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Original Research Article

A prospective study on correlation of high-resolution computed tomography temporal bone and surgical findings in squamosal chronic otitis media

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ABSTRACT

Background: Chronic otitis media (COM) is a common condition seen in patients attending ENT department. It is caused by persistent inflammation of the middle ear and mastoid cavity and when left untreated, can lead to significant complications, including the development of squamosal chronic otitis media (SCOM). The aim of this study is to assess the role of high-resolution computed tomography (HRCT) temporal bone in preoperative evaluation of squamosal chronic otitis media.
Methods: This study is a prospective study involving 50 cases of COM. All the patients underwent pre-operative HRCT followed by surgical exploration of middle ear cleft to compare the HRCT findings with the operative findings, thereby establishing a robust correlation between radiological assessment and surgical observations.
Results: The result of the study reveals varying levels of agreement between CT and operative findings across different structures, with generally high concordance rates and statistically significant p values, indicating the reliability of CT in diagnosing these conditions. All findings are statistically significant, emphasizing the consistency between CT and operative findings. The result also highlights that CT scans have high levels of reliability in detecting ossicular erosion, various types of malleus erosion, with good to very good agreement for head of malleus and handle of malleus erosion.
Conclusions: The study highlights the potential of HRCT to improve surgical outcomes by enabling more precise and targeted interventions, ultimately leading to better eradication of the disease from the middle ear cleft.

Keywords: HRCT, Temporal bone, Chronic otitis media

INTRODUCTION

The term "otitis media" refers to a middle ear infection. Acute otitis media (AOM), chronic otitis media (COM), and otitis media with effusion (OME) are among the disorders that fall under this spectrum. A perforated tympanic membrane without an intact tympanic membrane causing persistent otorrhea over a period of three to six weeks is known as chronic suppurative otitis media (CSOM) synonymously also called chronic otitis media (COM), which is caused by persistent inflammation of the middle ear and mastoid cavity. When left untreated, it can lead to significant complications, including the development of squamosal chronic otitis media (SCOM).

SCOM is characterized by the presence of squamous epithelium in the middle ear cleft, resulting in recurrent infections and potential complications such as hearing loss and intracranial complications.[1,2] Chronic otitis media can be broadly classified into two types-mucosal and squamous types both of which can be further categorized into inactive and active forms.[3] When there is prolonged

negative middle ear pressure in squamous COM, the tympanic retracts completely or in a specific location, most frequently the pars flaccida section of the tympanic membrane. The term "pocket" refers to this retracted portion.[3] In an inactive squamous COM, the drum retracts but there isn't any keratin accumulation inside the pocket. Increased keratin build-up within the retraction pocket is caused by active squamous COM, which prevents keratinous debris from migrating outside termed as "cholesteatoma". The inflammatory reaction triggered by cholesteatomas leads to localized osteitis and subsequent bone degradation.[3]

With the advent of high-definition CT scanning in the 1980s, a transformative shift occurred in the pre-operative evaluation for mastoid surgery. The integration of high-definition CT scans has elevated the precision and comprehensiveness of pre-operative assessments for mastoid surgery, ushering in a new era of diagnostic capabilities.[4] For the assessment of the temporal bone, high-resolution computed tomography has superseded traditional multidirectional tomography and has become an invaluable tool in providing detailed anatomical information for preoperative planning.[5,6]

The primary aim of this prospective study is to evaluate the pivotal role of HRCT temporal bone in the preoperative assessment of squamous chronic otitis media (SCOM).

METHODS

This prospective observational study was conducted in Jawaharlal Nehru Medical College and Hospital, Aligarh over a period of 2 years (October 2022 to October 2024) after study protocol being examined and approved by members of Institutional Ethics Committee.

50 patients with squamosal chronic otitis media of both sexes and different age groups (12 years and above) were selected from the Outpatient Department of Otorhinolaryngology, Head and Neck Surgery based on their symptoms and clinical findings during the time. For this study, we included patients who were at least 12 years of age of either sex with confirmed diagnosis of squamosal chronic otitis media. Patients with mucosal chronic otitis media, acute otitis media, neoplastic or granulomatous disease, or those below 12 years of age or those unfit for surgery were excluded from the study.

