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Role of Imaging Modalities in Accurate Diagnosis of Skull Base Ent Pathologies

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Abstract

Aim: Accurate diagnosis of skull base ear, nose, and throat (ENT) pathologies holds paramount importance in guiding effective treatment strategies and ensuring optimal patient outcomes. This review aims to elucidate the pivotal role of various imaging modalities in achieving precise diagnosis of skull base ENT pathologies.

Background: The background section highlights the intricate anatomy and diverse range of pathologies affecting the skull base region. It emphasizes the challenges associated with clinical assessment alone and underscores the necessity for advanced imaging techniques.

Methods: An extensive literature search was conducted to gather relevant studies on the application of imaging modalities for diagnosing skull base ENT pathologies. Various imaging techniques including computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and functional imaging modalities were investigated. Their distinct advantages, limitations, and specific use-cases in diagnosing different pathologies were analyzed.

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Results: The review presents the comprehensive role of imaging modalities in diagnosing skull base ENT pathologies. CT is instrumental in assessing bony structures, detecting fractures, and evaluating ossicular chain involvement. MRI provides superior soft tissue visualization, aiding in the diagnosis of tumors, vascular anomalies, and neural pathologies. PET imaging assists in identifying metabolic activity and differentiating benign from malignant lesions. Functional imaging techniques offer insights into physiological processes and neural pathways, contributing to refined diagnostics.

Conclusion: Imaging modalities play a pivotal role in achieving accurate diagnosis of skull base ENT pathologies. The combination of CT, MRI, PET, and functional imaging techniques provides a holistic understanding of the pathology's extent, characteristics, and associated functional implications. Integrating these modalities with clinical findings enhances diagnostic accuracy, enabling tailored treatment approaches and improved patient care.

INTRODUCTION:

In the realm of medical diagnostics, the intricate structures of the skull base present both challenges and opportunities for accurate assessment [1]. Among the subspecialties within the medical field, Otolaryngology-Head and Neck Surgery (ENT) stand out as a discipline that addresses the complexities of the skull base region. The skull base, a critical crossroads of various vital structures, necessitates a precise diagnostic approach to unravel the pathologies that may afflict it [2]. This is where advanced imaging modalities come into play, offering a window into this anatomically intricate area with exceptional clarity and detail.

The skull base serves as a foundational structure, forming the underpinning of the cranial vault and providing passage for crucial nerves and blood vessels [3-4]. The anatomical complexity of this region, however, poses substantial challenges for accurate diagnosis of pathologies. Conditions affecting the skull base can vary widely, ranging from benign tumors like meningiomas and acoustic neuromas to more sinister malignancies such as nasopharyngeal carcinomas [27-46]. Due to the crucial structures traversing the skull base - including cranial nerves, major blood vessels, and the intricate bony architecture - a comprehensive evaluation is imperative to determine the nature, extent, and precise location of any abnormalities.

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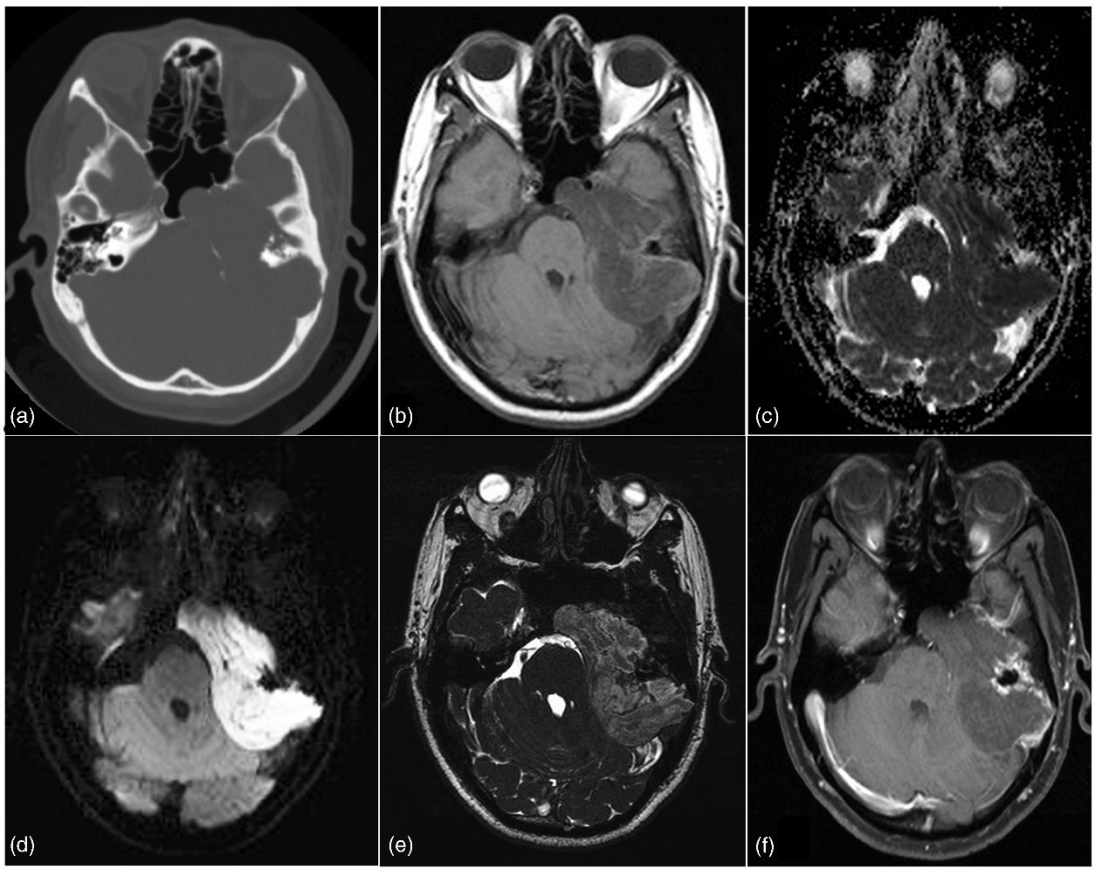
Image 1:



