DOI: https://doi.org/10.54393/pjhs.v5i12.2075

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (P): 2790-9352, (E): 2790-9344
Volume 5, Issue 12 (Deccember 2024)

Original Article

OPEN ACCESS

Advancing Diagnosis: The Role of Imaging Modalities in Accurate Assessment of Skull Base ENT Pathologies

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ARTICLE INFO

Keywords:
Skull Base Pathologies, Computed Tomography, Magnetic Resonance Imaging, Diagnostic Accuracy

How to Cite:
Hussain, A., Hussain, J., Mushtaq, A. B., Ashraf, S., Siddique, T. Z., & Afzal, M. (2024). Advancing Diagnosis: The Role of Imaging Modalities in Accurate Assessment of Skull Base ENT Pathologies: Imaging Modalities in Skull Base Ear Nose and Throat Pathologies. Pakistan Journal of Health Sciences,5(12), 139-143. https://doi.o rg/10.54 393/ pjhs.v5i12.2075

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Received date: 15th August, 2024
Accepted date: 13th December, 2024
Published date: 31st December, 2024

ABSTRACT

The skull base was a multifaceted anatomical region where important structures unite, including major blood vessels and cranial nerves. Precise diagnosis of Ear, Nose, and Throat disorders in this area was critical for effective treatment planning, but conventional diagnostic methods often lack the required detail. **Objective:** To determine the efficiency of Computed Tomography and Magnetic Resonance Imaging in correctly diagnosing skull base Ear, Nose, and Throat pathologies. **Methods:** A comparative study was carried out at Shahida Islam Medical Complex, Lodhran, from September 2023 to February 2024. A purposive sampling technique was used to select 100 patients who underwent Computed Tomography and Magnetic Resonance Imaging for suspected skull base Ear, Nose, and Throat pathologies. Imaging results were compared against final clinical diagnoses confirmed through biopsy. Diagnostic accuracy was measured using sensitivity, specificity, Positive Predictive Value, and Negative Predictive Value. Statistical analysis was performed using SPSS version 25.0. **Results:** Magnetic Resonance Imaging showed higher sensitivity (85.7%) and specificity (87.7%) compared to Computed Tomography (sensitivity 73.0%, specificity 82.0% respectively). Diagnostic accuracy of Magnetic Resonance Imaging for specific pathologies included meningioma (sensitivity 93.52%, specificity 87.32%), chordoma (sensitivity 79.92%, specificity 95.72%), and nasopharyngeal carcinoma (sensitivity 86.62%, specificity 83.12%). **Conclusions:** It was concluded that Magnetic Resonance Imaging demonstrated higher diagnostic accuracy compared to Computed Tomography in the diagnosis of Ear, Nose, and Throat pathologies of skull base due to having greater sensitivity and specificity. These findings indicate that Magnetic Resonance Imaging is a superior diagnostic tool for early detection of skull base disorders.

INTRODUCTION

Lesions originating from the bony-cartilaginous structures of the skull base or neighbouring regions either the extra-cranial head and neck below or the intracranial compartment above can significantly impact the central skull base. This region serves as a critical boundary between the intracranial compartment and extracranial structures of the head and neck, making its evaluation complex and essential. Clinical assessment of the skull base is often limited, necessitating the use of imaging techniques for accurate diagnosis, planning, and follow-up in patients with skull base lesions [1, 2]. The rationale for this study lies in addressing the diagnostic challenges posed by skull base Ear, Nose, and Throat (ENT) pathologies. Cross-sectional imaging, including Computed Tomography (CT) and Magnetic Resonance Imaging (MRI), has emerged as a cornerstone for overcoming these limitations by providing detailed visualization of both bony and soft tissue structures. Imaging plays a pivotal role