The patients were registered in this study and records were entered in the pre-structured proforma after taking written informed consent. The complete clinical history of each patient was taken, and a thorough systemic and local examination was performed.

Routine investigations such as complete blood count, blood sugar, renal function test, and other blood investigations as needed were performed. High-resolution computed tomography (HRCT) temporal bone was done in all the patients after registering them in our study. Other audiological investigations like pure tone audiogram were also done before surgery. Patients were subjected to high resolution computed tomography temporal bone scan in the Department of Radiodiagnosis, on a multi-slice CT scanner (Siemens Somatom Emotion) before surgery, and its findings were noted.

On the day of surgery, patients were shifted to the operation theatre and were assessed by an anesthesiologist. Patients were made to lie on the OT table and painting and draping were done. The decision regarding the type of surgery for each patient was decided based on the extent of the disease, ossicular erosion, and associated complications.

Patients with extensive disease were subjected to canal wall-down mastoidectomy whereas patients with limited disease were subjected to intact canal wall mastoidectomy. Intraoperative surgical findings were noted in the operation theatre and filled in the standard proforma. These findings were then compared with preoperative HRCT temporal bone scan findings. After the surgery, patients were shifted to a post-operative room, vitals were monitored and shifted to the ward under stable condition.

Patients were shifted to the ward the same day after the surgery and injectable antibiotics and analgesics were given. Patients were discharged three to five days after the surgery by properly explaining all the precautions on oral antibiotics and recalled for suture removal after one week of surgery. The patient's follow-up was done after two weeks, one month, three months, and six months and the well-being of the patient was assessed. The post-operatively audiological investigation was done after three months of surgery and compared with the preoperative audiological investigation.

After a thorough history and clinical examination, standard proformas were filled to assess the correlation of high-resolution computed tomography temporal bone scan and intraoperative surgical findings in squamosal chronic otitis media using concordance rate, mean, median, standard deviation, and Cohen's kappa correlation coefficient. The data was initially entered into a Microsoft Excel spreadsheet and was checked for discrepancies. Subsequent analysis was conducted using SPSS software (version 24.0)

RESULTS

In the study, the mean age of the study subjects was 24.98 years with a standard deviation of 10.4 years. Out of 50 patients, 28 (56.00%) were male and 22 (44.00%) were female. In 27 cases (54.00%), the affected ear was the left, while in 23 cases (46.00%), it was the right. Ear discharge was a symptom in 49 cases (98.00%), decreased hearing was reported in 41 cases (82.00%), and ringing sensation was present in 13 cases (26.00%). The mean duration of complaints of the study subjects was 10.38 years with a standard deviation of 8.23 years (Table 1).

Table 1: Frequency distribution of demographic variable.

Variable	Categories	Frequency	%
Gender	Men	28	56.00
	Women	22	44.00
Ear affected	Right	23	46.00
	Left	27	54.00
Symptom	Ear discharge	49	98.00
	Hearing impairment	41	82.00
	Ringing sensation	13	26.00

Table 2: Distribution of otoscopic findings.

Otoscopic findings	Frequency	%
Attic cholesteatoma	11	22.00
Attic perforation and scutal erosion	7	14.00
PSRP+Marginal perforation	10	20.00
PSRP+Cholesteatoma	22	44.00
Total	50	100.00

Table 3: Distribution of audiogram findings.

Audiogram finding	Frequency	%
Mild conductive hearing loss	9	18.00
Moderate conductive hearing loss	17	34.00
Moderately severe mixed hearing loss	11	22.00
Severe mixed hearing loss	12	24.00
Profound mixed hearing loss	1	2.00
Total	50	100.00

Table 4: Distribution of surgical procedure performed.

Surgery	Frequency	%
Canal wall down mastoidectomy	37	74.00
Intact canal wall mastoidectomy	13	26.00
Total	50	100.00

The otoscopic findings for the 50 cases showed varied distribution of conditions. Attic cholesteatoma was observed in 11 cases, representing 22.00% of the total. Attic perforation and scutal erosion were found in 7 cases, accounting for 14.00%. PSRP (Posterior Superior Retraction Pocket) with marginal perforation was seen in 10 cases, making up 20.00%. The most common finding was PSRP with cholesteatoma, observed in 22 cases, which is 44.00% of the total (Table 2). Audiogram findings indicated moderate conductive hearing loss in 17 cases (34.00%), severe mixed hearing loss in 12 cases (24.00%), and moderately severe mixed hearing loss in 11 cases (22.00%). Mild conductive hearing loss was observed in 9 cases (18.00%), and profound mixed hearing loss was present in 1 case (2.00%) (Table 3).