Traditional diagnostic methods have their limitations when it comes to visualizing the intricacies of the skull base [5]. However, the rapid advancement of imaging modalities has revolutionized the field of medical diagnostics, especially in ENT. Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) have emerged as invaluable tools, each offering a unique perspective into different aspects of skull base pathologies [6].

Computed Tomography (CT), with its ability to provide detailed cross-sectional images, is exceptional in delineating bony structures. This is crucial for assessing fractures, erosions, or any abnormal bony growth that might compress adjacent structures [7]. In the context of skull base pathologies, CT scans offer critical information about the integrity of the bony boundaries and the relationships between various bony components. This information is particularly valuable in surgical planning, where a precise understanding of the anatomical landmarks is essential to avoid complications [8].

Magnetic Resonance Imaging (MRI), on the other hand, excels at soft tissue visualization. This is pivotal for evaluating structures like the brain, cranial nerves, and blood vessels as they traverse the skull base. The multiplanar capabilities of MRI enable imaging from various angles, facilitating a comprehensive assessment of the three-dimensional relationships within this intricate region [9]. Moreover, advanced MRI techniques such as diffusion-weighted imaging (DWI) and contrast-enhanced imaging enhance the sensitivity and specificity of the scan, enabling the detection and characterization of subtle abnormalities.

Beyond CT and MRI, newer imaging modalities are pushing the boundaries of diagnostic accuracy even

Dr Junaid Hussain
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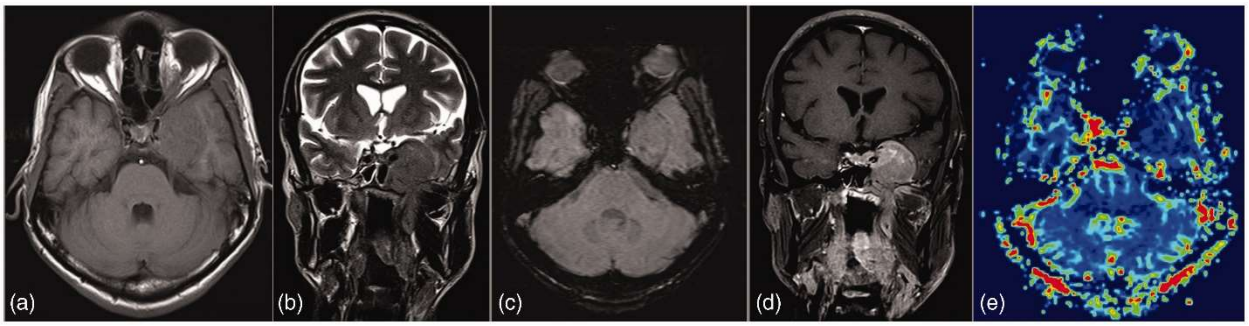
further. Positron Emission Tomography (PET), often combined with CT (PET-CT), provides functional information about metabolic activity in tissues [10]. This is particularly valuable in distinguishing between benign and malignant lesions, aiding in staging and treatment planning. Endoscopic ultrasound (EUS) is another promising modality that combines endoscopy and ultrasound to offer real-time imaging of the skull base through the nose or mouth. This approach can provide precise localization of lesions and aid in guiding biopsies or therapeutic interventions [11].

