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A Comparative Study Of Pre-Operative Cone Beam Computed Tomography Findings Versus Intraoperative Surgical Findings Of Facial Canal Overhang In Otosclerosis

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ABSTRACT

Introduction: Otosclerosis is a common cause of adult conductive hearing loss, characterized by abnormal bone remodeling of the otic capsule, predominantly affecting the stapes footplate. Facial canal overhang is a critical anatomical variation that can complicate stapedotomy surgery, increasing the risk of facial nerve injury. Cone Beam Computed Tomography (CBCT) has emerged as a promising imaging modality for detailed preoperative evaluation of temporal bone anatomy. This study compares preoperative CBCT findings with intraoperative surgical findings in identifying facial nerve overhang in otosclerosis patients.

Materials & Methods: A prospective comparative study was conducted at Bharath Medical College Hospital & Research Institute, Chennai, involving 50 patients diagnosed with otosclerosis who underwent stapedotomy. All patients underwent preoperative CBCT imaging, followed by intraoperative assessment for facial nerve overhang. Data were analyzed using descriptive statistics, Chi-square tests, and Kappa statistics to determine agreement between CBCT and surgical findings.

Results: Facial nerve overhang was identified preoperatively in 6 patients (12%) on CBCT and was confirmed intraoperatively in all these cases, showing 100% agreement. The diagnostic performance of CBCT showed a sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of 100% each. This highlights CBCT's high reliability for preoperative assessment.

Conclusion: CBCT is an accurate and dependable imaging tool for detecting facial nerve overhang in otosclerosis surgery. Its use can aid surgeons in identifying anatomical variations, improving surgical planning, and reducing intraoperative complications.

Keywords: *Otosclerosis, Facial nerve overhang, Cone Beam Computed Tomography, Stapedotomy, Temporal bone imaging, Middle ear surgery.*

1. INTRODUCTION

Otosclerosis is a primary osteodystrophy of the otic capsule characterized by abnormal bone remodeling, most commonly affecting the stapes footplate, leading to conductive hearing loss (1). Globally, otosclerosis accounts for approximately 5-10% of all cases of adult conductive hearing loss and is the most common cause of surgically correctable hearing loss in adults (2). The disease has a prevalence of 0.3-0.4% in the general population but can be as high as 2% in certain ethnic groups (3). In developed countries, with access to advanced audiological screening and surgical interventions, the incidence has decreased, but it still poses a significant burden, especially in young to middle-aged adults, resulting in reduced quality of life, social withdrawal, and economic consequences due to hearing disability (4).

Surgical treatment through stapedotomy or stapedectomy offers favorable hearing outcomes and remains the cornerstone for managing otosclerosis-related conductive hearing loss (5). However, intraoperative challenges, such as anatomic variations, can significantly impact surgical success and postoperative recovery. Among these variations, facial canal overhang is a critical factor. The tympanic segment of the facial nerve, located above the oval window niche, may present as a protruding or dehiscent structure, obscuring the stapes footplate and increasing the risk of facial nerve injury during surgery (6).

Facial canal overhang can obstruct the surgeon's direct access to the oval window, necessitating additional surgical maneuvers like curettage of the posterior canal wall or tympanic segment of the facial canal. These maneuvers, though essential, may elevate the risk of facial nerve paresis or paralysis (7). Hence, preoperative identification of such variations is crucial for surgical planning and to minimize complications.

Cone Beam Computed Tomography (CBCT) has emerged as a valuable imaging modality in the preoperative evaluation of otologic conditions due to its ability to generate high-resolution images of the temporal bone with relatively low radiation exposure (8). CBCT provides detailed visualization of the bony labyrinth, ossicles, oval window, and adjacent neurovascular structures, including the facial canal (9). While High-Resolution CT (HRCT) has been widely used in otology, CBCT offers similar spatial resolution with improved patient safety regarding radiation dose (10). However, despite its advantages, discrepancies between radiological findings and intraoperative anatomy remain an ongoing concern.

Several studies have reported that preoperative imaging may underestimate or overestimate the degree of facial canal overhang, leading to potential misjudgement in surgical strategy (11). Inaccuracies in detecting subtle dehiscences or protrusions can result in unanticipated surgical difficulties. Therefore, establishing the correlation between preoperative CBCT findings and intraoperative observations is essential for refining imaging protocols and improving patient outcomes.

The objective of this study is to conduct a comparative evaluation of preoperative CBCT findings versus intraoperative surgical findings of facial canal overhang in patients undergoing surgery for otosclerosis. This study aims to assess the diagnostic accuracy of CBCT in predicting facial canal variations, which can influence surgical planning and intraoperative decision-making.

