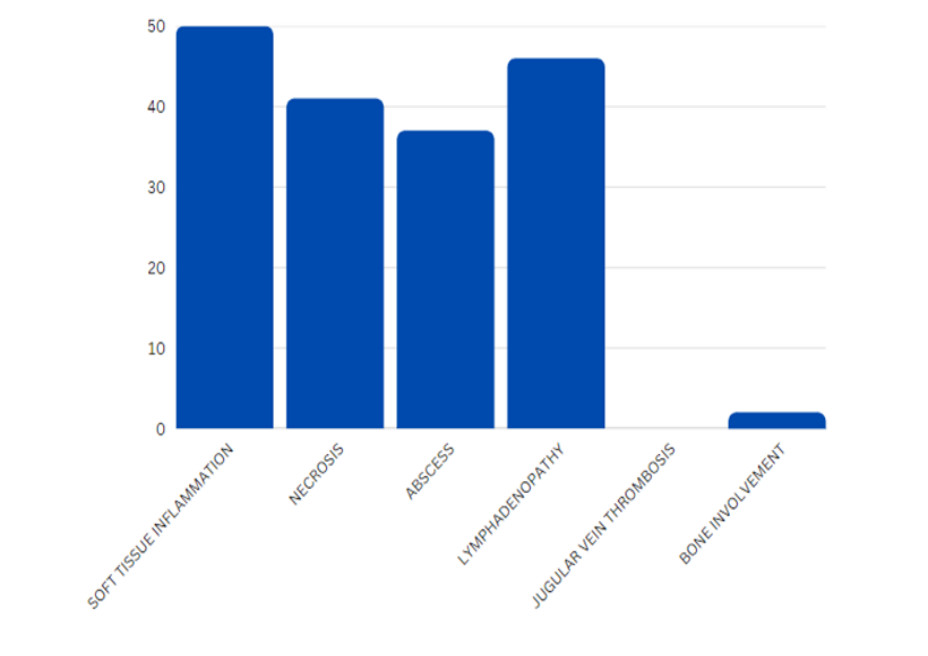

Chart 2: Distribution according to CT features of DNI

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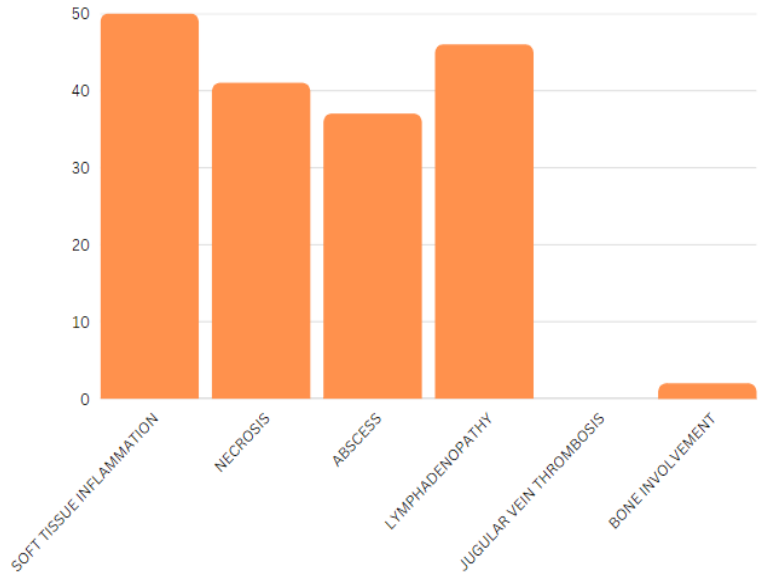

Chart 3: Distribution according to MRI features of DNI

Inference from chart no.2: Soft tissue inflammation was the most frequent feature occurring in 100% of the study population followed by reactive lymphadenopathy (92%) and necrosis (82%).74% of them presented with CT features of abscess with peripheral enhancement.

Inference from chart no.3: Soft tissue inflammation was the most frequent feature occuring in 100% of the study population followed by reactive lymphadenopathy (92%) and necrosis (82%).74% of them presented with MRI features of abscess with peripheral enhancement.

