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Original Article

Role of Pre-operative High Resolution Computed Tomography of Temporal Bone in Squamous Chronic Otitis Media

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ABSTRACT: OBJECTIVE : To study the role of High Resolution Computed Tomography (HRCT) of temporal bone as a diagnostic tool for pre-operative surgical management in cases of squamous chronic otitis media. PATIENTS AND METHODS: This pro-spective study included 40 patients of a tertiary care centre, their pre-operative HRCT temporal bone was compared with their peroperative findings to evaluate the accuracy, sensitivity and specificity of HRCT temporal bone in squamous chronic otitis media. RESULT: HRCT temporal bone is an excellent modality for diagnosing scutum erosion and presence of soft tissue mass in the middle ear cleft, it is good for diagnosing ossicular necrosis, tegmen erosion and lateral semicircular canal fistula. It's a poor diagnostic modality for facial nerve dehiscence and bony external canal erosion. CONCLUSION : The sensitivity, specificity and positive predictive value of HRCT temporal bone depends on the anatomical structures implicated in squamous chronic otitis media.

Key Words : HRCT temporal bones, Squamous chronic otitis media, Pre-operative, Per-operative.

INTRODUCTION : Chronic Otitis Media (COM) is the term used to describe any chronic inflammatory pathology of the middle ear. The relatively poor standards of living in developing countries lead to a higher incidence of COM. Chronic otitis media has been an important cause of middle ear disease since prehistoric times. Despite the valuable contribution of antibiotics, COM remains a common disease and its complications are challenging for both otologists and radiologists. Cholesteatoma is a non-malignant destructive lesion of the middle ear cleft who's short and long term sequelae may be devastating, the reason being the strategic location of the tympanomastoid compartment, separated from the middle and posterior cranial fossa by very thin bony partitions. Squamous type COM has the potential for intracranial and extracranial extension. Hence, it becomes very important to know the location and extent of the disease before proceeding to surgical treatment. Radiological examination of the temporal bone helps us to achieve this objective. It is the computed tomography (CT) which has made the most important contribution to radiology in otolaryngology. Though otitis media is essentially a clinical diagnosis but high resolution computed tomography (HRCT) is useful for showing evidence of bony erosion in acute and chronic mastoiditis, extent of pneumatization of the temporal bone and relationship of the pathology to adjacent critical neurovascular structures such as the dura, internal carotid artery, lateral sinus and facial nerve[1]. It is now being claimed that a cholesteatoma, as small as 3mm in size can be diagnosed much earlier by the use of HRCT and also for a cholesteatoma behind an intact eardrum, imaging is important. The main benefit of HRCT comes in cases where the cholesteatomas were combined with scarring granulation tissue or post surgical changes in which the resulting soft tissue masses were indistinguishable. One set of conditions in which the indication of pre-operative scanning is quite clear when there are central nervous system complications of COM. Other reasonable uses of HRCT scanning include pre-operative facial paralysis, vertigo with positive fistula test and when revision mastoidectomy is contemplated in the absence of details of the previous procedure. Its ability to determine the extent of soft tissue involvement of the antrum, middle ear and especially the posterior tympanic spaces may assist the surgeon in planning the extent of surgical procedure. Therefore, HRCT helps in guiding the ideal approach for surgery as well as emphasizing the need for surgery by revealing the extent of disease. Few authors recommend scanning as routine prior to all mastoid surgeries but others still feel it as an unnecessary financial burden on the patient. HRCT has a significant impact on the medical and surgical management of individuals with middle ear disease. It confirms and expands upon otoscopic findings, resolves clinical doubts, and in many circumstances, plays a significant role in determining surgical efficacy. However, routine HRCT scanning prior to all surgery of cholesteatoma can only be justified if it can be shown to influence clinical management. The routine use of CT was recommended in children, medically unfit patients, only or better hearing ears, patients in whom the tympanic membrane could not be adequately visualized, patients who have had previous mastoid surgery with no operative records and in patients with intratemporal and intracranial complications of the disease[1,2]. Since a considerable number of patients with squamous COM, with/without cholesteatoma attend services of our hospital, it was felt necessary to study in detail, the HRCT evaluation of squamous COM. In this study, we evaluated the role of HRCT in squamous chronic otitis media, and compared the per-operative findings on surgery with the pre-operative HRCT findings, thereby implicating the usefulness of HRCT as an important tool for pre-operative assessment of patients of squamous type COM and yielding anatomical details imperative for surgery. To this objective, the present study was conducted to evaluate how accurately HRCT scanning could define the extent and severity of the underlying disease in patients with squamous type COM, thereby altering the surgical plan and outcome. Thus, this study aims to study the sensitivity and specificity of pre-

