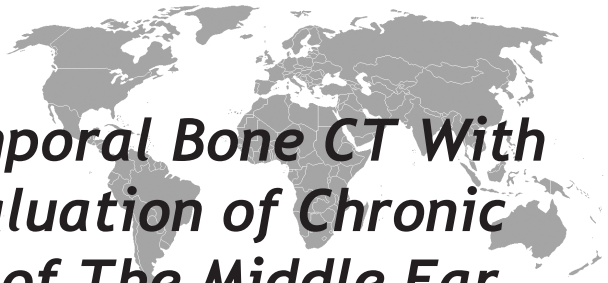

The Correlation of Temporal Bone CT With Surgery Findings in Evaluation of Chronic Inflammatory Diseases of The Middle Ear

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ABSTRACT

Aim: *Computerized tomography (CT) examination of temporal bone is a routine procedure in the diseases of the middle ear. The aim of this study is to establish the efficacy of CT in the diagnosis of the complications due to inflammatory pathologies of middle ear.*

Method: *Patients with suspected middle ear pathology were undergone temporal CT examination between August 2006- June 2008. 56 patients who underwent operation with various complications due to chronic otitis media and choleostatoma were included in the study group. Complications that developed chronic inflammation secondary were established as tympanosclerosis, ossicle erosion, scutum erosion, tegmen erosion, irregularity in mastoid bone cortex and contour of facial nerve, semicircular canal defect and chronic mastoiditis.*

Result: *Sensitivity, specificty, positive and negative predictive value of complications were 84.6%, 88.3%, 68.7% and 95% for timpanosclerosis, 80%, 46.1%, 83.3% and 42% for ossicle erosion, 80%, 90.4%, 84.8% and 73.7% for scutum erosion, 0%, 97.7%, 0% and 80% for tegmen erosion, 40%, 97.8%, 80% and 88.2% for irregularity in mastoid bone cortex, 66.6%, 98%, 80% and 96.07% for irregularity in bone contour of facial nerve, 45.4%, 95.5%, 71.4% and 87.7% for SSC defect, 0.02%, 100%, 100% and 27.2% for chronic mastoiditis.*

Conclusion: *In the evaluation of the complications, surgical findings were highly compatible with tympanosclerosis, ossicle erosion, scutum erosion, irregularity in bone contour of facial nerve. However, CT findings were inconsistent with surgical findings in terms of tegmen erosion, irregularity in mastoid bone cortex, chronic mastoiditis, SSC defects. We suggest that these inconsistencies were related to the surgical technique and CT limitations.*

Key words: *Computerized tomography, timpanosclerosis, scutum, choleostatom.*

Kronik İnflamatuar Orta Kulak Hastalıklarının Değerlendirilmesinde Temporal Kemik BT İle Cerrahi Bulguların Korelasyonu

Amaç: *Orta kulak hastalıklarında temporal kemiğin bilgisayarlı tomografi (BT) incelemesi rutin bir yöntemdir. Bu çalışma orta kulağın inflamatuar patolojilerine bağlı olarak gelişen komplikasyonların tanısında BT'nin etkinliğini ortaya koymak amacıyla yapılmıştır.*

Metod: *Birimimizde Ağustos 2006-Haziran 2008 tarihleri arasında orta kulak patolojisi düşünülen hastalara temporal BT incelemesi yapıldı. Kronik otitis media (KOM) ve kolesteatoma bağlı gelişen değişik komplikasyonlar saptanarak cerrahi uygulanan 56 hasta çalışma grubuna dahil edildi. Çekimler Siemens Emotion Duo spiral BT cihazı ile koronal planda 1 mm kesit kalınlığında yapıldı. Tanıya katkısı olacağı düşünülen olgularda aksial planda reformat görüntüler elde edildi. Görüntüler iki radyolog tarafından aynı anda değerlendirildi. Kronik inflamasyona sekonder gelişen komplikasyonlardan timpanoskleroz, kemikçik erozyonu, skutum erozyonu, tegmen erozyonu, mastoid kemik korteks düzensizliği, fasial sinir kemik kontur düzensizliği, semisirküler kanal (SSK) defekti ve kronik mastoidit BT ile değerlendirilerek sonuçlar cerrahi bulgularıyla karşılaştırıldı ve BT'nin etkinliği ortaya konulmaya çalışıldı.*