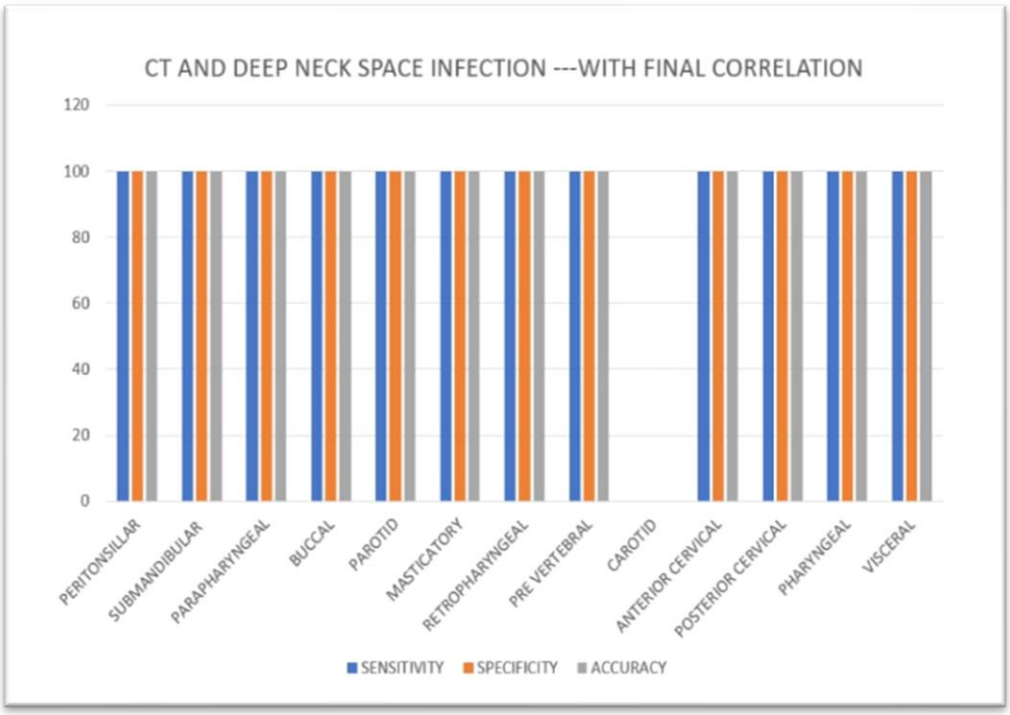

Chart 4

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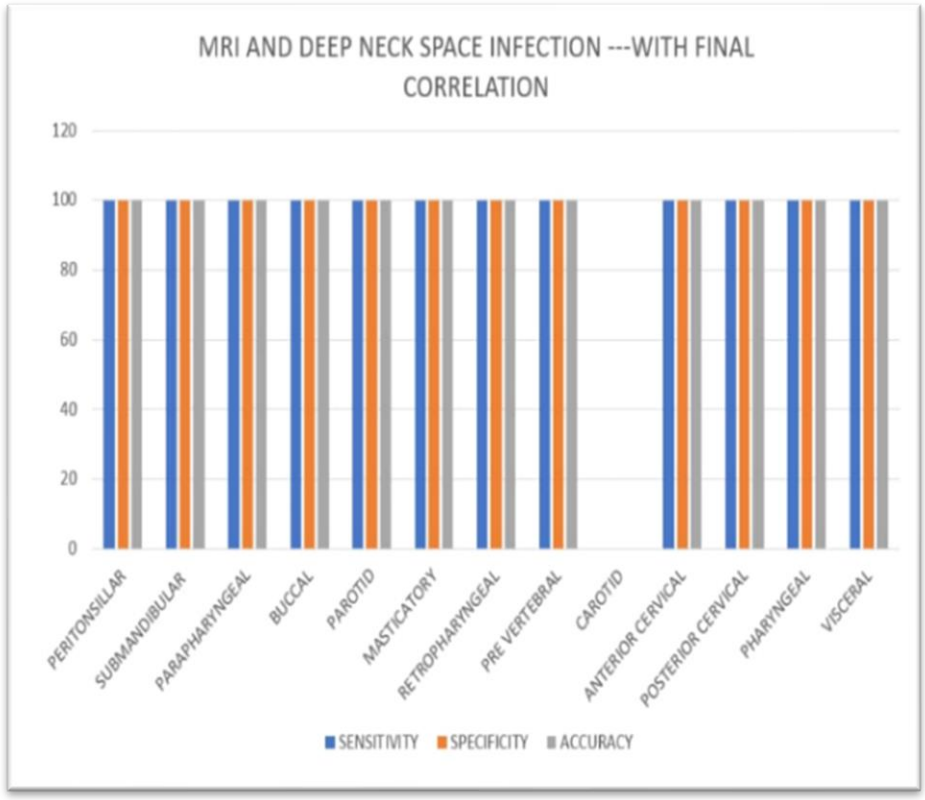