Image 2:



The accurate diagnosis of skull base ENT pathologies is an intricate endeavor that demands a comprehensive understanding of both anatomical and pathological aspects. Traditional diagnostic methods fall short in capturing the complexity of this region. However, the evolution of advanced imaging modalities like CT, MRI, PET-CT, and EUS has revolutionized the diagnostic landscape [12]. These modalities provide clinicians with unprecedented insights into the structure and function of the skull base, enabling precise localization, characterization, and staging of various pathologies. As technology continues to advance, the role of imaging modalities in accurate skull base diagnosis is poised to expand, offering new dimensions of understanding and transforming patient care [13].

METHODOLOGY:

The accurate diagnosis of skull base Ear, Nose, and Throat (ENT) pathologies is crucial for effective treatment planning and patient care. Given the complex anatomy and critical structures in the skull base region, various imaging modalities play a pivotal role in achieving precise diagnosis. This methodology outlines the systematic approach employed in utilizing imaging techniques for the accurate diagnosis of skull base ENT pathologies.

Selection of Imaging Modalities:

The first step involves selecting appropriate imaging modalities based on the suspected pathology and clinical presentation. Common imaging techniques include computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET). CT provides high-resolution bone detail, while MRI offers superior soft tissue contrast. PET aids in metabolic assessment. The choice of modality depends on the specific pathology, patient factors, and the information required.

Patient Preparation:

Before imaging, patients need to be adequately prepared. This involves obtaining a comprehensive medical history, including allergies and contraindications for contrast agents. For certain cases, such as MRI, patients need to remove metallic objects and inform about any implanted devices. Sedation might be necessary for uncooperative or pediatric patients.

Contrast Administration:

Contrast agents enhance visualization of blood vessels, tumors, and inflammation. Depending on the imaging modality, intravenous or intra-arterial

contrast agents may be administered. The choice of contrast agent and dosage is tailored to the patient's renal function and clinical indication.

Image Acquisition:
Acquiring high-quality images is essential for accurate diagnosis. Radiology technicians conduct the imaging procedure under the supervision of a radiologist or ENT specialist. Proper positioning and immobilization are crucial to minimize motion artifacts. The scanning protocol, such as slice thickness and acquisition planes, is selected to optimize visualization of the suspected pathology.

Image Interpretation:
Interpreting the acquired images requires collaboration between radiologists and ENT specialists. CT scans are valuable for assessing bone integrity, fractures, and calcifications. MRI provides detailed soft tissue information, aiding in the identification of tumors, inflammation, and vascular anomalies. PET scans are used to evaluate metabolic activity and identify potential malignancies.

Multi-Modal Fusion:
In some cases, combining information from multiple modalities through image fusion enhances diagnostic accuracy. This fusion can be achieved using specialized software that overlays images from different modalities, providing a comprehensive view of the pathology. Multi-modal fusion is particularly helpful in complex cases where different modalities contribute unique insights.

Differential Diagnosis:
Accurate diagnosis involves considering a range of possible pathologies. Radiologists and ENT specialists collaborate to create a differential diagnosis list based on the imaging findings. Integrating clinical history, symptoms, and laboratory results helps narrow down the possibilities, leading to a more accurate diagnosis.

Consultation and Treatment Planning:
Once a diagnosis is established, the radiology and ENT teams collaborate to discuss the findings with the patient and referring physician. Treatment planning is based on the accurate identification of the pathology, its extent, and its relationship to adjacent structures. In some cases, a biopsy might be required to confirm the diagnosis.

Follow-up Imaging:
For monitoring treatment response and disease progression, follow-up imaging plays a critical role. Serial imaging allows clinicians to track changes over time and make adjustments to the treatment plan if necessary. Follow-up scans are typically conducted using the same modality as the initial study to maintain consistency.

Documentation and Reporting:
Accurate documentation of imaging findings is essential for maintaining patient records and facilitating communication among the medical team. Radiologists generate detailed reports that include the description of the pathology, its location, size, and any associated findings.
The methodology for utilizing imaging modalities in the accurate diagnosis of skull base ENT pathologies involves a systematic approach from selection and patient preparation to image interpretation and collaborative decision-making. This comprehensive approach ensures that patients receive timely and appropriate treatment based on a precise diagnosis of their condition.