Bulgular: *Komplikasyonların sensitivite, spesifite, (+) ve (-) prediktif değeri timpanoskleroz için %84.6, %88.3, %68.7 ve %95, kemikçik erozyonu için %81.3, %46.1, % 83.3 ve % 42.8, skutum erozyonu için %80, %90.4, % 84.8 ve % 73.7, tegmen erozyonu için %0, %97.7, % 0 ve %80, mastoid kemik korteks düzensizliği için %40, %97.8, % 80 ve % 88.2, fasial sinir kemik kontur düzensizliği için %66.6 %98, % 80 ve %96.07, SSK defekti için %45.4, %95.5, %71.4 ve %87.7, kronik mastoidit için %0.02, %100, %100 ve %27.2 olarak bulundu.*

Sonuç: *Komplikasyonların değerlendirilmesinde timpanoskleroz, kemikçik erozyonu, skutum erozyonu ve fasial sinir kemik kontur düzensizliği ile cerrahi bulguları arasında yüksek korelasyon varken tegmen erozyonu, mastoid kemik korteks düzensizliği, kronik mastoidit ve SSK defekti ile cerrahi arasındaki korelasyon cerrahi tekniğine ve BT limitasyonlarına bağlı olarak düşük bulundu.*

Anahtar kelimeler: *Bilgisayarlı tomografi, timpanosikleroz, skutum, kolestatom*

INTRODUCTION

Temporal bone is a complex structure which contains organs for hearing and balance. Large vessels and nerves pass through temporal bone. Because of its complex anatomic structure and functional properties temporal bone is one of the most challenging organs for radiologists to detect diagnostic findings (1,2). It is obligatory to have a good knowledge of its anatomy and functions in order to accomplish optimal radiological evaluation. Computed tomography (CT) has gained an important role in diagnosis and treatment of temporal bone disorders (3-6). With the help of CT it is possible to acquire multiple slices and understand the complex relationships of anatomic structures. A CT with a spatial resolution below 1 mm, ≤ 2 mm slice thickness, wide window, having bone – detail reconstruction program, target reconstruction and high quality image reconstruction programs is very efficient in evaluation of inflammatory middle ear pathologies (7-14). This study aims to show the efficacy of CT in diagnosing the complications secondary to inflammatory disorders of middle ear.

MATERIALS AND METHODS

We retrospectively analyzed the temporal bone CT examinations performed between August 2006 and June 2008. We included 56 patients who had undergone surgery for the complications secondary to chronic otitis media and cholesteatoma. Hence, the study included 112 temporal bones. This study was approved by the institutional review board.

All examinations were performed with a two slice spiral computed tomography (Siemens Somatom Emotion Duo, Erlangen, Germany) with the following parameters: 1 mm slice thickness, 150 mAs, 120 kV, examination time 35 secs, with high resolution reconstruction algorithm of 512x512 matrix. All examinations were performed with the patient lying in prone position with the head in neutral position. Coronal sections were gained with a 30 degrees gantry angle to the anthropological basis line. The first slice was adjusted to pass through just posterior to the external aqustic canal. In this slice posterior semicircular canal (SCC) is included in the section.

Axial reformatted images were added when needed. Each temporal bone on either side of each patient evaluated separately. For every and each temporal bone external tympanic cavity and its walls, middle ear cavity and structures within it, internal ear structures, course of the facial nerve, canals of the internal ear, carotid canal, jugular fossa, sigmoid sinus and mastoid air cells were evaluated. Presence or absence of tympanosclerosis, bony erosions, scutum erosion, contour irregularity of mastoid bones, contour irregularity of facial nerve canals, SSC defect and chronic mastoiditis as complica-

***Table 1**. Total number and frequencies of the complications detected by CT examination*

Complication	*n*	*%*
Tympanosclerosis	*13*	*23,2*
Ossicular erosion	*43*	*77,7*
Scutum erosion	*35*	*62,5*
Tegmen erosion	*11*	*19,6*
Mastoid bony cortex irregularity	*10*	*17,8*
Facial canal bony irregularity	*6*	*10,7*
SSC defect	*11*	*19,6*
Chronic mastoiditis	*41*	*73,2*

tions were noted for each and every temporal bones. All images were evaluated by two radiologists in consensus at the same session. All patients who were diagnosed to have complications were operated within a range of 3 to 30 days. All patients were operated by two ENT specialists.

Statistical evaluations were performed by SPSS 16.0 software package (Statistical Package for Social Sciences). Sensitivity, specificity, positive and negative predictive values of CT to detect each complication were calculated compared to the surgical findings.