2. MATERIALS & METHODS

This study was designed as a prospective comparative study conducted Bharath Medical College Hospital & Research Institute, Chennai, Tamil Nadu, India. The research was carried out over 1 year after obtaining ethical and scientific committee approvals. The study included patients diagnosed with otosclerosis who were scheduled to undergo stapedotomy surgery. All patients were evaluated pre-operatively using cone beam computed tomography (CBCT) and intraoperatively for surgical findings.

Inclusion Criteria: 1) Patients with clinically and audiometrically confirmed otosclerosis. 2) Patients providing written informed consent for participation in the study.

Exclusion Criteria: 1) Patients with a history of middle ear surgery. 2) Patients with active ear infections or cholesteatoma. 3) Patients with congenital anomalies of the temporal bone. 4) Patients with contraindications to CT imaging.

Preoperative Assessment: All enrolled patients underwent a detailed clinical examination, including Pure tone audiometry, Tympanometry, High-frequency audiological evaluation.

Each patient then underwent CBCT imaging of the temporal bone using standardized protocols. The CBCT images were analyzed for the following parameters:

- Facial nerve canal overhang.

Surgical Procedure: All patients underwent standard stapedotomy under general anesthesia or local anesthesia (depending on patient and anesthesiologist preference) by an experienced otologic surgeon. During surgery, direct visualization of the facial nerve canal overhang, oval window niche, and footplate morphology was performed using an operating microscope. The intraoperative findings were carefully recorded in a standardized proforma.

Preoperative CBCT findings were compared to intraoperative findings, focusing on Presence or absence of facial nerve overhang.

A detailed study proforma was used to record patient demographics, CBCT findings, and surgical observations. The intraoperative data were independently assessed and compared to CBCT results.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version [insert version]. The statistical analysis included Descriptive statistics for baseline characteristics (age, gender). Chi-square test and Fisher's exact test for comparing categorical variables. Paired sample t-test for continuous variables where applicable. Kappa statistics to assess agreement between CBCT and surgical findings. A p-value of <0.05 was considered statistically significant.

The study was approved by the Institutional Ethics Committee and followed the ethical guidelines outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants before inclusion in the study.

3. RESULTS

A total of 50 patients diagnosed with otosclerosis were included in this study. The key findings regarding the facial nerve overhang as observed preoperatively on CBCT scans and intraoperatively during stapedotomy surgery are summarized below:

Table 1: Age Distribution

Age Group (Years)	Number of Patients (n)	Percentage (%)
21 – 30	7	14%
31 – 40	15	30%
41 – 50	12	24%
51 – 60	13	26%
61 – 70	3	6%
Total	50	100%

The study population predominantly consisted of patients in the 31 to 40 years age group, accounting for 30% of the total participants. The mean age of the patients was 43.58 years (SD ±11.91), reflecting that otosclerosis commonly affects individuals in the young to middle-aged group. A significant proportion of patients also fell into the 51 to 60 years (26%) and 41 to 50 years (24%) age brackets, while fewer patients were found at the extremes, with 14% between 21-30 years and 6% in the 61-70 years range.

Table 2: Gender Distribution

Gender	Number of Patients (n)	Percentage (%)
Male	26	52%
Female	24	48%
Total	50	100%

The gender distribution in this study showed a slight male predominance, with 52% of the patients being male and 48% being female. This finding is slightly different from most literature, where otosclerosis often shows a female preponderance, particularly during childbearing years due to hormonal influences. However, in this study cohort, the distribution was almost balanced between both genders

Table 3: Side Involved

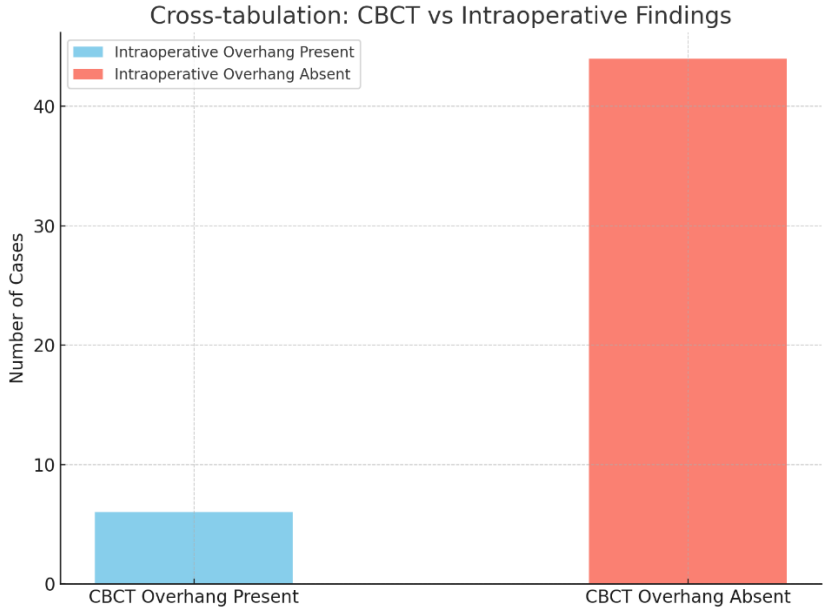
Side	Number of Patients (n)	Percentage (%)
Right	35	70%
Left	15	30%
Total	50	100%