In 13 cases (26.00%), the surgery performed was intact canal wall mastoidectomy, while in 37 cases (74.00%), canal wall down mastoidectomy was performed (Table 4). In the present study, the correlation between HRCT temporal bone scans and surgical findings in squamosal chronic otitis media cases between several anatomical structures has been evaluated which showed a good agreement as indicated by the kappa values that are reported to be 0.746 for tegmen tympani erosion, 0.754 for tegmen mastoidium erosion, 0.94 for sinus plate erosion, and 0.735 for LSCC fistula. Moderate agreement was noted for facial canal dehiscence (kappa value: 0.457) (Table 5).

This study provides a detailed comparison between CT scan findings and operative findings for various anatomical regions within the ear, assessing the extent of disease. For epitympanum disease, there is a 98% concordance rate between CT and operative findings, with a kappa value of 0.658, indicating good agreement. For mesotympanum disease, the CT and operative findings show a 96% concordance rate and a kappa value of 0.920, reflecting very good agreement, also highly significant with a p value of <0.0001.

The assessment of hypotympanum disease reveals a 98% concordance rate and a kappa value of 0.898, indicating very good agreement, with the p value again being highly significant at <0.0001. In cases of aditus widening, the concordance rate is 98%, and the kappa value is 0.935, signifying very good agreement, with a highly significant p value of <0.0001. For sinus tympani disease, there is a 98% concordance rate and a kappa value of 0.959, indicating very good agreement. The p value is <0.0001, showing high statistical significance.

Prussak's space disease shows perfect agreement between CT and operative findings, with a 100% concordance rate and a kappa value of 1, denoting very good agreement. This finding is also highly significant with a p value of <0.0001. Finally, for facial recess disease, the concordance rate is 98%, with a kappa value of 0.960, indicating very good agreement. The p value is <0.0001, highlighting high statistical significance (Table 6). This study also compares the findings of CT scans with operative findings for the erosion of the ossicles in the ear, specifically the malleus, incus, and stapes. In summary, the data highlights that CT scans have high levels of reliability in detecting ossicular erosion (Table 7).

For head of malleus erosion, the concordance rate is 98%, with a 2% discordance rate. This suggests that CT scans are reliable for identifying this type of erosion. In the case of both head and handle of malleus erosion, there is perfect agreement between CT and operative findings, with a 100% concordance rate and a kappa value of 1, indicating

very good agreement. The p value of <0.0001 further underscores the high reliability of CT scans for detecting combined head and handle of malleus erosion. This study also compares CT scan findings with operative findings for different types of incus erosion, demonstrating varying levels of agreement and statistical significance. For complete incus erosion, the concordance rate is 100% with 0% discordance rate. The kappa value of 1 indicates perfect agreement and the p value of <0.0001 is highly significant. Long process of incus erosion shows very good agreement, with 96% concordance rate, kappa value of 0.920, and highly significant p value of <0.0001. Long and lenticular process of incus erosion has a 98% concordance rate and a 2% discordance rate, with a kappa value of 0.935, indicating very good agreement and high statistical significance. Lastly, body and long process of incus erosion shows a 100% concordance rate and 0% discordance rate, with kappa value of 1, indicating perfect agreement, and highly significant p value of <0.0001. Overall, the data suggests that CT scans are generally reliable for diagnosing various types of incus erosion, with good to perfect agreement in most categories and all findings being statistically significant (Table 8, Table 9).

Table 5: Inter-rater kappa agreement in structures involved between CT and operative (per-op) findings.