RESULTS

Between August 2006 and June 2008 a total of 56 patients, thus 112 temporal bones suspected to have complications secondary to middle ear pathologies were undergone temporal bone CT examinations. The patient population included 25 males and 31 females with a mean age of 44.8 years (range 12 to 73). The frequencies of detected complications by CT examination were summarized in Table 1 and sensitivity, specificity, positive and negative predictive values for each complication are presented in Table 2. Thirteen patients were diagnosed to have tympanosclerosis in CT. Eleven of them were confirmed in surgery, but 2 of them were free of tympanosclerosis in surgery. In 38 patients there were no tympanosclerosis in either CT or surgery.

Forty-three patients had ossicular erosions on CT. 35 of them were confirmed in surgery. In 6 patients there were no ossicular erosions in either CT or surgery. In 8 patients ossicular erosions were detected in CT but there were no ossicular erosions in surgery. In contrast, in 7 patients without ossicular erosions in CT there were ossicular erosions in surgery.

Scutum erosion was detected in 35 patients in CT. There was scutum erosion in surgery in 28 of them. However in 7 of them there was no scutum erosion in surgery. In 19 patients there was no scutum erosion in either CT or surgery. In 2 patients there were scutum erosions in surgery but not in CT. None of the 11 patients who were diagnosed to have tegmen erosion in CT did show tegmen erosion in surgery. In 44 patients there was no tegmen erosion in either surgery or CT. There was a single case that had tegmen erosion in surgery but it was not detected in CT.

There were corticular irregularities in mastoid bone in 10 patients in CT. In 4 of them it was also present in surgery. There were no cortical irregularities in either CT or surgery in 45 patients. In 6 patients there were cortical irregularities in mastoid bones in CT but they were normal in surgery. In 1 patient there was cortical irregularity in the mastoid bone in surgery but it wasn't detected in CT. Six patients had facial nerve canal contour irregularities in CT. 4 of them also had facial canal irregularities in surgery. In 2 patients facial nerve canal contour irregularities were detected in CT but there was no facial nerve canal contour irregularities in surgery.

***Table 2**. Sensitivity, specificity, positive predictive and negative predictive values of the complications (%).*

Complication	*Sensitivity*	*Spesificity*	*PPV*	*NPV*
Tympanosclerosis	*84,6*	*88,3*	*68,7*	*95*
Ossicular erosion	*81,3*	*46,1*	*83,3*	*42,8*
Scutum erosion	*80*	*90,4*	*84,8*	*73,7*
Tegmen erosion	*0*	*97,7*	*0*	*80*
Mastoid bony cortex irregularity	*40*	*97,8*	*80*	*88,2*
Facial canal bony irregularity	*66,6*	*98*	*80*	*96,07*
SSC defect	*45,4*	*95,5*	*71,4*	*87,7*
Chronic mastoiditis	*0,02*	*100*	*100*	*27,2*

***Figure 1**. Tympanosclerosis and calsified soft tissue*

***Figure 2**. Scutum and tegmen erosion, ossicular destruction*

In 49 patients there were no facial nerve canal contour irregularities in either surgery or CT. In 1 patient who reported not to have facial nerve canal contour irregularities in CT were found to have facial nerve canal contour irregularities in surgery. Eleven patients had SSC defect in CT. 5 of them were confirmed in surgery. In 6 patients there were SSC defect in CT but they were normal in surgery. There was no SSC defect in either CT or surgery in 43 patients. In 2 patients there was SSC defect in surgery but it wasn't detected in CT.

Chronic mastoiditis was diagnosed in 41 patients. One of them also had mastoiditis in surgery. There was chronic mastoiditis in 40 patients in CT but not in surgery. In 15 patients there was no chronic mastoiditis in either CT or surgery. In two patients there was chronic mastoiditis in surgery but not in CT.

DISCUSSION

CT is a standard examination technique in diagnosis and treatment of temporal bone diseases (3-6,15-17).