Regarding laterality, the right ear was more commonly involved, with 70% of the cases showing right-sided otosclerosis, while the left ear was affected in 30% of the patients. This right-sided predominance in otosclerosis has been variably reported in studies, although the reasons for this asymmetry are not clearly understood.

Table 4 & Figure 1: Facial Nerve Overhang - CBCT vs Intraoperative Findings

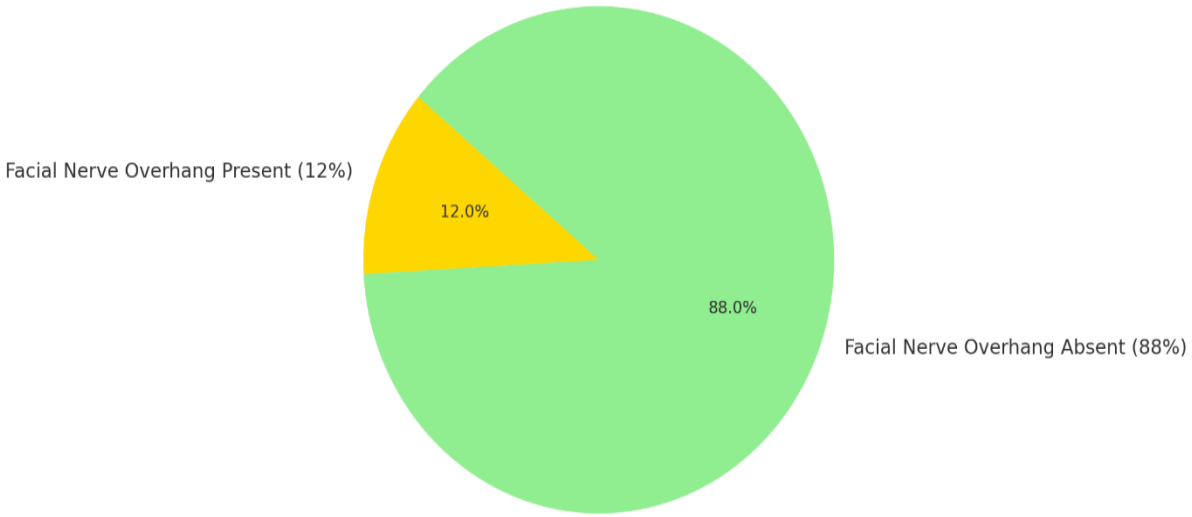
Pre-Operative CBCT	Intraoperative Finding Present	Intraoperative Finding Absent	Total
Overhang Present	6	0	6
Overhang Absent	0	44	44

Pre-Operative CBCT	Intraoperative Finding Present	Intraoperative Finding Absent	Total
Total	6	44	50



In this study, pre-operative CBCT identified facial nerve overhang in 6 out of 50 patients (12%). Intraoperative findings perfectly matched the imaging results, confirming the presence of overhang in the same 6 patients (12%). There were no false positives or false negatives observed. Among the remaining 44 patients (88%), neither CBCT nor surgery detected any overhang. This demonstrates a 100% agreement between CBCT imaging and intraoperative surgical findings, highlighting CBCT as a highly accurate tool for preoperative assessment of facial nerve overhang in otosclerosis surgery. This level of precision helps in anticipating surgical challenges and planning the surgical approach effectively.

