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High-resolution computed tomography for evaluation of temporal bone diseases

Abstract

This cross-sectional study intends to evaluate the extent of middle ear infections and benign and neoplastic conditions involving temporal bone according to the compartment involved. For this purpose, a total of 65 patients with symptoms related to temporal bone pathology referred to the Department of Radiology and Imaging were included in this study after approval from the Institutional Review Board. Patients with electric devices at the skull base, such as cochlear implants, un-cooperative patients, patients with a history of trauma, those with congenital lesions, and patients who didn't give consent were excluded from the study. Almost half of the patients were aged 31-40 years, and male to female ratio was 1.6:1. Regarding the signs and symptoms, all patients had deafness, followed by 73.8% otorrhea and 67.7% tinnitus. In the High-Resolution Computed Tomography (HRCT) evaluation, 80.0% of the patients had inflammatory, followed by 16.9% benign and 3.1% malignant lesions. The validity test of the CT scan in the evaluation for benign lesions had a sensitivity of 81.8%, specificity of 96.3%, accuracy of 93.8%, positive predictive values of 81.8%, and negative predictive value of 96.3%. HRCT in the evaluation for malignant lesions had a sensitivity of 100.0%, specificity of 96.9%, accuracy of 96.9%, positive predictive values of 33.3%, and negative predictive values of 100.0%. HRCT in the evaluation for inflammatory lesions had a sensitivity of 94.3%, specificity of 83.3%, accuracy of 92.3%, positive predictive values of 96.2%, and negative predictive values of 76.9%.

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Introduction

Ear disease is one of the most common reasons for visiting a primary care physician and, finally, an otorhinolaryngologist, with inflammatory conditions of the middle ear being a frequent reason to prescribe antibiotics and perform surgery in children and teenagers.[1] Temporal bone diseases are most evaluated by Computed tomography (CT) and magnetic resonance imaging (MRI).[2] CT scanning is the most reliable, accurate, and convenient method for evaluating bone and air space anatomy and associated pathologies.[3] With the evolution of helical scanning techniques, CT is increasingly the imaging study of choice for definitive preoperative temporal bone imaging.[4] HRCT is widely used to diagnose inflammatory middle ear diseases, such as chronic otitis media or cholesteatoma, and to evaluate the middle ear following mastoidectomy or tympanoplasty.[5] The fundamental techniques for HRCT were first described by Naidich et al., Nakata et al., and Zerhouni et al.[6] Shankhwar et al.[7] study was the pioneer of HRCT in temporal bone diseases. This article concluded that HRCT helps us to know about the extent of the disease, anatomical variants, and possible complications. HRCT has high reliability for parameters such as scutum erosion, ossicular erosion, mastoid pneumatization, anterior lying sigmoid, Korner's septum, cholesteatoma extension, presence of complications such as mastoiditis and mastoid abscess, sigmoid sinus plate erosion, facial canal dehiscence, labyrinthine fistula, and intracranial complications. Jyothi and Shrikrishna,[8] studied the pathological processes of the temporal bone and their extent using HRCT. They found infection followed by the neoplasm, which were the most common pathologies affecting the temporal bone. Bagul[9] evaluated the temporal bone's traumatic bone conditions in addition to the congenital, inflammatory, and neoplasm, with the conclusion that inflammation is followed by trauma, benign neoplasm, congenital anomalies, and malignant neoplasm. Thukral et al.[10] concluded that HRCT provides a good sensitivity of 80.65% in the gross detecting gross osseous changes, except for facial canal dehiscence with approximate sensitivity of 33%. A meta-analysis by Jumaily[11] showed mixed results.

Methodology

Patients who presented to the Department of Radiology and Imaging for High-Resolution Computed Tomography (HRCT) of Temporal bone with symptoms related to temporal bone pathologies were collected. Then, an HRCT of the temporal bone was done using the proper protocol. HRCT findings and diagnoses of the pathologies were then correlated with the histopathological reports. It was a cross-sectional study done in the Department of Radiology and Imaging, BSMMU, from January 2016 to December 2017, after approval from the Institutional Review Board. Patients referred to the Department of Radiology and Imaging, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, with symptoms related to temporal bone pathology referred for HRCT were included in this study. A consecutive type of purposive sampling method was used. The inclusion criterion includes patients who are clinically suspected of having symptoms related to temporal bone. The exclusion criteria include patients with a history of congenital anomalies, trauma, and cochlear implants.