Structures involved		CT (%)	Per-op (%)	Concordance	Concordance (%)/ discordance rate (%)	Kappa	P value
Mastoid reduced pneumatisation	Absent	0 (0)	0 (0)	-	100/0	1	<0.0001
	Present	50 (100)	50 (100)	50			
Scutum erosion	Absent	22 (44)	22 (44)	22	100/0	1	<0.0001
	Present	28 (56)	28 (56)	28			
Tegmen tympani erosion	Absent	30 (60)	32 (64)	28	88/12	0.746	<0.0001
	Present	20 (40)	18 (36)	16			
Tegmen mastoidium erosion	Absent	28 (56)	30 (60)	26	88/12	0.754	<0.0001
	Present	22 (44)	20 (40)	18			
Sinus plate erosion	Absent	40 (80)	39 (78)	39	98/2	0.94	<0.0001
	Present	10 (20)	11 (22)	10			
Facial canal dehiscence	Absent	40 (80)	36 (72)	33	80/20	0.457	0.001
	Present	10 (20)	14 (28)	7			
LSCC fistula	Absent	44 (88)	43 (86)	42	94/6	0.735	<0.0001
	Present	6 (12)	7 (14)	5			

Table 6: Inter-rater kappa agreement in extent of disease between CT and operative (per-op) findings.

Extent of disease		CT (%)	Per-op (%)	Concordance	Concordance (%)/ discordance rate (%)	Kappa	P value
Epi-tympanum disease	Absent	1 (2)	2 (4)	1	98/2	0.658	<0.0001
	Present	49 (98)	48 (96)	48			
Meso-tympanum disease	Absent	28 (56)	26 (52)	26	96/4	0.920	<0.0001
	Present	22 (44)	24 (48)	22			
Hypo-tympanum disease	Absent	44 (88)	45 (90)	44	98/2	0.898	<0.0001
	Present	6 (12)	5 (10)	5			
Aditus widening	Absent	40 (80)	41 (82)	40	98/2	0.935	<0.0001
	Present	10 (20)	9 (18)	9			
Sinus tympani disease	Absent	20 (40)	19 (38)	19	98/2	0.959	<0.0001
	Present	30 (60)	31 (62)	30			
Prussacks space disease	Absent	32 (64)	32 (64)	32	100/0	1	<0.0001
	Present	18 (36)	18 (36)	18			
Facial recess disease	Absent	24 (48)	23 (46)	23	98/2	0.960	<0.0001
	Present	26 (52)	27 (54)	26			

Table 7: Inter-rater kappa agreement in ossicles between CT and operative (per-op) findings.

Ossicles		CT (%)	Per-op (%)	Concordance	Concordance (%)/ discordance rate (%)	Kappa	P value
Malleus erosion	Absent	47 (94)	45 (90)	45	96/4	0.730	<0.0001
	Present	3 (6)	5 (10)	3			
Incus erosion	Absent	10 (20)	7 (14)	7	94/6	0.789	<0.0001
	Present	40 (80)	43 (86)	40			
Stapes erosion	Absent	27 (54)	20 (40)	20	86/14	0.724	<0.0001
	Present	23 (46)	30 (60)	23			

Table 8: Inter-rater kappa agreement in malleus erosion between CT and operative (per-op) findings.

Malleus erosion		CT (%)	Per-op (%)	Concordance	Concordance (%)/ discordance rate (%)	Kappa	P value
Handle of malleus erosion	Absent	49 (98)	48(96)	48	98/2	0.658	<0.0001
	Present	1 (2)	2 (4)	1			
Head of malleus erosion	Absent	50 (100)	49 (98)	49	98/2	NA	-
	Present	0 (0)	1 (2)	0			
Handle+head of malleus erosion	Absent	48 (96)	48 (96)	48	100/0	1	<0.0001
	Present	2 (4)	2 (4)	2			

Table 9: Inter-rater kappa agreement in incus erosion between CT and operative (per-op) findings.

Incus erosion		CT (%)	Per-op (%)	Concordance	Concordance (%)/ discordance rate (%)	Kappa	P value
Complete incus erosion	Absent	48 (96)	48 (96)	48	100%/0%	1	<0.0001
	Present	2 (4)	2 (4)	2			
Long process of incus erosion	Absent	24 (48)	22 (44)	22	96%/4%	0.920	<0.0001
	Present	26 (52)	28 (56)	26			
Long+lenticular process of incus erosion	Absent	41 (82)	40 (80)	40	98%/2%	0.935	<0.0001
	Present	9 (18)	10 (20)	9			
Body+long process of incus erosion	Absent	47 (94)	47 (94)	47	100%/0%	1	<0.0001
	Present	3 (6)	3 (6)	3			