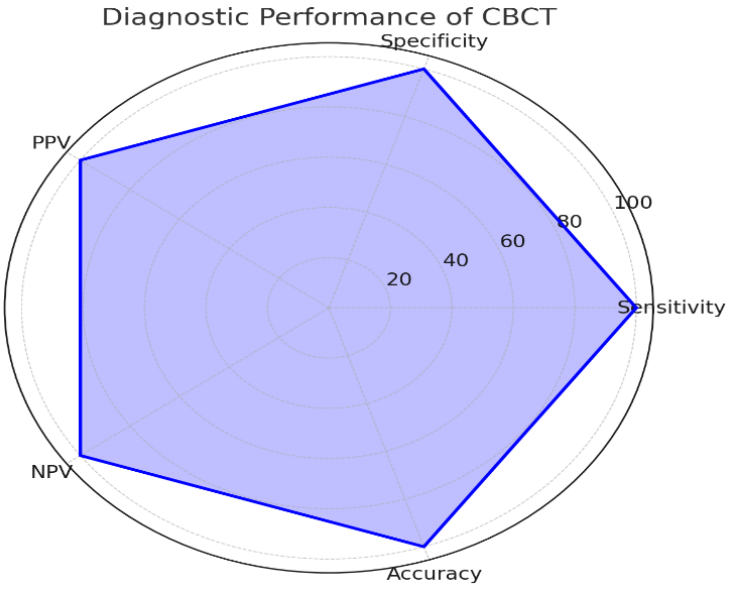
Figure 2: Incidence of Facial Nerve Overhang



Pie Chart showing the incidence of facial nerve overhang (12% present vs 88% absent).

Table 5 & Figure 3: Diagnostic Performance of CBCT

Parameter	Value (%)
Sensitivity	100
Specificity	100
Positive Predictive Value (PPV)	100
Negative Predictive Value (NPV)	100
Diagnostic Accuracy	100



The diagnostic performance of CBCT in detecting facial nerve overhang in this study was exceptional, with all performance metrics showing 100%. The sensitivity and specificity indicate that CBCT could accurately identify all true positive and true negative cases without any errors. Similarly, the positive predictive value (PPV) and negative predictive value (NPV) being 100% reflect that every CBCT finding of overhang was confirmed intraoperatively, and all normal CBCT results corresponded with normal surgical findings. The diagnostic accuracy of 100% further reinforces that CBCT is a highly reliable and precise tool for preoperative evaluation of facial nerve overhang in otosclerosis patients.

4. DISCUSSION

The present study aimed to compare the preoperative CBCT findings with intraoperative surgical findings in detecting facial nerve overhang in patients undergoing stapedotomy for otosclerosis. Our study demonstrated 100% sensitivity, specificity, PPV, NPV, and diagnostic accuracy of CBCT in identifying facial nerve overhang when compared to intraoperative findings. This suggests that CBCT is a highly reliable imaging modality for preoperative assessment of critical middle ear structures, specifically the tympanic segment of the facial nerve.

In our study, facial nerve overhang was detected in 12% of cases (6 out of 50 patients) on CBCT, which was confirmed intraoperatively. This finding aligns with the reported incidence range of facial canal overhang or dehiscence in otologic literature, which varies between 8% to 30%, depending on the population studied and imaging modality used (1,2).

Shin et al. (2012), in a similar study using high-resolution computed tomography (HRCT), found a sensitivity of 93.3% and specificity of 96.8% for detecting facial canal overhang preoperatively (3). Compared to their results, our CBCT-based study showed even higher diagnostic reliability, likely due to CBCT's superior spatial resolution and lower susceptibility to beam-hardening artifacts in the temporal bone region.

Another study by Moon et al. (2007) reported challenges in preoperative prediction of facial canal overhang using CT imaging, emphasizing that subtle protrusions or incomplete bony coverage of the facial canal can be difficult to assess accurately on HRCT (4). Our findings suggest that CBCT, due to its focused field-of-view and isotropic voxel acquisition,

may overcome some of the limitations associated with HRCT.

Furthermore, Vincent et al. (2006) in their large series of stapedotomies noted that unanticipated facial nerve overhang was one of the common intraoperative difficulties affecting surgical outcomes (5). Preoperative identification of such variations using CBCT can potentially reduce intraoperative surprises and the risk of facial nerve trauma.

The perfect agreement between CBCT and intraoperative findings in our study highlights the utility of CBCT not only for detecting facial nerve overhang but also for improving surgical preparedness. This could help in deciding the need for adjunctive techniques such as posterior canal wall curettage or facial canal decompression during stapes surgery.

Overall, our findings support the growing body of evidence suggesting that CBCT is a valuable addition to the otologic surgeon's preoperative assessment toolkit, especially in otosclerosis cases where detailed anatomical visualization of the middle ear is essential.

5. CONCLUSION

This study concludes that CBCT is a highly accurate and reliable tool for detecting facial nerve overhang in otosclerosis patients undergoing stapedotomy. With 100% diagnostic accuracy compared to intraoperative findings, CBCT effectively identifies critical anatomical variations, aiding in surgical planning and reducing intraoperative complications. Therefore, CBCT is recommended as a valuable preoperative imaging modality in otologic surgeries.

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