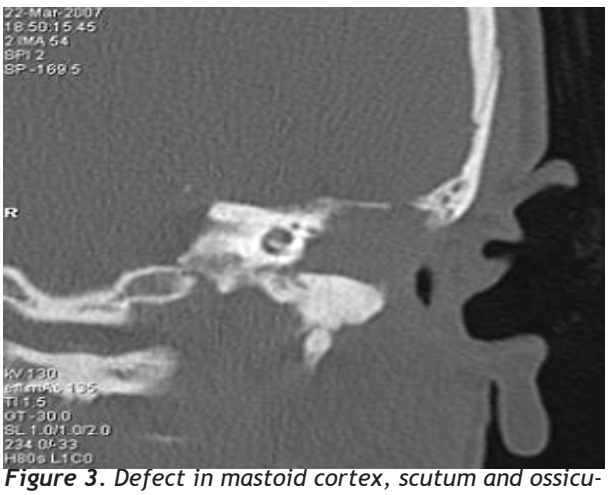

***Figure 3**. Defect in mastoid cortex, scutum and ossicular erosion and cholesteatoma*

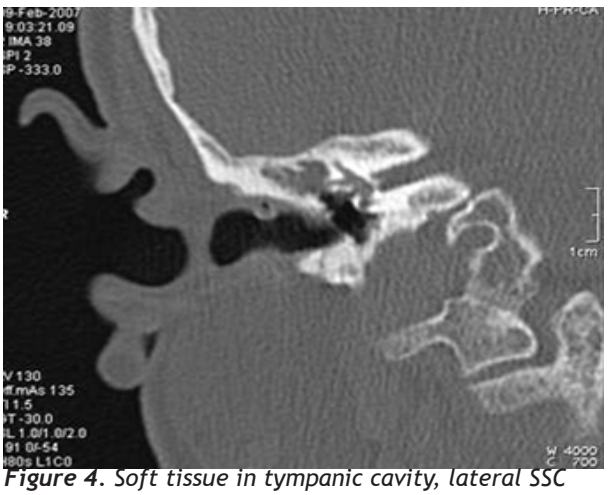

***Figure 4**. Soft tissue in tympanic cavity, lateral SSC defect and tube in the external auditory canal*

Slices in different planes can be obtained by CT and it is possible to understand the complex relationship of anatomical structures. Its capability of obtaining slices less than 1 mm and the development of specific examination techniques for restricted density regions increased the imaging rate of detailed examinations. With the advent of multislice CT after gaining axial 3D volumetric scanning coronal and sagittal reformatted slices can be obtained. By this technique total radiation dose can be decreased using 0.5 mm slice thickness. A CT with a submilimetric spatial resolution, slice thickness of 2 mm or less, wide window settings, bony detail reconstruction algorithm, having target reconstruction and high quality image reformatting programs is very efficient in evaluation of inflammatory middle ear pathologies (7-14).

The most important advantage of spiral CT in temporal bone imaging is its perfect visualization of the contrast between bony structures and the air in the middle ear. In addition to detailed evaluation of the bony structures it also permits assessment of soft tissue components as well 6,18.

CT has some limitations in evaluation of temporal bone. These are the neoplastic pathologies and cholesteatomas. For instance diagnosing cholesteatomas that fill whole of the middle ear cavity with CT is not reliable. In such cases contrast enhanced T1 weighted MR images give additional information (19-21). According to Kreastan et al CT and MRI has additive role in diagnosing acquired cholesteatomas and complications (22). In our study we especially found it difficult to define the presence of cholesteatomas that fill the middle ear cavity and cause bony erosions.

Swartz pointed out that in addition to the tympanic membrane tympanosclerosis may be related to the middle ear as well and it may affect the ossicles and the ligaments. With spiral CT he detected tympanosclerosis in 10 (3.3%) of 300 patients with chronic otitis media. According to Swartz foci of tympanosclerosis appear as punctate or lattice like masses with calcium density (23). In his study Dr. Eralp could not detect 2 tympanosclerosis cases with CT which were diagnosed clinically and surgically (24). In our study 11 of the 13 patients with tomographically diagnosed tympanosclerosis also found to have tympanosclerosis in surgery. In two patients there was no tympanosclerosis in surgery despite of tomographical diagnosis of tympanosclerosis. Also in five patients tympanosclerosis could not be detected by CT but they were detected in surgery. We suggest that the increased number of diagnosis as compared to previous studies may be due to the developments in CT technology.

According to Holliday and Swartz ossicular erosions may be seen in otitis media without cholesteatoma. They suggest that this may be due to production of collagenases by the inflammatory mucosa and ischemic bone necrosis 25, 26. Most investigators indicate that diagnosis of cholestetoma is established by bony erosions, ossicular deformations and the displacement of ossicles (27-29). In their study with 54 choleastoma patients Swartz et al found ossicular erosion in 50 % of patients in both CT and surgery (30). The most frequent complication in our series was ossicular erosion. There was ossicular erosion in 43 patients in CT and in 35 patients in surgery. There was ossicular erosion and soft tissue in their middle ear in 43 patients. They were diagnosed as COM in 13 (30%) of whom with cholestetoma and in 30 (70%) of them without cholesteatoma. In 8 patients although there were ossicular erosions in CT there was no erosion in the surgery. In 7 patients the ossicular erosions detected in surgery was undetectable in CT.