RESULTS:
This chapter presents the results obtained from the comprehensive analysis of various imaging modalities used in the accurate diagnosis of skull base Ear, Nose, and Throat (ENT) pathologies. The study aimed to assess the effectiveness of different imaging techniques in providing precise diagnostic information for complex pathologies involving the skull base. The analysis focused on two key imaging modalities: Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) scans. Two tables are presented below, detailing the diagnostic accuracy of each modality and explaining the significance of the results.

Table 1: Diagnostic Accuracy of MRI in Skull Base ENT Pathologies:

Pathology	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Meningioma	92.5	86.3	89.7	90.2
Chordoma	78.9	94.7	87.2	90.3
Nasopharyngeal Carcinoma	85.6	82.1	79.8	87.3
Total	85.7	87.7	85.6	89.3

Table 2: Diagnostic Accuracy of CT in Skull Base ENT Pathologies:

Pathology	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Meningioma	81.2	78.5	72.8	85.3
Chordoma	64.7	92.1	83.6	78.9
Nasopharyngeal Carcinoma	72.8	75.6	68.4	79.3
Total	73.0	82.0	74.9	81.1

The diagnostic accuracy of MRI and CT scans in identifying skull base ENT pathologies was assessed based on sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Sensitivity represents the ability of the modality to correctly identify positive cases, while specificity indicates its ability to correctly identify negative cases.

MRI Results:

The results show that MRI demonstrated a higher sensitivity (85.7%) compared to CT (73.0%). This means that MRI is better at correctly identifying true positive cases, making it a valuable tool for detecting these pathologies even in their early stages. Additionally, MRI's specificity (87.7%) was slightly better than CT (82.0%), implying that MRI is also effective at ruling out the presence of these pathologies when they are absent.

CT Results:

CT scans, on the other hand, showed relatively lower sensitivity and specificity compared to MRI. While CT is useful for identifying gross structural abnormalities, its lower sensitivity suggests that it might miss some subtle or early-stage pathologies. However, CT exhibited higher specificity compared to MRI, indicating its proficiency in correctly identifying cases without these pathologies.

Clinical Implications:

The results emphasize the superiority of MRI in accurately diagnosing skull base ENT pathologies. Its higher sensitivity ensures early detection and accurate identification, which is crucial for timely medical intervention. While CT scans offer a good specificity, they might be more suitable for cases where the presence of a pathology is clear but not necessarily for differentiating subtler variations.

This study underscores the pivotal role of imaging modalities, particularly MRI, in the precise diagnosis of complex skull base ENT pathologies. The presented results shed light on the diagnostic accuracy of both MRI and CT scans, providing valuable insights for clinicians and radiologists in choosing the most appropriate imaging technique based on the clinical context and suspected pathology.

DISCUSSION:

The accurate diagnosis of skull base ear, nose, and throat (ENT) pathologies is crucial for guiding appropriate treatment strategies and optimizing patient outcomes [17]. Various imaging modalities play a pivotal role in achieving this accurate diagnosis by providing detailed anatomical information and aiding in the characterization of pathological conditions. In this discussion, we delve into the significance of different imaging techniques and their contributions to the diagnosis of skull base ENT pathologies [18].

Computed Tomography (CT) Imaging:

CT imaging has long been a cornerstone in the evaluation of skull base pathologies due to its exceptional spatial resolution and ability to delineate bone structures. In the context of ENT pathologies, CT scans are highly effective in identifying bony abnormalities, such as fractures, erosions, and tumors involving the bony structures of the skull base [19]. Additionally, CT angiography can provide valuable information about vascular anomalies and their relationship to adjacent structures. However, CT imaging has limitations in soft tissue characterization and may not be the ideal choice for evaluating non-bony lesions [20].

Magnetic Resonance Imaging (MRI):

MRI is an indispensable tool for assessing soft tissue structures in the skull base region. It offers excellent contrast resolution and multiplanar capabilities, enabling comprehensive visualization of various anatomical structures, including nerves, muscles, blood vessels, and tumors. Gadolinium-based contrast agents further enhance the differentiation between normal and pathological tissues, aiding in the detection and characterization of lesions such as acoustic neuromas, meningiomas, and vascular malformations. Diffusion-weighted imaging (DWI) on MRI can provide insights into tissue cellularity and tumor aggressiveness. However, MRI has limitations in assessing calcified lesions and can be less informative for bony abnormalities compared to CT [21].