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when clinical findings are inconclusive or when complications like intracranial spread or bone involvement are suspected [3]. For example, imaging is often critical in determining the need for surgery when conservative treatment fails. Experts recommend imaging in ENT patients under specific conditions to rule out clinically silent issues [4]. Contrast-enhanced high-resolution CT is widely regarded as the gold standard for detecting bone loss caused by inflammation [5]. However, contrast-enhanced MRI has demonstrated greater sensitivity for identifying cerebral infections and evaluating soft tissue involvement [6]. In many cases, both CT and MRI are employed to achieve a comprehensive understanding of the pathology [6, 7]. Cross-sectional imaging techniques provide detailed definitions of bony structures and tumor boundaries, allowing clinicians to assess the relationship between a lesion and its surrounding tissues [8]. This detailed evaluation aids in establishing differential diagnoses based on the lesion's origin and nature. The ongoing advancements in imaging technology have significantly transformed the diagnostic landscape in ENT. Techniques such as Positron Emission Tomography-Computed Tomography (PET-CT), CT, and MRI enable accurate localization and characterization of skull base lesions, offering insights that were previously unattainable [9]. MRI is particularly valuable for visualizing soft tissues, while CT excels in assessing bony structures. Endoscopic ultrasonography, a novel method combining endoscopy and ultrasonography, provides real-time imaging through the mouth or nose. This technique is particularly useful for biopsies and therapeutic interventions, offering precise lesion localization [10]. Conventional diagnostic approaches often fail to capture the complexity of the skull base region. In contrast, advanced imaging modalities provide unparalleled insights into both anatomical and pathological features, allowing for accurate detection and improved patient care [11]. Differentiating benign from malignant lesions, staging diseases, and planning treatments are increasingly dependent on these advanced technologies [12]. As imaging technology evolves, its role in diagnosing skull base ENT pathologies is expected to expand, further enhancing patient outcomes.

This study aims to clarify the key roles of different imaging modalities in accurately diagnosing selected ENT pathologies of the skull base. By exploring the strengths and limitations of these techniques, the study seeks to underscore their critical contributions to modern diagnostic strategies.

METHODS

This cross-sectional study was carried out at Shahida Islam Medical Complex, Lodhran, Pakistan, from September 2023 to February 2024. The patients undergoing CT and MRI imaging for suspected skull base ENT pathologies were selected according to the inclusion criteria set for the study. A purposive sampling technique was used to select 100 patients. The sample size was estimated on the base of power analysis ensuring statistical significance between different imaging modalities to detect ENT pathologies. The following formula was used to calculate the sample size for the study; $n=Z21-a/2\times Sn(1-Sn)/L2-P$. Where Sn was sensitivity; P was Prevalence; L was the margin of error (0.05) and Z1-α/2 was the confidence interval (1.96 at α=0.05). All the values were taken according to the estimated results of sensitivity and prevalence of neurodegenerative diseases at Shahida Islam Medical Complex, Lodhran, Pakistan and previous reported studies [13]. The inclusion criteria included patients of 20 to 70 years of age of any gender having clinical symptoms indicating Meningioma, Chordoma or Nasopharyngeal Carcinoma in the skull base and had experienced any of the two imaging modalities (CT and MRI) or both, at Shahida Islam Medical Complex, Lodhran. The patients having incomplete medical records, and those who had undergone imaging for non-ENT-related conditions or having contraindications for CT scan or MRI were excluded from the study. For detailed soft tissue contrast, the imaging modalities comprised of Computed Tomography (CT) for high-resolution bone detail assessment and Magnetic Resonance Imaging (MRI) were applied. Collection of a detailed medical history, including allergies and contraindications to differentiate agents, disclosure of implanted devices, and removal of metallic objects before MRI procedures were involved in the patient's preparation. Image interpretation involves a mutual effort among the radiology and ENT experts. CT scans were measured for fractures, calcifications, and bone integrity, while MRI provided detailed soft tissue evaluation for identifying tumors, inflammation, and vascular abnormalities. For the patient records, correct documentation and reporting were maintained, where radiologists were formulating comprehensive reports with the location and size of the ENT pathology, and associated findings. The diagnostic accuracy of each one of the imaging modalities was evaluated by evaluating imaging findings and the final diagnosis which were confirmed through biopsy. Statistical analysis was carried out using SPSS version 25.0, employing techniques such as sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) measurements [14]. The study was conducted as per the ethical standards of the Institutional Ethical Committee, Shahida Islam Medical Complex, Lodhran, (SIMC/H.R./7725/23) with written informed consent obtained from all patients or their guardians prior to inclusion.

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RESULTS

The mean age of the patients was 44.31 years, along with a standard deviation of 9.17 years. This showed that most of the patients were in their mid-40s, with the ages ranging from 35 to 53 years. The results showed that most of the patients in the study were from rural areas (62%), whereas 38% from urban areas (Table 1).

Table 1: Socio-Demographic Characteristics of Patients (n=100)

Variables	Frequency (%)/ (Mean ± SD)
Age	44.31 ± 9.17
Gender	
Male	58 (58%)
Female	42 (42%)
Residence	
Urban	38 (38%)
Rural	62 (62%)

MRI (85.7%) has a better level of sensitivity as compared with the results of CT (73.0%), which means MRI was a more beneficial technique for diagnosing pathologies in their early stages due to being precise in identifying positive cases. Additionally, the specificity of MRI (87.7%) was a little higher than CT's (82.0%), which showed that MRI can also be used to rule out the presence of certain diseases when they were not present (Table 2).