All the relevant collected data was analyzed using a statistical package for social scientists (SPSS). The results were presented in Tables, Figures and Diagrams, etc. The sensitivity, specificity, accuracy, positive predictive values, and negative predictive values of

HRCT and biopsy findings in the diagnosis of temporal bone lesions were calculated. A "p" value <0.05 was considered as significant. (Figures 1-5)

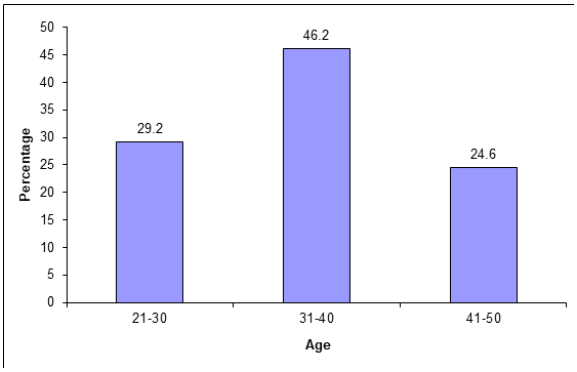

Figure 1 Bar diagram showing the age of the study patients.

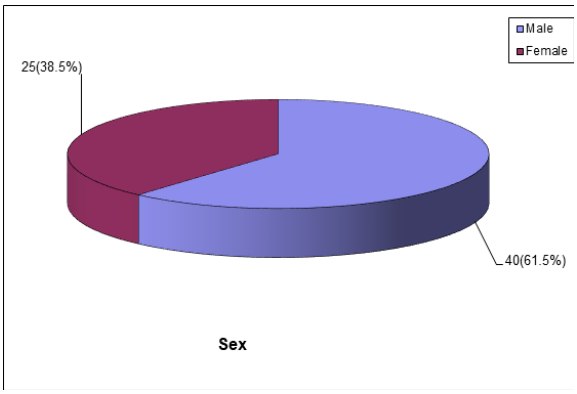

Figure 2 Pie chart showing the sex of the study patients.

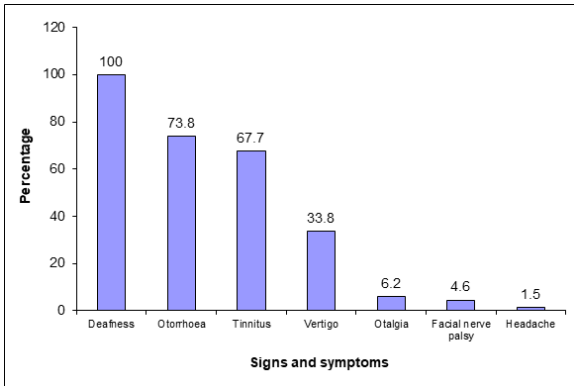

Figure 3 Bar diagram showing signs and symptoms of the study patients.

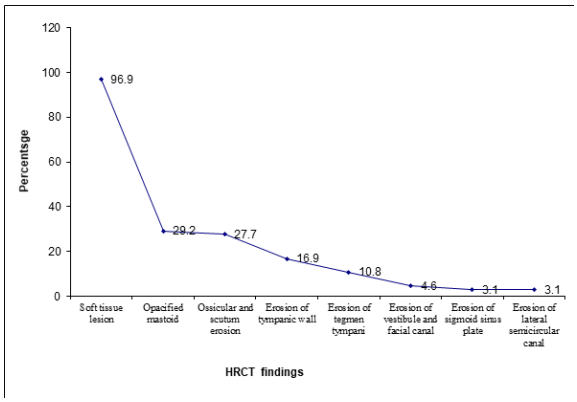

Figure 4 Line chart showing HRCT findings of the study patients.

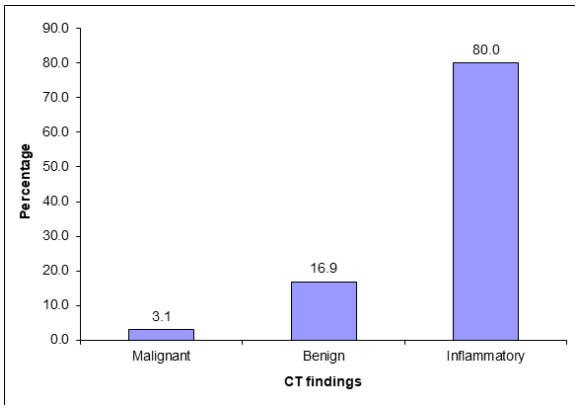

Figure 5 Bar diagram showing CT findings of the study patients.