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operative HRCT temporal bone in squamous type chronic otitis media.

PATIENTS AND METHODS : This prospective study included 40 patients of a tertiary care centre aged 8-70 years clinically diagnosed with squamous COM. It excluded patients with mucosal COM. All these patients underwent a pre-operative HRCT, Temporal Bone using Siemens Somaton Emotion 6 machine. Reformatting was done to a slice thickness of 0.69 mm. These patients then underwent mastoidectomy by senior faculty and the surgical findings were recorded and compared with pre-operative HRCT findings of the microanatomical structures of the middle ear cleft which included extent of the soft tissue in the middle ear cleft, degree of ossicular necrosis (malleus, incus, stapes), erosion of lateral semicircular canal, facial nerve dehiscence, tegmen and scutum erosion and erosion of the external auditory canal.

RESULTS : In our prospective study of 40 patients, 55% were females. The commonest age group involved in both males and females was 11-20 years group. 40% patients were found to be in this category. Ear discharge was the most common presenting symptom (97.5%) followed by hearing loss (80%). Less common symptoms were otalgia (25%), tinnitus (22.5%), vertigo (15%), headache (5%), facial paresis/ paralysis (5%) and nasal obstruction (2.5%). The most common presenting group of symptoms was the combination of ear discharge and hearing loss (37.5%). HRCT reported soft tissue density in the middle ear cleft in 35 patients, all correctly diagnosed i.e. there were no false positives. Soft tissue in the middle ear cleft was found in 37 patients intra-operatively which infers that HRCT missed 2 cases i.e. there were 2 false negative cases bringing the true positive count to 35 (Table-1). The sensitivity and specificity of HRCT for diagnosing soft tissue in the middle ear cleft pre-operatively was 94.59% and 100% respectively p=0.157 (Fig-1). Malleus necrosis was present in 20 patients intra-operatively while HRCT diagnosed the same in 19. This entity was over diagnosed by HRCT in 2 patients (false positives) and under diagnosed in 3 (false negatives). So the true positive count was 17 and the true negatives were 18 (Table-1) The sensitivity and specificity of HRCT for diagnosing malleus necrosis pre-operatively was 85% and 90% respectively. p=0.655 (Fig-1). Intra-operative incus necrosis was present in 31 patients. HRCT diagnosed the same in 28 patients with 3 false positives, missing this finding in 6 patients (false negatives). Thus the true positive count came down to 25 and true negative count to 6 (Table-1). The sensitivity and specificity of HRCT for diagnosing incus necrosis pre-operatively was 80.65% and 66.67% respectively. p=0.317. HRCT diagnosed 18 patients as having stapes necrosis. The finding was confirmed in 15 patients intra-operatively with HRCT missing the necrosis in 7 patients (false negative) and over diagnosing it in 10 patients (false positive). The true positive count was 8 and true negatives were 15. The sensitivity and specificity of HRCT for diagnosing stapes necrosis pre-operatively was 53.3% and 60% respectively. p=0.467. Lateral SCC erosion was a feature that was seen in 4 patients on HRCT while present only in 2 intra-operatively. HRCT was accurate for 1 patient (true positive) who had this feature and for 35 patients (true negatives) who did not have this feature. The false positive counts for lateral SCC erosion were 3 and false negative count was 1. The sensitivity and specificity of HRCT for diagnosing lateral SCC erosion pre-operatively was 50% and 92.11% respectively. p=0.317. 19 patients had a dehiscent facial nerve intra-operatively. HRCT claimed the dehiscence in 6. There were 6 true positives, 21 true negatives. There were no false positives and 13 false negatives. Thus facial nerve dehiscence was a feature that was underdiagnosed by HRCT in13, but was not over diagnosed in any. The sensitivity and specificity of HRCT for diagnosing facial nerve dehiscence pre-operatively was 31.58% and 100% respectively. p=0.000. Tegmen erosion was seen in 3 patients intra-operatively and was diagnosed in 6 patients intra-operatively. There was 1 true positive and 32 true negative cases. HRCT over diagnosed tegmen erosion in 5 patients (false positives) and under diagnosed the same in 2 patients (false negatives). The sensitivity and specificity of HRCT for diagnosing tegmen erosion pre-operatively was 33.33% and 86.49% respectively. p=0.257. During surgery, we found an eroded scutum in 29 patients. The same was