Table 2: Diagnosis Accuracy of MRI in selected ENT Pathologies of Skull Base

Pathology	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	True Positive	False Positive	True Negative	False Negative
Meningioma	93.52	87.32	90.72	91.22	43	4	31	3
Chordoma	79.92	95.72	88.22	91.32	30	4	37	8
Nasopharyngeal Carcinoma	86.62	83.12	80.82	88.32	39	5	30	6
Total	86.72	88.72	86.62	90.32	-	-	-	-

As compared to MRI, CT scans displayed a little lower sensitivity and specificity. Although CT supports detecting structural abnormalities, its reduced sensitivity may increase the possibility of overlooking some of the subtle or early-stage diseases. On the other hand, CT showed improved specificity as compared to MRI, which showed its ability to spot the instances lacking these diseases. These findings highlight MRI's advantage in diagnosing ENT disorders of the skull base. Because of its high sensitivity, it can recognize and discover things at an early stage, which is important for medical intervention at an initial level. Even though CT scans have a high specificity, and can be suitable in situations where the pathology was clear from more subtle alterations (Table 3).

Table 3: Diagnosis Accuracy of CT in Selected ENT Pathologies of Skull Base

Pathology	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	True Positive	False Positive	True Negative	False Negative
Meningioma	82.22	79.52	73.82	86.32	37	6	25	8
Chordoma	65.72	93.12	84.62	79.92	27	3	37	14
Nasopharyngeal Carcinoma	73.82	76.62	69.42	80.32	34	7	27	12
Total	74.02	83.02	75.92	82.12	-	-	-	-

DISCUSSION

This study highlights the strengths and limitations of CT scans and MRI in diagnosing skull base ENT pathologies, focusing on their effectiveness in various conditions. The results of our study showed that CT scans have an 82.22% sensitivity in diagnosing meningiomas compared with MRI, which has a 93.52% sensitivity and an overall positive predictive value of 92.72%. This demonstrates MRI's superior sensitivity in identifying meningiomas. Ren *et al.*, conducted a study on 153 patients to diagnose different ENT pathologies using MRI, CT scans, and PET, concluding that while MRI produced better accuracy, combining all three modalities provided the most comprehensive understanding of the disease [14]. However, previous studies reveal conflicting results. For instance, Jans *et al.*, found that CT scans performed better in diagnosing structural lesions in patients suspected of having sacroiliitis compared to MRI [15]. CT scans excel in detecting bone-related abnormalities, such as tumors, erosions, and fractures, but are limited in evaluating non-bony lesions due to their lower soft tissue resolution [16, 17]. On the other hand, MRI is a powerful technique for evaluating soft tissue features in the skull base. Techniques like Diffusion-Weighted Imaging (DWI) enhance MRI's ability to detect detailed changes in tumors and surrounding tissues [18]. In this study, MRI was generally more sensitive than CT in detecting skull base disorders, including meningioma, chordoma, and nasopharyngeal carcinoma. This sensitivity is critical for early diagnosis and timely medical intervention. Kalita and Misra studied Japanese Encephalitis (JE) patients,

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comparing MRI and CT for diagnosing JE. They found that thalamic and extrathalamic abnormalities were detected more easily by MRI than by CT [19]. Similarly, Kidwell *et al.*, compared MRI and CT in identifying acute intracerebral hemorrhage in patients with acute focal stroke symptoms, concluding that MRI was superior for detecting persistent intracerebral bleeding [20]. Despite its advantages, CT remains an essential diagnostic tool due to its cost-effectiveness and widespread availability, particularly in resource-limited settings. This makes CT an invaluable first-line imaging modality in many healthcare contexts, especially for detecting bone-related pathologies and structural abnormalities. Its accessibility and rapid imaging capabilities further enhance its utility in urgent clinical scenarios. Combining imaging techniques, such as CT, MRI, and PET scans, provides a more comprehensive diagnosis by overcoming the limitations of individual modalities [21, 22]. By integrating multiple imaging approaches, clinicians can achieve a more precise understanding of complex conditions.

CONCLUSIONS

The results of this study show that MRI is a better imaging modality compared to CT scans for diagnosing skull base ENT pathologies. However, the importance and accessibility of CT scans, especially in resource-limited settings, should not be overlooked. Combining results from multiple imaging techniques improves the accuracy of diagnosing conditions such as meningioma, chordoma, and nasopharyngeal carcinoma.

Authors Contribution

Conceptualization: AH
Methodology: JH, ABM
Formal analysis: SA
Writing, review and editing: JH, TZS, MA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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