Results

Table 1 Distribution of the study patients by demographic variable (n=65)

Demographic variable	Number of patients	Percentage
Age		
21-30	19	29.2
31-40	30	46.2
41-50	16	24.6
Sex		
Male	40	61.5
Female	25	38.5

Table 1 shows the demographic variables of the study patients. Almost half (46.2%) of patients were between the ages of 31 and 40, and almost two-thirds (61.5%) were male.

Table 2 Distribution of the study patients by their presenting signs and symptoms (n=65)

Signs and symptoms	Number of patients	Percentage
Deafness	65	100.0
Otorrhea	48	73.8
Tinnitus	44	67.7
Vertigo	22	33.8
Otalgia	4	6.2
Facial nerve palsy	3	4.6
Headache	1	1.5

Table 2 shows the Signs and symptoms of the study patients. It was observed that all (100.0%) patients had Deafness, followed by 48(73.8%) otorrhea, 44(67.7%) tinnitus, 22(33.8%) vertigo, 4(6.2%) otalgia, 3(4.6%) facial nerve palsy, and 1(1.5%) headache. Multiple responses were considered.

Table 3 Distribution of the study patients HRCT findings (n=65)

HRCT findings	Number of patients	Percentage
Soft tissue lesion	63	96.9
Opacified mastoid	19	29.2
Ossicular and scutum erosion	18	27.7
Erosion of tympanic wall	11	16.9
Erosion of tegmen tympani	7	10.8
Erosion of vestibule and facial canal	3	4.6
Erosion of sigmoid sinus plate	2	3.1
Erosion of lateral semicircular canal	2	3.1

Table 3 shows HRCT findings of the study patients, it was observed that majority (96.9%) patients had Soft tissue lesion, followed by 19(29.2.8%) opacified mastoid, 18 (27.7%) ossicular and scutum erosion, 11(4.6%) Erosion of tympanic wall, 7(10.8%) erosion of tegmen tympani, 3(4.6%) erosion of vestibule and facial canal and 2(3.1%) erosion of sigmoid sinus plate and 2(3.1%) erosion of lateral semicircular canal. Multiple responses were considered.

Table 4 Distribution of the study patients by distribution of the lesion (n=65)

Distribution of the lesion	Number of patients	Percentage
Middle ear	64	98.5
Inner ear	1	1.5

Table 4 shows the distribution of the lesion in the study patients. It was observed that the majority (98.5%) of patients had middle ear and 1(1.5%) inner ear.

Table 5 Distribution of the study patients by CT findings based on their etiology (n=65)

CT finding	Number of patients	Percentage
Benign	11	16.9
Malignant	2	3.1
Inflammatory	52	80.0

Table 5 shows the histopathological findings of the study patients. The majority (81.5%) of the patients had Inflammatory lesions, followed by 11 (16.9%) benign and 1(1.5%) malignant lesion.

Table 6 Distribution of the study patients by CT diagnosis (n=65)

CT diagnosis	Number of patients	Percentage
Inflammatory lesions		
Chronic otitis media	34	53.8
Cholesteatoma	18	27.7
Benign lesions		
Glomus tumor	5	7.7
Nerve sheath tumor	3	4.6
Otosclerosis	2	3.1
Meningioma	1	1.5
Malignant lesions		
Carcinoma	2	3.1

Table 6 shows the CT findings of the study patients. The majority (80.0%) of the patients had Inflammatory lesions, followed by 11(16.9%) benign and 2(3.1%) malignant lesions.

Table 7 Distribution of the study patients by histopathological findings (n=65)

Histopathological findings	Number of patients	Percentage
Benign	11	16.9
Malignant	1	1.5
Inflammatory	53	81.5

Table 7 shows CT diagnosis of the study patients, it was observed that more than half (53.8%) patients had chronic otitis media, followed by 18(27.7%) cholesteatoma, 5(7.7%) glomus tumor, 3(4.6%), 2(3.1) otosclerosis, 1(1.5%) meningioma and 2(3.1%) carcinomas.