DISCUSSION

The study participants aged 13-50 years had a mean age of 24.98±10.4 years. In a similar study by Jadia et al, 52 patients in 9-56 years of age with a mean age of 23.2 years.[7] In another study by Cruz et al, the mean age reported was 21.3 years with a range of 4-62 years.[8] In our study, the male-to-female ratio was 28:22 with a percentage frequency of 56:44%. Borgohain and Saikia noted that a maximum number of patients belonged to the age group of 11-30 years with a male: female ratio of 1.5:1.[9] In our study, site-wise distribution showed that the right-side ear was more frequently affected compared to the left counterpart (R:L=27:23).

In another study, Murali et al. found that the left ear was more commonly affected in their study participants compared to the right ear (R:L=16:21±43.2:56.8%).[10] Prata et al. reported in their study that 63.41% of ears had intermittent otorrhea and 32.92% had chronic otorrhea.[11] According to certain studies on COM sufferers like Bakir et al and Lailach et al, hearing loss is the most severe symptom, worse than tinnitus or otorrhea.[12,13] In our study, the patients were symptomatic for an average duration of 10.38±8.23 years. In another study, Kabdwal et al discovered that the duration of ear discharge was always shorter than the period of hearing loss.[14] In a study by Grewal et al, an equal number of patients (n=22) had duration of symptoms for 1-5 years and 6-10 years respectively.[15] In our study, the findings of otoscopy for the 50 cases show varied distribution of conditions that

reveal maximum incidence (n=22, 44%) of posterior superior retraction pocket (PSRP)+cholesteatoma which is 44% of the total, followed by attic cholesteatoma (n=11, 22%) representing 22% of the total, posterior superior retraction pocket (PSRP)+marginal perforation (n=10, 20%) making up 20%, and finally Attic perforation and scutal erosion were found in 7 cases accounting for (14%). In a study by Grewal et al, an equal number of patients (n=22) had posterosuperior retraction with cholesteatoma was seen in 36% of cases, posterosuperior retraction pocket in 27% of cases, anterior retraction in 20% of cases, and attic cholesteatoma was seen in 17% of cases.[15]

In our study, audiogram analysis shows that 17 cases representing (34.00%) of the total had moderate conductive hearing loss, 12 cases representing (24.00%) of the total had severe mixed hearing loss, and 11 cases representing (22.00%) of the total had moderately severe mixed hearing loss. Nine instances making up (18.00%) of the total had mild conductive hearing loss, while one case accounting for (2.00%) had profound mixed hearing loss. In another study, Maharjan et al conducted a screening of children in Monastic schools in Nepal and observed that chronic otitis media was prevalent in 10.83% of the population. According to their study, 77.82% of all occurrences of hearing loss were caused by COM alone.[16]

In our present study, surgical management of cases comprised thirty-seven cases representing (74.0%) of the total who underwent canal wall down mastoidectomy (CWD) whereas thirteen cases accounting for (26.00%) of the total underwent intact canal wall mastoidectomy (ICW). Patient with extensive disease underwent CWD mastoidectomy and patients with limited disease underwent ICW mastoidectomy. In another study by Yuan et al, four had a complete canal wall down mastoidectomy (CWD) together with tympanoplasty, 55 had intact canal wall mastoidectomy (ICW) + tympanoplasty, and 120 had simple tympanoplasty.[17] A study by Jackson et al. stated that when a patient experiences their first bout of acute mastoiditis, they usually have a canal wall-up mastoidectomy (CWU).18 Patients who have experienced recurrent cholesteatoma or persistent chronic otitis media are typical candidates for canal wall-down mastoidectomies (CWD).