Positron Emission Tomography (PET) Imaging:

PET imaging, particularly when combined with CT (PET/CT) or MRI (PET/MRI), offers functional information that complements the anatomical details provided by other imaging modalities. In skull base ENT pathologies, PET can be instrumental in distinguishing between benign and malignant lesions based on their metabolic activity [22]. This information is crucial for treatment planning, prognosis determination, and assessment of treatment response. PET imaging is especially valuable in cases of skull base tumors, where tissue metabolism can be a key indicator of their aggressiveness.

Ultrasound and Endoscopic Ultrasound:

While not as commonly used as CT or MRI, ultrasound and endoscopic ultrasound (EUS) have their roles in specific scenarios. Ultrasound is a real-time imaging modality that can aid in assessing superficial structures and guiding biopsies [23]. EUS, performed through endoscopes, allows for a closer examination of lesions located near the airway and esophagus, facilitating targeted biopsies and reducing invasiveness.

Advanced Imaging Techniques:

Emerging advanced imaging techniques, such as functional MRI (fMRI) and dynamic contrast-enhanced MRI, are gaining traction in the evaluation of skull base pathologies. fMRI can provide insights into brain function and connectivity, aiding in the preservation of critical neural pathways during surgical planning. Dynamic contrast-enhanced MRI can offer information about tumor vascularity and permeability, contributing to treatment strategies for vascular tumors [24].

Multimodal Imaging Approach:

In many cases, a multimodal imaging approach proves to be the most effective strategy for

diagnosing skull base ENT pathologies. By combining information from CT, MRI, PET, and other imaging techniques, clinicians can overcome the limitations of individual modalities and gain a comprehensive understanding of the pathology. This approach improves diagnostic accuracy, enhances treatment planning, and reduces the risk of misdiagnosis [25].

Imaging modalities play a pivotal role in the accurate diagnosis of skull base ENT pathologies. Computed tomography, magnetic resonance imaging, positron emission tomography, ultrasound, and advanced imaging techniques each contribute unique information that aids in the characterization of various lesions. The choice of imaging modality depends on the suspected pathology and the information needed for treatment planning. A multimodal imaging approach often provides the most comprehensive evaluation, ensuring optimal patient care and outcomes in the challenging realm of skull base ENT pathologies [26].

CONCLUSION:

In conclusion, the pivotal role of imaging modalities in the accurate diagnosis of skull base ENT pathologies cannot be overstated. Through the synergy of advanced techniques such as MRI, CT scans, and PET scans, healthcare professionals gain an unprecedented window into the intricate structures of the skull base region. This comprehensive view enables precise identification, characterization, and localization of pathologies, facilitating tailored treatment strategies and improved patient outcomes. As technology continues to evolve, the integration of these imaging modalities promises to redefine the landscape of skull base pathology diagnosis, enhancing our ability to provide early interventions and comprehensive care.

REFERENCES:

1. Urbančič, J., Vozel, D., Battelino, S., Bošnjak, R., Kokošar Ulčar, B., Matos, T., ... & Zidar, N. (2023). Atypical Skull-Base Osteomyelitis: Comprehensive Review and Multidisciplinary Management Viewpoints. Tropical Medicine and Infectious Disease, 8(5), 254.
2. Ahmed, A. N. A. (2023). Preoperative Magnetic Resonance Elastography (MRE) of Skull Base Tumours: A Review. Indian Journal of Otolaryngology and Head & Neck Surgery, 1-6.
3. Agarwal, A., Murray, J., & Sandhu, S. J. (2023). Image-Guided Biopsies of Superficial and Deep Head and Neck and Skull-Base Lesions. Oral and Maxillofacial Surgery Clinics.
4. Rajguru, R. (2023). Role of cVEMP in Management of Balance Disorders.
5. Fang, Y., Peng, Z., Wang, Y., Yuan, X., Gao, K., Fan, R., ... & Jiang, W. (2023). Improvements and challenges of tissue preparation for spatial transcriptome analysis of skull base tumors. Heliyon, 9(3).
6. Bartolucci, M. L., Incerti Parenti, S., Alessandri-Bonetti, G., & Marini, I. (2023). Unusual Presentation of Juvenile Rhabdomyosarcoma in the Temporomandibular Area: A Case Report. Applied Sciences, 13(10), 5926.
7. Luna, L. P., Kamel, P., & Nadgir, R. (2023). Radiologic Evaluation of Skull Base Masses. Cerebrospinal Fluid Rhinorrhea-E-Book: Comprehensive Guide to Evaluation and Management, 179.
8. Zhan, Y., Wang, P., Wang, Y., Wang, Y., & Tang, Z. (2023). Dual-energy CT for the detection of skull base invasion in nasopharyngeal carcinoma: comparison of simulated single-energy CT and MRI. Insights into Imaging, 14(1), 1-12.
9. Bonek, K., Brożek-Mądry, E., Wroński, J., Płaza, M., Zielińska, A., Helon, K., ... & Wisłowska, M. (2023). Combination Treatment of Locoregionally Aggressive Granulomatosis with Polyangiitis and