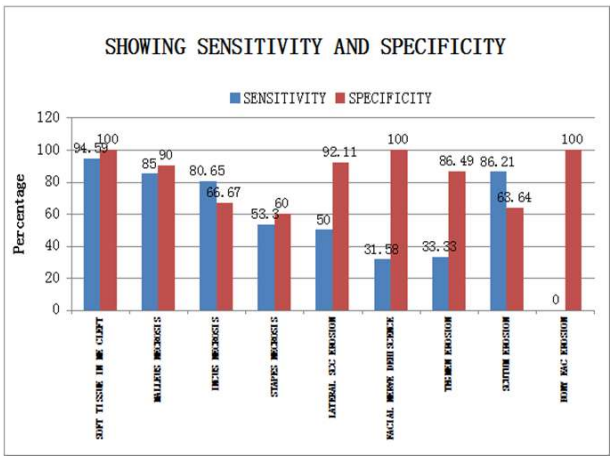

Figure 1 : Age distribution of patients studied.

S. No.	Feature	On HRCT n = 40	Intra-operative n = 40	False positives	False negatives	Sensitivity	Specificity	Positive predictive value	Negative predictive value	p value
1	Soft tissue in ME cleft	35 (87.5%)	37 (92.5%)	0	2	94.59%	100%	100%	60%	0.157
2	Malleus necrosis	19 (47.5%)	20 (50%)	2	3	85%	90%	89.47%	85.71%	0.655
3	Incus necrosis	28 (70%)	31 (77.5%)	3	6	80.65%	66.67%	89.29%	50%	0.317
4	Stapes necrosis	18 (45%)	15 (37.5%)	10	7	53.3%	60%	44.44%	68.18%	0.467
5	Lateral SCC erosion	4 (10%)	2 (5%)	3	1	50%	92.11%	25%	97.22%	0.317
6	Facial nerve dehiscence	6 (15%)	19 (47.5%)	0	13	31.58%	100%	100%	61.76%	0.000
7	Tegmen erosion	6 (15%)	3 (7.5%)	5	2	33.33%	86.49%	16.67%	94.12%	0.257
8	Scutum erosion	29 (72.5%)	29 (72.5%)	4	4	86.21%	63.64%	86.21%	63.64%	1.000
9	Bony EAC erosion	0 (0%)	5 (12.5%)	0	5	0%	100%	-	87.50%	0.025

Table-1 : Age distribution of patients studied.

the number diagnosed by HRCT. But of these 29, HRCT diagnosed accurately only in 25. There were 4 false positives and 4 false negatively diagnosed patients. The sensitivity and specificity of HRCT for diagnosing scutum erosion pre-operatively was 86.21% and 63.64% respectively. p=1.000. HRCT missed all 5 cases of bony external auditory canal erosion that were found intra-operatively, thus there were no false positive and false negative cases. The sensitivity and specificity of HRCT for diagnosing bony EAC erosion pre-operatively was 0% and 100% respectively. p=0.025. HRCT of temporal bone delineates the bony and the soft tissue anatomy with high accuracy. It is an excellent modality for diagnosing scutum erosion which is an earliest and confirmatory sign of presence of an attic cholesteatoma. HRCT has an added advantage in revision surgery and its complications.