In the present study, the correlation between HRCT temporal bone scans and surgical findings in squamosal chronic otitis media cases between several anatomical structures has been evaluated which showed a good agreement as indicated by the kappa values that are reported to be 0.746 for tegmen tympani erosion, 0.754 for tegmen mastoidium erosion, 0.94 for sinus plate erosion, and 0.735 for LSCC fistula. Moderate agreement was noted for facial canal dehiscence (kappa value: 0.457). The overall results yield a higher concordance and a lower discordance rate. O'Reilly et al. have reported an agreement rate of 67% to 94.5% for different anatomic structural findings on computed tomography (CT) and their correlation with the surgical findings and mentions that when the soft tissue is overlying the facial nerve canal, it causes loss of contrast gradient obscuring a small dehiscence.[19] In a similar study, Rogha et al reported that the radio-surgical correlation was highest for sigmoid plate erosion (kappa coefficient 1) followed by aditus widening with a kappa coefficient of 0.92.[20]

Similarly, in the present study, analysis of the extent of disease reveals that the concordance rate between pre-operative CT findings and intra-operative surgical findings ranged from 96% to 100% (corresponding to a discordance rate of 4% to 0%). In the present study, for epitympanum disease, there is a 98% concordance rate between CT and operative findings, with a kappa value of 0.658, indicating good agreement. This finding is statistically significant with a p value of <0.0001. In a similar study, Jadia et al reported that 52 cases had disease extension up to the epitympanum while intraoperative findings revealed only 50 cases with such extension, yielding a concordance rate of 96%.[7]

The findings of CT and operative procedure for mesotympanum in the present study show a 96% concordance rate and a kappa value of 0.920, reflecting very good agreement, also highly significant with a p value of <0.0001. The study by Jadia et al, found an extension of disease to mesotympanum in 41 cases out of 52, from which only 26 had an extension to mesotympanum when evaluated surgically yielding a concordance rate of 71.15% which is far from the agreement observed in the present study.[7] Khan et al, found that on high-resolution computed tomography (HRCT), the kappa coefficient for the mesotympanum was 0.822, indicating an almost perfect agreement, with a p value of less than 0.005.[21] Furthermore, the assessment of hypotympanum disease reveals a 98% concordance rate and a kappa value of 0.898, indicating very good agreement, with the p value again being highly significant at <0.0001 in the present study. The study by Jadia et al. had a concordance rate of 69.23% for the hypotympanum extension while Khan et al. reported a kappa coefficient of 0.485 for the same indicating a moderate agreement between HRCT and surgical findings for the extension of disease to hypotympanum.[7,21] Notably, the present study had the highest agreement between surgical and HRCT findings for Prussacks space disease with a concordance rate of 100%, which was followed by aditus widening, sinus tympani disease, and facial recess disease each with 98% concordance.

In Rogha et al's a similar study reported that the radio-surgical correlation was highest for sigmoid plate erosion (kappa coefficient 1) followed by aditus widening with a kappa coefficient of 0.92.[20] Poorest correlation was seen for fallopian canal erosion in their study which had a kappa coefficient of only 0.2. A hundred percent radio-surgical agreement for aditus widening has also been reported by Jadia et al. in their study.[7] The study of erosion of auditory ossicles using the present study showed that HRCT and operative findings show a concordance rate of 96% and a

discordance rate of 4% for Malleus erosion. The kappa value is 0.730, indicating good agreement, and the p value is <0.0001, which is highly significant. Thus, the findings of the present study align with those observed by Singh et al. and Gerami et al reported a sensitivity of 92% and specificity of 54% in diagnosing ossicular bone erosion.[22,23] Jackler et al could predict ossicular erosion in only 7.1% of the cases.[24]

Despite the above-mentioned benefits, the study has its limitations. CT cannot categorically differentiate between cholesteatoma and granulation tissue. Partial volume averaging of thin structures like facial nerve canal may at times give erroneous results. The tympanic membrane condition, existence of lateral semicircular canal fistula and the integrity of incudostapedial joint cannot be predicted using HRCT.

CONCLUSION

In conclusion, the study successfully assessed the role of HRCT in the preoperative evaluation of squamosal chronic otitis media. HRCT temporal bone cannot be solely relied-on in squamosal chronic otitis media due to its varying degree of accuracy in predicting the relevant information. However, undoubtedly it is a very useful aid to management to a well-trained, experienced, and alert surgeon and is the key to an accurate diagnosis and successful management of squamosal chronic otitis media. Furthermore, by demonstrating a significantly high concordance rate between HRCT and operative findings, the study suggests that the integration of HRCT in preoperative evaluations can enhance the overall quality of life for patients by reducing disease-related complications and improving social outcomes.

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