Table 8 Distribution of the study patients by histopathology diagnosis (n=65)

Histopathology diagnosis	Number of patients	Percentage
Inflammatory lesions		
Chronic otitis media	34	52.3
Cholesteatoma	19	29.2
Benign lesions		
Glomus tumor	5	7.7
Nerve sheath tumor	3	4.6
Otosclerosis	2	3.1
Meningioma	1	1.5
Malignant lesions		
Carcinoma	1	1.5

Table 8 shows the histopathology diagnosis of the study patients. More than half (52.3%) of patients had chronic otitis media, followed by 19(29.2%) cholesteatoma, 5(7.7%) glomus tumors, 3(4.6%) nerve sheath tumors, 2(3.1%) otosclerosis, 1(1.5%) meningioma, and carcinoma, respectively.

Table 9 Comparison of CT findings of Benign lesions with histopathology (n=65)

CT finding	Histopathological finding		Total
	Positive	Negative	
Positive for Benign	9 (true positive)	2 (false positive)	11
Negative for Benign	2 (False negative)	52(true negative)	54
Total	11	54	65

Table 10 Comparison of CT findings of Malignant lesions with histopathology (n=65)

CT finding	Histopathological finding		Total
	Positive	Negative	
Positive for Malignant	1 (true positive)	1 (false positive)	2
Negative for Malignant	0 (False negative)	63 (true negative)	63
Total	1	64	65

Table 10 shows the histopathological findings of the study patients. The majority (81.5%) of the patients had Inflammatory lesions, followed by 11 (16.9%) benign and 1(1.5%) malignant lesion.

In this current series, it was observed that true positive 9 cases, false positive 2 cases, false negative 2, and true negative 52 cases are identified by histopathological findings.

Table 11 Comparison of CT findings of Inflammatory lesions with histopathology (n=65)

CT finding	Histopathological finding		Total
	Positive	Negative	
Positive for Inflammatory	50 (true positive)	2 (false positive)	52
Negative for Inflammatory	3 (False negative)	10 (true negative)	13
Total	53	12	65

Table 12 Sensitivity, specificity, accuracy, positive and negative predictive values of Benign, Malignant and Inflammatory diseases

Validity test	Benign	Malignant	Inflammatory
Sensitivity	81.8	100.0	94.3
Specificity	96.3	96.9	83.3
Accuracy	93.8	96.9	92.3
Positive predictive value	81.8	33.3	96.2
Negative predictive value	96.3	100.0	76.9

In this current series, histopathological findings identified true positive 1 case, false positive 1 case, false negative 0, and true negative 63 cases.

In this current series, it was observed that true positive 50 cases, false positive 3 cases, false negative 2, and true negative 10 cases are identified by histopathological findings.

The validity test of benign tumors has a sensitivity of 81.8%, specificity of 96.3%, accuracy of 93.8%, positive predictive values of 81.8%, and negative predictive value of 96.3%. The validity test of CT in the evaluation for malignant has a sensitivity of 100.0%, specificity of 96.9%, accuracy of 96.9%, positive predictive values of 33.3%, and negative predictive values of 100.0%. The validity test of CT in the evaluation for inflammation has a sensitivity of 94.3%, specificity of 83.3%, accuracy of 92.3%, positive predictive values of 96.2%, and negative predictive values of 76.9%.

Discussion

A total of 65 patients were included in a cross-sectional study to study the extent of middle ear infections and benign and neoplastic conditions involving temporal bone according to the compartment involved. In this current study, it was observed that almost half (46.2%) of clinically suspected patients having symptoms related to temporal bone belonged to age 31-40 years, followed by 29.2% age belonged to 21 -30 years, and 24.6% age belonged to 41 -50 years which was per the study performed by Bagul[9] which matches with Shankhwar et al.[7] and Gerami et al.[12] study. Regarding male to female ratio, it was observed that nearly two-thirds (61.5%) of patients were male and 38.5% female as well as male to female ratio was 1.6:1 which resembles to Bagul,[9] with male: female was 2:1. Similarly, male predominance was also observed by Jyothi & Shrikrishna,[8] Shankhwar et al.,[7] and Vlastarakos et al.[13]

Regarding the signs and symptoms, it was observed that in this current series, all patients had deafness followed by 73.8% otorrhoea, 67.7% tinnitus, 33.8% vertigo, 6.2% otalgia, 4.6% facial nerve palsy and 1.5% had a headache which was also reported by Bagul,[9] that a maximum number of patients presented with the chief complaints of hearing problem or deafness 65.0% followed by otorrhea 58.0% and other chief complaints were otalgia, vertigo, tinnitus, ataxia, and facial nerve palsy. Patients with intracranial complications had headaches, fever, and vomiting in addition to the above complaints. Almost similar signs and symptoms were also observed.[7,10,11]