Chart 5

CT could identify the neck lesions in all the spaces with 100 % sensitivity; specificity; accuracy (**Chart 4**) MRI could identify the neck lesions in all the spaces with 100 % sensitivity; specificity; accuracy (**Chart 5**)

Neck Spaces	Sensitivity CT	Specificity CT	Sensitivity MRI	Specificity MRI	PPV CT	PPV MRI	NPVCT	NPV MRI	Accuracy CT	Accuracy MRI	P Value CT	P Value MRI
Peritonsillar	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Submandibular	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Parapharyngeal	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Buccal	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Parotid	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Masticatory	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Retropharyngeal	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Pre Vertebral	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Carotid	NA	NA	NA	NA	NA	NA	NA		NA	NA	NA	NA
Anterior Cervical	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Posterior Cervical	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Visceral	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Pharyngeal Mucosal	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01

Table 1: Comparison of MRI and CT in Detecting deep neck space infections of various spaces

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Inference From Table No. 1: Good agreement of CT and MRI identifying infection in all deep neck spaces with 100 % sensitivity; specificity; accuracy.

Features	Sensitivity CT	Sensitivity MRI	Specificity CT	Specificity MRI	PPV CT	PPV MRI	NPV CT	NPV MRI	Accuracy CT	Accuracy MRI	P Value CT	P Value MRI
Soft Tissue Inflammation	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Necrosis	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Abscess	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Lymphadenopathy	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Jugular Vein Thrombosis	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01
Bony Involvement	100	100	100	100	100	100	100	100	100	100	<0.01	<0.01

Table 2: Comparison of MRI and CT in detecting features of deep neck space infections ----corelation with final clinical diagnosis

Inference from table no 2: Good agreement of CT and MRI identifying features of deep neck space infection with 100 % sensitivity; specificity; accuracy.

There was perfect interobserver agreement represented by kappa (Ƙ) value of 1.

Clinically 60% of the cases were suspected to be abscess; 20% were suspected to be inflammatory phlegmon; 20 % were suspected to be cellulitis. Radiologically 74% of the cases were diagnosed to be abscess; 10 % were suspected to be inflammatory phlegmon; 16 % were suspected to be cellulitis.100 % of patients with cellulitis responded to sole medical management while 100% of patients with abscess required surgical management. Patients with phlegmon were attempted to be conservatively managed with antibiotic but they required surgical intervention in some form.

Image 1: CT scan showing a peri tonsillar abscess with surrounding soft tissue inflammation causing partial obstruction of oropharynx

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Image 2: MRI scan showing a peri tonsillar abscess with surrounding soft tissue inflammation causing partial obstruction of oropharynx

DISCUSSION

This observational Cross sectional and prospective study was performed in the Department of Radio-diagnosis and Imaging, Burdwan Medical College and Hospital, Burdwan. A total of 50 consecutive patients suspected to have deep neck space infection were evaluated by CT and MRI, after being clinically examined at the Department of ENT and SURGERY of Burdwan Medical College and Hospital. After their imaging they were followed up with respect to development of complications and choice of management.

In the present study an attempt has been made to study the importance of the CT and MRI scan in evaluation of deep neck space infections. These includes studying usefulness of CT and MRI not only in identifying the lesion but also in delineating the extension of lesion. The CT and MRI neck scans of 50 patients who were found to have deep neck space infections were analysed with available similar studies.

We evaluated 50 DNSI patients. Minimum age of patient was 13 years and a maximum age of patient was 59 years. The majority of patients were in the 49-54 year age group, followed by the 55–60 year age group. So majority of our patient was in the fifth decade. This is in contrast with the studies by Parischar et al.[9] and Meher et al.[10] in which 50% and 60% patients were in the third and fourth decade of life, respectively.

Out of a total of 50 patients, 35 (70%) were male and 15 (30%) were female; with a male: female ratio of 2.33:1. In our study, a male predominance was seen, which is consistent with studies by Meher et al.[10] and Parischar et al.[9] all of which showed male preponderance.

Fever was the most common symptom, found in 47 patients (94%), followed by neck pain in 45 patients (90%%), dysphagia in 42 patients (84%), neck swelling in 40 patients (80%), odynophagia in 40 patients (80%), trismus in two patients (4%), and torticollis in one patient (2%). This is a contrast in of Bakir et al.[11] Meher et al.[10] and Marioni et al.[12] with pain as the most common symptom followed by swelling, dysphagia/odynophagia, and trismus.