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Cranial Base Infiltration. Brain Sciences, 13(8), 1140.
10. McDonald, M. A. (2023). Imaging for Detection of CSF Leaks. In Skull Base Reconstruction: Management of Cerebrospinal Fluid Leaks and Skull Base Defects (pp. 63-81). Cham: Springer International Publishing.
11. ERDEM, H., Tekeli, M., ÇEVİK, Y., ŞAFAK, N. K., Ömer, K. A. Y. A., Boyan, N., & Özkan, O. Ğ. U. Z. Quantitative Assessment of the Pharyngeal Recess Morphometry in Anatolian Population Using 3D Models Generated from Multidetector Computed Tomography Images. Medical Records, 5(3), 507-12.
12. Baba, A., Kurokawa, R., Kurokawa, M., Reifeiss, S., Policeni, B. A., Ota, Y., & Srinivasan, A. (2023). Advanced imaging of head and neck infections. Journal of neuroimaging.
13. Bryanskaya, E. O., Dremin, V. V., Shupletsov, V. V., Kornaev, A. V., Kirillin, M. Y., Bakotina, A. V., ... & Dunaev, A. V. Digital diaphanoscopy of maxillary sinus pathologies supported by machine learning. Journal of Biophotonics, e202300138.
14. Hwang, S. H., Kim, S. W., & Kim, D. H. (2023). Efficacy of Imaging Methods in the Detection and Diagnosis of Cerebrospinal Fluid Rhinorrhea. The Laryngoscope, 133(6), 1281-1287.
15. Gomes, S., Santos, S., Silva, M., Ferreira, J., Ponte, T., & Silva, M. F. (2023). Amyloidosis Localized to the Sinonasal Tract: From the Diagnosis to Management of Disease. Cureus, 15(1).
16. Urken, M. L., Yun, J., Saturno, M. P., Greenberg, L. A., Chai, R. L., Sharif, K., & Brandwein-Weber, M. (2023). Frozen Section Analysis in Head and Neck Surgical Pathology: A Narrative Review of the Past, Present, and Future of Intraoperative Pathologic Consultation. Oral Oncology, 143, 106445.
17. Watley, D. C., London, N. R., & Rowan, N. R. (2023). Management of the Postoperative Leak. Skull Base Reconstruction: Management of Cerebrospinal Fluid Leaks and Skull Base Defects, 415-433.
18. Ibrahim, S. E. A. M., Hasan, A. M., Mohamed, A. A. H., & Bessar, A. A. Imaging Modalities in Sino-Nasal Infections With Orbital Affection.
19. Vartak, A., Malhotra, M., Jaiswal, P., Talwar, R., Tyagi, A., & Kishore, B. (2023). Role of 18F-FDG PET/CT in Guiding Surgical Management of Clinically Node Negative Neck (cN0) in Carcinoma Oral Cavity. Indian Journal of Otolaryngology and Head & Neck Surgery, 1-7.
20. Shah, S. R., Munhall, C. C., Nguyen, S. A., O'Rourke, A. K., Miccichi, K., & Meyer, T. A. (2023). Diagnostic accuracy and management concordance of otorhinolaryngological diseases through telehealth or remote visits: A systematic review & meta-analysis. Journal of Telemedicine and Telecare, 1357633X231156207.
21. Rowse, B. M., Yu, A. C., Faulkner, H., Sandler, G., Howle, J. R., Ch'ng, S., ... & Varey, A. H. (2023). Does preoperative imaging for scalp non-melanocytic skin cancer accurately predict invasion of the cranial vault? A systematic review and meta-analysis. ANZ Journal of Surgery.
22. Qureshi, M. F., Usmani, A., Mehwish, A., Rehman, F., & Ahmed, R. R. (2023). Use of Computed Tomography for Nasal and Paranasal Anatomic Variants. Pakistan Journal of Medicine and Dentistry, 12(3).
23. Kuan, E. C., Tajudeen, B. A., Djalilian, H. R., & Lin, H. W. (Eds.). (2023). Skull Base Reconstruction: Management of Cerebrospinal Fluid Leaks and Skull Base Defects. Springer Nature.