In HRCT findings it was observed in this present series that the majority (96.9%) patients had soft tissue lesions, followed by 29.2.8% opacified mastoid, 27.7% ossicular and scutum erosion, 4.6% Erosion of tympanic wall, 10.8% erosion of tegmen tympani, 4.6% erosion of vestibule and facial canal and 3.1% erosion of sigmoid sinus plate and 3.1% erosion of lateral semicircular canal. Findings were comparable to the study conducted by Bagul[9] which showed the common HRCT findings in the cholesteatoma were soft tissue lesion at 100% followed by ossicular and scutum erosion at 95%, erosion of tympanic wall 90%, opacified mastoid 57%, erosion of sigmoid plate 42%, erosion of lateral semicircular canal wall and tegmen tympani 19% and erosion of vestibule and fascial canal 9.5%. Cholesteatoma may be associated with extratemporal and intracranial complications, and almost all the complications are usually secondary to bone destruction and infected cholesteatoma.[14] Similar findings were observed in the Shankhwar et al.[7] Sirigiri & Dwaraknath[15] studies.

In this study, it was observed that the majority (98.5%) of patients had middle ear and 1.5% had inner ear lesions, which matched with the study of Shankhwar et al.,[7] who mentioned in their study that the middle ear is most involved. The investigators also demonstrated that careful and thorough evaluation is needed for middle and inner ear lesions for the early diagnosis and treatment of the disease to prevent complications and determine their surgical approach.

According to histopathological evaluation, more than eighty percent (81.5%) of patients in this series had Inflammatory lesions, followed by 16.9% benign and 1.5% malignant lesions. Similarly, Bagul[9] observed that the most common temporal bone pathologies were inflammatory (50.0%), followed by traumatic (11.66%), benign neoplasm (10.0%), congenital (6.66%), and malignant neoplasm (5.0%), which was under our present study.

Many imaging modalities are available for the evaluation of the temporal bone, including plain radiographs, contrast cisternography, computed tomography (CT), and magnetic resonance imaging.[7] With the advent of helical scanning techniques, CT is increasingly the imaging study of choice for definitive preoperative temporal bone imaging.[4] HRCT is widely used in the diagnosis of inflammatory middle ear diseases, such as chronic otitis media or cholesteatoma, and in the evaluation of the middle ear following mastoidectomy or tympanoplasty.[5,16] Regarding the CT evaluation, it was observed in this current study that eighty percent of patients had inflammatory lesions, followed by 16.9% benign and 3.1% malignant lesions.

According to CT diagnosis, it was observed in this present study in Inflammatory lesions, more than half (53.8%) of patients had chronic otitis media & 27.7% had Cholesteatoma. In benign lesions, 7.7% of patients had glomus tumors, 4.6% nerve sheath tumors, 3.1% had otosclerosis, 1.5% meningioma, and in malignant lesions, 3.1% had carcinoma. Cholesteatoma characteristically causes bone erosion, and when this feature was present in association with a soft tissue mass on CT, both Jackler et al.[16] and O'Donoghue et al.[17] found cholesteatoma to be present in 80% of cases explored. Using the same criteria, Thukral et al.[10] detected 25 out of 30 cases of cholesteatoma on surgical exploration. Thukral et al.[10] obtained in their study that clinical/otoscopic findings in most cases were suggestive of active squamosal chronic otitis media (COM) in 54.0% of cases followed by inactive squamosal chronic otitis media (COM) in 20%, active mucosal chronic otitis media (COM) in 16.0%, inactive mucosal chronic otitis media (COM) in 2.0%.

Asymptomatic complications in the middle ear can be determined with the use of CT imaging, and although there are inevitable false negatives, Yates et al.[18] suggested that the surgeon should always approach potential hazards with caution (areas such as the LSCC, facial nerve, or stapes footplate). Overall, there is information to be gained by the CT regarding the anatomy and condition of the middle ear and mastoid despite the possibility of false positives and negatives. In this study, it was observed that a total of 11 cases were identified as benign lesions evaluated by CT findings; among them, 9 cases were true positive, 2 cases were false positive, 2 cases were false negative, and 52 cases were true negative confirmed by histopathology. A similar study done by Jumaily[11] found that there were five false positives and four false negatives, and the authors concluded that while high-resolution CT provides a good correlation to the status of the facial nerve canal, surgeons should still be cautious.