DISCUSSION : Historically, mastoid surgery has been undertaken with otoscopy, audiometry and possible plain X-ray as the only pre-operative investigation. The advent of HRCT in 1980 has allowed excellent pre-operative imaging of anatomy, evidence of extent of disease and a screening for asymptomatic complications. It has however, not gained wide acceptance as an essential aid in planning surgery as most otologists reserve pre-operative scanning for selected cases such as squamous COM with complications, suspected congenital abnormalities or with loss of landmarks due to previous surgery. However, routine HRCT scanning prior to all surgeries for squamous COM can be justified only if it can be shown to influence the clinical management, thus helping to convert a surgical exploration into a planned procedure to a significant extent. In the present study named "Role of pre-operative HRCT temporal bone in squamous chronic otitis media", the age of patients varied from 9-65 years with maximum number of cases presenting between 11-20 years age group (40%). With reference to national and international studies, the commonest age group involved was similar and females were affected more than males[4,5]. Though squamous COM has various clinical presentations, the most frequently reported symptom in our study was ear discharge in 97.5% patients followed by hearing loss in 80% and otalgia in 25% cases. Other less frequent symptoms were tinnitus in 22.5%, vertigo in 15%, fever in 5%, headache in 5% and nasal obstruction in 2.5%. But the commonest presentation in the outdoor was a combination of ear discharge with hearing loss in 37.5%. These series of symptoms of presentation can be well correlated with a study by Adel et al[6] in 2004. In this prospective study of 40 patients, 87.5% patients showed a non-dependant homogenous soft tissue in the Middle Ear Cleft on HRCT whereas 92.5% patients were found to have soft tissue in middle ear cleft intra-operatively, thus proving the HRCT specificity of 100% while a sensitivity of 94.59% in detecting a soft tissue mass pre-operatively. A similar prospective study done by Garg et al[2] in 2012 showed similar results of HRCT sensitivity of 89.65% and specificity of 100% in detecting soft tissue in the middle ear cleft. Sirigiri et al[7] in 2011, in his study, also showed HRCT sensitivity of 92% which is compatible with our study. After statistically analyzing and comparing HRCT and intra-operative findings for soft tissue density in the middle ear cleft in our patients, p = 0.157 was not significant, making HRCT a good modality for diagnosing soft tissue in the middle ear cleft by HRCT pre-operatively. Tendency of cholesteatoma towards the destruction of bone and failure of non-surgical treatment for it have caused conditions in which a proper diagnosis and an appropriate surgical approach for dealing with it have become of great importance. In our study, HRCT detected malleus erosion in 47.5% patients while intra-operative findings showed malleus erosion in 50% patients. There were 2 false positive and 3 false negative cases, thus indicating that the sensitivity of HRCT for malleus erosion was 85% while its specificity was 90%. The findings of this study can be well collaborated with a study conducted by Rogha et al[8] in 2014, who also reported HRCT sensitivity of 82.4% for detecting malleus erosion. Garg et al[2] have reported similar findings in their study of 60 patients showing 90.9% sensitivity and a specificity of 89.47%, thus recognizing malleus erosion or intactness. HRCT in our study has demonstrated to be within satisfactory norms with high sensitivity, specificity and negative predictive value. Similarly, Shah et al[9] in 2014 have also reported a sensitivity of 81.3% and a 91.1% specificity which is comparable with our results. p = 0.655 was not significant making HRCT a good diagnostic modality for diagnosing malleus necrosis. Pre-operative erosion of incus was seen in 70% patients while 77.5% patients showed incus necrosis intra-operatively so there were 6 false negative cases, hence the HRCT sensitivity after calculation was 80.65% while specificity dropped to 66.67%. The findings of our study are comparable to a study by Shah et al[9] in 2014 who also quoted a sensitivity and specificity of 90% and 66.7% respectively. Comparable results are also seen in a study conducted by Rai[10] in 2014, by Zhang et al[11] in 2004 and by Chee and Tan[12] in 2001 who all show a HRCT sensitivity of 85% for incus erosion. Gomma et al[13] in 2013 in their study of 56 patients have reported HRCT sensitivity of 85.7% for incus necrosis. Datta et al[4] in 2014 has also reported in a study of 25 cases, sensitivity of HRCT for incus necrosis to be 87%. Rogha et al[8] in 2014 have reported comparable results of 90.6% of sensitivity and 50% of specificity of HRCT in lieu of incus necrosis. So according to the above mentioned literature, our findings are comparable and compatible with previous studies. The calculated p value for incus necrosis, p = 0.317 was not significant. We can thus infer that HRCT is a good investigation for diagnosing incus necrosis pre-operatively. In studies on efficiency of HRCT in pre-operative detection of stapes necrosis, Rogha et al[8] in 2014 and Garg et al[6] in 2011 have found sensitivity of 61.9%, specificity of 66.7% and sensitivity of 40% and specificity of 26.67% respectively. According to literature, the reason for its low sensitivity and specificity is that stapes is not consistently visualized on HRCT and when seen, it appears as a structure of soft tissue density in the oval window niche. For this reason, it was not possible to distinguish between the destruction of stapes and its mere envelopment by soft tissue. This evidence supports low HRCT sensitivity and specificity of 53.3% and 60% respectively in diagnosing