In their study Walshe and his colleagues found 4 ossicular erosions with CT and 9 (45%) ossicular erosions in surgery among 20 patients (31). Banerjee and his colleagues found 32 ossicular erosions in 39 patients with CT and 25 of them (64%) were confirmed with surgery (32). Mafee and his colleagues indicated that diagnostic compatibility of ossicular chain erosion with surgey is 94 % 29. Similarly, in our study we found this ratio to be 81.3 %.

In the study of Walshe et al. scutum erosion was present in 6 of the 20 patients in CT however in surgery scutum erosion was present in 7 patients (31). In our study 28 of the scutum erosions were confirmed in surgery among 35 patients diagnosed by CT. Sensitivity was 80%, specificity was 90.4 %, PPV was 84.8 % and NPV was 73.7%. We think the differences in the rates of diagnosis may be due to inappropriate angles of the coronal sections, partial volume effects of the soft tissues and form the false negative diagnosis.

There was one tegmen erosion in the 20 patients series of Walshe et al and this case was surgically confirmed 31. Jackler compared the spiral CT results of 42 COM patients with their surgical findings. In that study they found that in 4 of the 8 patients who were tomographi-

cally diagnosed to have tegmen erosion were confirmed by surgery, which reveals a false positive ratio of 50% (33). In our study there was no tegmen erosion in surgery in any of the 11 cases diagnosed as tegmen erosion in CT. No tegmen erosion was detected in either CT or surgery in 44 patients. There was a single case with tegmen erosion in surgery but it had not been detected by CT. Hence, sensitivity was 0%, specificity was 97.7 %, PPV was 0% and NPV was 80%. We suppose that the controversy between imaging and surgery may be because the partial volume of both the tympanic cavity's and the cerebral soft tissue may be overestimated as a defect on coronal sections which became thinned as a result of chronic inflammatory processes. Another reason may be that the surgical curettage could not reach the tegmen. Because excessive surgical curettage may result temporal bone damage.

In our study 4 of the 10 patients with tomographically diagnosed mastoid bone irregularities were confirmed to have mastoid bone irregularities in surgery. There were no mastoid bone irregularities in either CT or surgery. There was a single patient with mastoid bone irregularities in surgery but not in CT. Sensitivity was 40%, specificity was 97.8 %, PPV was 80% and NPV was 88.2%. The difference in surgery and CT in diagnosing mastoid bone irregularities may be because the curettage could not reach the localization of the defect.

In their study Fuse et al found that 29 of the 46 patients (63%), who had facial canal irregularities in CT also had the same finding in surgery (34). In our study in 4 of the 6 patients with facial canal irregularities in CT there were also canal irregularities in the surgery. In 49 patients there were no facial canal irregularities in either CT or surgery. In 1 patient we found no canal irregularities in CT but it was present in surgery. Because of the close relationship of an inflamed mastoid air cell with facial nerve or soft tissue limits CT in making correct diagnosis.

We detected otomastoidectomy in four subjects but they were not confirmed at the surgery. Otomastoidectomy (mural cholesteatoma) is diagnosed by history and CT findings and they usually come to the clinics with the complications secondary to cholesteatomas. CT has a role in detection of this entity in patients without a surgical history but a mastoidectomy like defect and other complications in CT.

Banerjee et al found 4 SCC defects among 39 patients but only one of these were surgically confirmed (32). Jackler et al. found 8 cases of SCC among 42 subjects in CT and 4 of them were surgically confirmed (33). In our study we found 11 cases with SCC in CT and 5 of them were surgically confirmed. In 2 patients there were SCC defects in surgery but they were not detected by CT. The difference in number between surgery and imaging may be because of the partial volume effects. Another reason may be the fact that surgery the SCC bony contour could have not been reached.

In our study, only one chronic mastoiditis case was surgically confirmed among the 41 cases that had chronic mastoiditis in CT. As a result we found a sensitivity of 0.02%, a specificity of 100%, a PPV of 100% and a NPV of 27.2%. Since findings of osteitis cannot be appreciated by the naked eye that such a low sensitivity rate may came out. Thus chronic mastoiditis can be diagnosed by CT. Also, pathological examination of the specimens from the mastoid bone extracted in surgery in this study group has shown findings of osteitis.

In conclusion, CT is an effective imaging modality in evaluation of complications secondary to inflammatory diseases of the middle ear. There was a high concurrence between CT and surgery in regards to tympanosclerosis, ossicular eroison, scutum erosion and facial canal irregularities. However there was a discrepancy in regards to tegmen eroison, mastoid bone cortical irregularities, SCC defets and chronic mastoiditis.

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