Submandibular involvement was the most common space involved in 19 patients (38%%), followed by peritonsillar space in 9 patients (18%),parapharyngeal space in 7 patients (14%), retropharyngeal space in 3 patients(6%), parotid (4%), masticatory (4%), pharyngeal

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mucosal (4%) space in two patients each , anterior space (2%), posterior cervical (2%); buccal space (2%); visceral space (2%) in one patients each. This correlates with study performed by Khode et al.[13] It also correlates with the study performed by results from Parischar et al.[9] and Stalfor et al.[14] with peritonsillar and as the second and third most common presentation. However it was in contrast to the study conducted by Crespo et al Sao Paulo Med J 2004[15] which found lateral parapharyngeal space to be the most commonly involved space.

In the majority of cases, the etiological factor was odontogenic in origin (20 patients, 40%). This was follwed by tonsillo-pharyngitis in about 17 patients (34%). This was followed by infective lymphadenopathy in about 5 patients (10%); salivary gland infection in 4 patients (8%); trauma in 2 patients (4%) and unknown in 4% of patients. In a study by Tschiassny et al.[16] 70% of cases of DNSI were odontogenic in origin. In a retrospective study by Parhiscar et al.[9] odontogenic infections were declared as the most common cause of DNSI (43%). Huang et al.[17] and Eftekharian et al.[18] also reported similar results that odontogenic problems were the most common causative factor for DNSI, in 42%, 38.8% and 49% cases, respectively. Studies by Harel G.et al.[9] also showed the major cause of DNSI to be dental in origin Thus, our study results are consistent with those of these previous studies.

Lazor JB et al (1994)[19] compared CT and surgical findings in deep neck infections in a 10 year retrospective study on 38 patients.In their study false positive rate was 13.2% and false negative rate was 10.5%. The sesnsitivity of CT for detection of parapharyngeal space or retropharyngeal space abscess was 87.9%. In our case we experienced a better detection with a sensitivity specificity PPV and NPV of 100%

HoltGr et al[20] studied deep neck space infection on 22 patients and identified neck abscess in 6 cases in their study there were no false positives or false negatives in the series. In all six cases the abscesses and the anatomical location of the abscess are accurately identified by CT, allowing a more accurate planning of surgical approach.

Out of 50 patients, twenty (40%) had diabetes mellitus, five (10%) were on immunosuppressant therapy and two (4%) were known iv drug abusers. So in our studies 40 % patients were diabetic; which is a bit higher when compared with the study of Huang et al[17] which reported 30.3% patients of diabetes mellitus.

Out of 50 patients, 42 (84%) underwent intervention consisting of either incision and drainage or needle aspiration and all of them diagnosed as abscess showed presence of pus in varying quantities. Eight patients (16%) were managed by medical treatment alone and mainly comprised of the patients of cellulitis. In the study by SY Chuang et al[21] there were some limitations affecting the differentiation of abscesses and cellulitis, particularly in the retropharyngeal space. This may be attributed to imaging development.

None of the patient who participated in the study suffered from mortality during the hospital stay period. Only two they developed septicemic changes which responded well to antibiotics post drainage. None of them required ICU admissions secondary to complications. Thus establishing the fact that earlier imaging helped in reducing associated mortality and morbidity.

A contrast CT and MRI scan is the most appropriate imaging tool, not only for the diagnosis of deep neck space infections, but also to show the extent of disease. CT and MRI scans are not only beneficial in differentiating between cellulitis and abscesses, but also have an important role in the evaluation of serious complications. A CT scan also helps to decide whether a surgical intervention is indicated, as patients with radiological evidence of cellulitis respond well to medical treatment, whereas those with abscess have a higher incidence of complications and usually require surgical management due to the aggressive nature of this condition.

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CONCLUSION

Increased prevalence of dental and periodontal disease is contributing significantly to deep neck space infection with submandibular space involvement being the most common.

CT and MRI can accurately detect the soft tissue inflammation, reactive lymphadenopathy, necrosis, abscess formation; bony involvement in DNIs with 100 % sensitivity; specificity; accuracy.

Overall there was good agreement between MRI and CT in detection of deep neck space infection in terms of identification of the extent and features of deep neck space infection with perfect interobserver agreement.

Early identification of the deep neck space infections via imaging helps in identification of high risk pathologies and planning of proper management thereby reducing mortality and morbidity significantly. Since CT is fast, well tolerated, readily available, comparatively cheaper it can be used for initial evaluation; pre operative planning; post operative follow up and reserve MRI as a complementary imaging modality for those whom we are avoiding radiations.

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