stapes necrosis in our study. There were 10 false positive and 7 false negative cases in our study of 40 cases. The p value so calculated for stapes necrosis (p=0.467) was insignificant too, therefore, HRCT could diagnose stapes necrosis well. Labyrinthine fistula continues to be one of the most common complications of squamous COM. In nearly 90% of the patients, the labyrinthine fistula is located in the lateral semicircular canal. An extensive clinical examination supported by imaging studies is essential for its pre-operative diagnosis. Use of both the planes - coronal and axial, to be employed for detecting LSCC fistula. Lateral semicircular canal was eroded in 10% cases (4 patients) on HRCT and was found in 5% cases (2 patients) intra-operatively out of the 40 cases in our study. There were 3 false positives and 1 false negative case. Hence sensitivity and specificity in our study was 50% and 92.11% respectively showing moderate sensitivity of HRCT in diagnosing lateral SCC fistulas. A high false positive rate has also been reported, which is comparable to our study by Chee et al[12] in 2001. Comparable sensitivity of approximately 55% with regard to LSCC erosion has been reported by Parisier et al[14] in1991 and by Vanden,et al[15] in1993. Our findings of sensitivity and specificity of HRCT with regard to lateral semicircular canal erosion are consistent with Garget al6 who also report a sensitivity and specificity of 66.67% and 83.33% respectively. Gerami et al[16] in 2009 too have reported a specificity of 95% for LSCC erosion which is comparable with our study. p value was calculated for lateral SCC erosion in our study. p=0.317 was insignificant, thus HRCT was a good pre-operative diagnostic modality to look for lateral SCC erosion. According to literature, the sensitivity of HRCT in detecting facial canal dehiscence was 25% according to Freng et al[17],. In our study, 15% patients (6 cases) showed facial nerve dehiscence on HRCT while 47.5% patients (19 cases) actually had facial nerve dehiscence intra-operatively. There were 13 false negative cases. The sensitivity and specificity of HRCT for facial nerve dehiscence in our study was 31.58% and 100% respectively. These non compliant results can be explained by the fact that the visualization of thin bony structures like facial nerve canal may be misleading due to errors in computer reconstruction of their images. These structures may appear eroded due to the fact that the computer averages their density with adjacent soft tissue and air[1]. Our findings are consistent with Rai[10] in 2014, who quotes a sensitivity of 33.33% and specificity of 100% for facial canal dehiscence. Similar results were found by Alzoubi[18] in 2008 and by Garber[19] in 1994. Almost similar sensitivity of 40% and specificity of 95% has been reported by Garg et al[2] in 2011. In our study, when p value was calculated for facial nerve dehiscence after comparing HRCT and intra-operative findings, it was found to be highly significant. p value of 0.000 made HRCT a very poor imaging technique for pre-operative diagnosis of facial nerve dehiscence. Tegmen tympani represents the roof of the middle ear cavity. Its erosion is well seen on coronal imaging. Compatibility of radiological and intra-operative results in diagnosing erosion on tegmen tympani in our study were found to be weak. There were 15% patients reported of tegmen erosion on HRCT while intra-operatively, 7.5% patients showed tegmen erosion. Thus there were 5 false positive and 2 false negative cases in our study. On applying the above mentioned data of our study of 40 cases, HRCT sensitivity for tegmen erosion was 33.3% while its specificity for the same was 86.49%. According to review of the articles, HRCT was found to be poorly sensitive to detect tegmen tympani erosion which agrees with results by Gerami et al[16] in 2009. Comparable results to our study have been reported by