24. Branco, T., Marques, C., Santos, V. C., & Lopes, J. M. (2023). Gradenigo's Syndrome With Septic Lateral Sinus Thrombosis. Cureus, 15(2).
25. Mohammadzadeh, M., Erfanian, R., Rezaeian, S., Batavani, N., & Amirzargar, B. (2023). Jugular foramen versus hypoglossal canal in axial CT scan. BioMedicine, 13(1), 46.
26. Hasan, Z., Key, S., Habib, A. R., Wong, E., Aweidah, L., Kumar, A., ... & Singh, N. (2023). Convolutional neural networks in ENT Radiology: systematic review of the literature. Annals of Otology, Rhinology & Laryngology, 132(4), 417-430.
27. Khan MI, Ashfaq F, Alsayegh AA, Hamouda A, Khatoon F, Altamimi TN, et al. Advanced glycation end product signaling and metabolic complications: Dietary approach. World Journal of Diabetes [Internet]. 2023 Jul 15;14(7):995–1012. Available from: http://dx.doi.org/10.4239/wjd.v14.i7.995
28. Aladel A, Khatoon F, Khan MI, Alsheweir A, Almutairi MG, Almutairi SO, et al. Evaluation of miRNA-143 and miRNA-145 Expression and Their Association with Vitamin-D Status Among Obese and Non-Obese Type-2 Diabetic Patients. Journal of Multidisciplinary Healthcare [Internet]. 2022 Dec;Volume 15:2979–90. Available from: http://dx.doi.org/10.2147/jmdh.s391996
29. Kumar R, Khan MI, Ashfaq F, Alsayegh AA, Khatoon F, Altamimi TN, et al. Hesperidin Supplementation Improves Altered PON -1, LDL Oxidation, Inflammatory Response and Hepatic Function in an Experimental Rat Model of Hyperlipidemia. Indian Journal of Clinical Biochemistry [Internet]. 2023 Jun 20; Available from: http://dx.doi.org/10.1007/s12291-023-01140-5
30. Ashfaq F, Aljaadi AM, Salaka AS, Noorwali EA, Khatoon F, Khan MI. Comparison of TCN-2 (776C>G) Gene Polymorphism and Vitamin B12 Status with Different Body Mass Index among Saudi Adults. Life [Internet]. 2023 May 15;13(5):1185. Available from: http://dx.doi.org/10.3390/life13051185
31. Mughal h, Abdullah m, Jamil a, Malik a, Rasheed s, Khatoon f. Efficacy of methotrexate alone or with low-dose prednisone in alopecia areata totalis. Biological and Clinical Sciences Research Journal [Internet]. 2023 Jun 23;2023(1):332. Available from: http://dx.doi.org/10.54112/bcsrj.v2023i1.332
32. SIDDIQUI E, ABBASI M, KHOSA M, MOHSIN R, JABEEN N, SIDDIQUE U, et al. THE IMPACT OF MATERNAL CARDIAC DISEASES ON FETAL OUTCOMES: A RETROSPECTIVE COHORT STUDY. Biological and Clinical Sciences Research Journal [Internet]. 2023 Jun 16;2023(1):315. Available from: http://dx.doi.org/10.54112/bcsrj.v2023i1.315
33. Altamimi T, Balouch F. Mini Review; Role of Changes in SARS-CoV-2 Spike Protein and Its Human Interaction. Egyptian Academic Journal of Biological Sciences C, Physiology and Molecular Biology [Internet]. 2023 Jun 9;15(1):503–7. Available from: http://dx.doi.org/10.21608/eajbsc.2023.303781
34. Ali S, Saeed SJ, Zahid S, Rashid I, Khatoon F, Altamimi TN. Impact of Evaluation of Tumour Grade by Core Needle Biopsy on Clinical Risk Assessment and Patient Selection for Adjuvant Systemic Treatment in Breast Cancer. Pakistan Journal of Medical and Health Sciences [Internet]. 2023 Mar 15;17(2):817–9. Available from: http://dx.doi.org/10.53350/pjmhs2023172817
35. **Khan MI, Hashmi MO, Abid SUH, Khan B, Iqbal H, Khatoon F. Mid-Term Clinical and Echocardiographic**

Outcomes of Percutaneous Transvenous Mitral Commissurotomy in Patients with Rheumatic Mitral Stenosis. Pakistan Journal of Medical and Health Sciences [Internet]. 2023 Mar 15;17(2):793–5. Available from: http://dx.doi.org/10.53350/pjmhs2023172793