This study observed that a total of 2 cases were diagnosed as malignant lesions evaluated by CT diagnosis. Among them, true positive 1 case, false positive 1 case, false negative not found, and true negative 63 cases identified by histopathology. In this study, it was observed that a total of 52 cases were diagnosed as Inflammatory lesions identified by CT diagnosis among the true positive 50 cases,

false positive 2 cases, false negative 3, and true negative 10 cases identified by histopathology.1 case of cholesteatoma was falsely diagnosed as being malignant by HRCT. In their study, Shankhwar et al.[7] observed that HRCT diagnosed tumors as 4 cases of Acoustic neuroma, 1 Glomus tympanicum, and 1 Metastasis. On surgical follow-up, it was found that one case of Meningioma was falsely diagnosed as Acoustic neuroma on HRCT, and one case of the inflammatory polyp was falsely branded as a neoplastic polyp by HRCT.

In this present study, it was observed that the validity test of CT scan in the evaluation for benign lesions had a sensitivity of 81.8%, specificity of 96.3%, accuracy of 93.8%, positive predictive values of 81.8%, and negative predictive value 96.3%. On the other hand, the validity test of CT in the evaluation for malignant lesions had a sensitivity of 100.0%, specificity of 96.9%, accuracy of 96.9%, positive predictive values of 33.3%, and negative predictive values of 100.0%. Sensitivity and specificity for diagnosing malignancy by HRCT in Shankhwar et al.[7] study were found to be 85.7% & 97%, respectively, and PPV & NPV for diagnosing malignancy by HRCT were found to be 85.7% & 97% respectively which were a bit lower compared to our study Similarly, the validity test of CT in the evaluation for inflammatory lesion had sensitivity 94.3%, specificity 83.3%, accuracy 92.3%, positive predictive values 96.2% and negative predictive values 76.9%. Shankhwar et al.[7] found that HRCT is 100% sensitive and specific in knowing the type of mastoid pneumatisation. Sensitivity, specificity, PPV & NPV of HRCT in diagnosing CSOM (with cholesteatoma and mastoiditis) were found to be 100% each, like our study. HRCT was found to be excellent in detecting other complications, such as mastoiditis and mastoid abscess, with 100% sensitivity and specificity. The findings are in concordance with the study of Kanotra et al.[19]. Shankhwar et al.[7] also reported that HRCT detected scutum erosion accurately in all cases and found it 100% sensitive and specific to detect scutum erosion. Similar findings were also observed by Rai.[20] Thukral et al.[10] reported that the surgical and radiological findings showed a high level of sensitivity, 89.29%, in the identification of cholesteatoma. HRCT provides a good sensitivity of 80.65% in the identification of changes to the ossicular chain despite the presence of surrounding soft tissue. HRCT was highly informative in the identification of erosion of the lateral semicircular canal. In the diagnosis of facial canal dehiscence, HRCT had a low sensitivity of 33.33%. The sensitivity of HRCT was 91.3% in otosclerosis,[21] which correlated well with our study.

High-resolution CT is the most sensitive method for the imaging and classification of temporal bone fractures, including labyrinthine damage and ossicular chain injuries. Carefully directed tomography can be more effective in cases of atypical fractures with an unfavorable relationship to the CT planes. In most cases, high-resolution CT replaces conventional radiology and should be the method of choice for comprehensive radiological examination of the temporal bone. The HRCT temporal bone gives valuable information for evaluating congenital anomalies, inflammatory diseases, otosclerosis, tumors and cerebellopontine angle lesions, post-operative mastoid cavities, anatomical variants, and temporal bone trauma.

Conclusion

The histopathological diagnosis of temporal bone pathology in this study correlated significantly well with high-resolution computed tomography, where the validity tests are higher in the evaluation of malignant lesions followed by inflammatory and benign. So, it can be concluded that high-resolution computed tomography is a useful diagnostic modality that enables the characterization of a wide range of temporal bone pathology, and it should be worth noting here that high-resolution computed tomography can be used as a reliable tool with which we can assess temporal bone pathology and can be used to plan the subsequent appropriate management in most cases.

Acknowledgments

None.

Conflicts of interest

Authors declare that there is no conflicts of interest.

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