Rai[10] in 2014 with 33.3% sensitivity and 100% specificity of HRCT in detecting tegmen erosion. p = 0.257 was not significant. We could thus conclude that HRCT could adequately diagnose tegmen erosion pre-operatively. The criteria indicating cholesteatoma as "blunting of the scutum's normally sharp tip which is often the earliest sign of attic cholesteatoma". Gurano et al[20] stated that signs indicating cholesteatoma in the attic include erosion or destruction of scutum and widening of the aditus and antrum with loss of the 'Figure of 8' appearance. In the present study, HRCT scans show blunting of scutum's normally sharp tip in 72.5% patients) while scutum erosion intra-operatively was also seen in 72.5% patients. However there were 4 false positive and 4 false negative cases, thus reducing the sensitivity and specificity of HRCT for this entity to 86.21% and 63.64% respectively. Thus, HRCT appears to be under acceptable sensitivity limits as per regards to scutum erosion. Rogha et al[8] reported HRCT sensitivity of 96.4% and specificity of 87.5% in diagnosing scutum erosion. In a study conducted by Rai et al[10] in 2014, HRCT could diagnose scutum erosion with 100% sensitivity and specificity. However, Keskin et al[21] in his study in 2010 showed sensitivity and specificity of 80% and 90.4% respectively for scutum erosion. p value of 1.000 was very insignificant. Hence, HRCT was an excellent investigation for diagnosing erosion of scutum pre-operatively. After the above discussion with reference to national and international studies, it is our impression that HRCT has a role in evaluation of cases of squamous COM but must be interpreted with caution in view of its certain limitations. Both axial and coronal sections should be done as important structures are best seen after evaluating them in both the planes. This HRCT analysis and surgical correlation has shown that sensitivity, specificity and positive predictive value of HRCT scans depend on the anatomical structure implicated in squamous COM damage. Hence HRCT is valuable in diagnosing and in guiding the surgical management of squamous COM and its use by otologist is to be encouraged, especially in patients who are suspected of having complex problems and in whom maximum information is desirable, as an adjunct to better pre-operative assessment and better surgical outcome, thus reducing disease morbidity. Limitations of HRCT should be considered and improved by newer radiological modalities. In short, we can say that HRCT serves as a road map to assist the surgeon during surgery.

CONCLUSION : In this prospective study which included 40 patients attending a tertiary care centre and presenting with clinical picture of squamous COM, the following conclusions were made:

1. The most common age group to be affected by squamous COM is 11-20 years group.

2. Squamous COM affected females more than males, the male to female ratio being 1:1.2.
3. The most common presenting symptom for this disease was ear discharge seen in 97.5% patients.
4. The sensitivity, specificity and positive predictive value of HRCT scans depend on the anatomical structure implicated in squamous COM damage.
5. HRCT Temporal Bone is an excellent modality for diagnosing scutum erosion, which is the earliest as well as a confirmatory sign for the presence of an attic cholesteatoma.
6. It is a good pre-operative diagnostic modality for indentifying the presence of soft tissue in the middle ear cleft, malleus, incus and stapes necrosis, for diagnosing erosion of the tegmen and the presence of a fistula in the lateral semicircular canal.
7. HRCT Temporal Bone could not diagnose, with adequate accuracy, the presence of erosion of the bony external auditory canal.
8. Facial nerve dehiscence was very poorly evaluated by HRCT Temporal Bone, making it a very unreliable imaging modality for diagnosing the same.

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