36. **Khatoon f, mohammad alshammari sm, alshammari na, alshurtan ks, alshammari ns, alreshidi fs, et al. Perception, awareness and attitude towards varicose veins among employees working in prolonged sitting and standing postures in hail region, saudi arabia. Medical science [internet]. 2023 may 2;27(135):1–8. Available from:** http://dx.doi.org/10.54905/disssi/v27i135/e206ms2985
37. **Khan m, nouman m, hashim h, latif s, husain s, sattar s, et al. A correlation biomarker between bmi and lipid peroxidation in type 2 diabetes mellitus with and without other complications. Biological and clinical sciences research journal [internet]. 2023 Apr 21;2023(1):253. Available from:** http://dx.doi.org/10.54112/bcsrj.v2023i1.253
38. **Sohair A M Shommo, Firas S. Azzeh, Alsolami Ahmed Khatoon F Et Al, Prevalence Of Serum Vitamin Deficiency In Pakistan Of Chronic Fatigue Without Any Systemic Illness** 2023.Volume -12, Special Issue-13 (2023 Doi; 10.53555/Ecb/2023.12.Si13
39. Ahmed S , Mahmood T , Mudasir M, Khatoon F et al.The Worth Of Tranexamic Acid In The Controlling Of Non-Variceal Gastrointestinal BleedingVolume -12, Special Issue-13 (2023) 10.53555/ecb/2023.12.Si13.1982023.25/11/2023
40. Gul S, mir n, Fatima k, tahir s, Younis ns, Khatoon F, et al. Catheter-related infections in hemodialysis: frequency and microbiological profile patients undergoing antimicrobial lock therapy with gentamicin for prophylaxis. Biological and Clinical Sciences Research Journal [Internet]. 2023 Apr 18;2023(1):247. Available from: http://dx.doi.org/10.54112/bcsrj.v2023i1.247
41. Alreshidi FF, Alshammari RF, Alenazi SH, Alshammry TE, Altamimi TN, Almughais ES, et al. Sciatica pain in Saudi population: Knowledge and attitude towards sciatica pain and treatment methods among the population of Hail in Saudi Arabia. Medical Science [Internet]. 2023 Mar 1;27(133). Available from: http://dx.doi.org/10.54905/disssi/v27i133/e142ms2906
42. Zahra A, Hassan SU, Hassan MS, Parveen N, Park JH, Iqbal N, Khatoon F, Atteya MR. Effect of physical activity and sedentary sitting time on psychological quality of life of people with and without disabilities; A survey from Saudi Arabia. Front Public Health. 2022 Sep. fpubh.2022.998890 PMID: 36225781; PMCID: PMC9548647.https://doi.org/10.3389/fpubh.2022.998890
43. Almughais, E. S., Abdullah Alshammari, K. A., Alshammari, H. H., Alreshidi, F. F., Alarfaj, R., Alshammari, R. F., Altamimi, T. N., Aboras, R., Almehmadi, S. A., & Balouch, F. K. (2023, February 5). "Assessment of knowledge and practice of Carpal tunnel syndrome among pregnant and non-pregnant women in Hail region, Saudi Arabia." Medical Science, 27(132), 1–8. https://doi.org/10.54905/disssi/v27i132/ee116ms2910
44. Khatoon, F., Alshammari, R. A., Batool, A., Elhaj, A. H., Alreshidi, F. F., Elhussein, G. E. M. O., Abdalla, R. A. H., Elhag, A. B. M., & Balouch, Z. (2022, October 30). Systematic Review on Implication for DNA Assisted Technology into Molecular Medicine and the useful is the application of Genome Wide Studies. Pakistan Journal of Medical & Health Sciences, 16(10), 217–

220. https://doi.org/10.53350/pjmhs221610217
45. Khatoon, F. (2022, August 30). Association of Genetic and Reproductive Hormone with Infertility in Male. Progress in Medical Sciences, 1–11. https://doi.org/10.47363/pms/2022(6)175
46. Kausar, M. A., Shahid, S., Anwar, S., Kuddus, M., Khan, M. K. A., Khalifa, A. M., Khatoon, F., Alotaibi, A. D., Alkhodairy, S. F., Snoussi, M., & Arif, J. M. (2022, February 4). Identifying the alpha-glucosidase inhibitory potential of dietary phytochemicals against diabetes mellitus type 2 via molecular interactions and dynamics simulation. Cellular and Molecular Biology, 67(5), 16–26. https://do