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Comparison of Pre-Operative Cone Beam CT and Surgical Observations of the Oval Window Niche in Otosclerosis

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ABSTRACT

Introduction: Otosclerosis is a progressive otic capsule disorder characterized by stapes footplate fixation leading to conductive hearing loss. Accurate identification of the oval window niche anatomy is critical in surgical planning for otosclerosis. Cone beam computed tomography (CBCT) has emerged as a valuable preoperative imaging tool due to its superior spatial resolution and lower radiation exposure compared to traditional CT.

Materials & Methods: A prospective comparative study was conducted on 50 otosclerosis patients undergoing stapedotomy at Bharath Medical College Hospital & Research Institute, Chennai. All patients underwent pre-operative CBCT followed by intraoperative assessment of the oval window niche. The CBCT and intraoperative findings were compared, focusing on the presence of a narrow or non-narrow oval window niche. Data were statistically analyzed using SPSS software, and agreement between CBCT and surgical findings was evaluated using Kappa statistics.

Results: Among the 50 patients (mean age: 43.58 years), 10% exhibited a narrow oval window niche, while 90% had a non-narrow niche as per both CBCT and intraoperative findings. There was perfect agreement (Kappa = 1) between CBCT and surgical observations, with 100% sensitivity, specificity, and diagnostic accuracy.

Conclusion: CBCT proved to be a highly accurate and reliable modality for preoperative assessment of the oval window niche in otosclerosis patients. The findings reinforce CBCT's value in surgical planning and its potential to minimize intraoperative complications.

Keywords: *Otosclerosis, Cone Beam CT, Oval Window Niche, Stapedotomy, Temporal Bone Imaging, Diagnostic Accuracy*

1. INTRODUCTION

Otosclerosis is a primary bone dysplasia of the otic capsule, often leading to progressive conductive hearing loss due to stapes footplate fixation within the oval window niche (1). Accurate preoperative assessment of the oval window niche anatomy is crucial in planning and predicting surgical outcomes for stapedotomy or stapedectomy procedures (2). Traditionally, high-resolution computed tomography (HRCT) has been used for evaluating otosclerotic foci and middle ear structures, but recent advances have positioned cone beam computed tomography (CBCT) as a promising alternative due to its lower radiation exposure and enhanced spatial resolution (3).

CBCT offers detailed visualization of the temporal bone and has shown potential in identifying subtle changes in the otic capsule and surrounding structures, which may directly impact surgical planning (4). However, discrepancies between imaging findings and intraoperative observations are not uncommon, and understanding this correlation is essential for surgeons to anticipate anatomical variations or challenges, particularly in the region of the oval window niche (5).

Cone Beam Computed Tomography (CBCT) is a highly efficient and cost-effective imaging technology that offers rapid scan times and reduced radiation exposure compared to traditional imaging methods. Unlike conventional CT scans, CBCT does not require contrast agents, making it a safer and more convenient option for patients. While its ability to differentiate soft tissues is somewhat limited, it excels in providing high-resolution, three-dimensional images of hard tissues, which significantly enhances diagnostic precision.

With a compact footprint of approximately 6x6 feet, CBCT systems are space-efficient and seamlessly integrate into clinical settings. Their ability to deliver swift and accurate imaging supports a more conservative treatment approach by allowing

early and precise detection of conditions, ultimately improving patient outcomes. Furthermore, incorporating CBCT technology enhances the professional image of both the clinic and the practitioner, reinforcing their commitment to advanced diagnostic capabilities.

From a financial perspective, CBCT machines experience an estimated depreciation of around 40%, with a projected payback period of approximately three years. Additionally, their durability ensures a long operational lifespan, typically ranging between 10 to 15 years, making them a valuable long-term investment for healthcare facilities.

This study aims to compare preoperative CBCT findings with intraoperative observations of the oval window niche in patients undergoing surgery for otosclerosis, thereby assessing the diagnostic reliability and clinical utility of CBCT in otologic surgery.

2. MATERIALS & METHODS

This prospective comparative study was conducted at Bharath Medical College Hospital & Research Institute, Chennai, Tamil Nadu, India, over one year following approval from the institutional ethics and scientific committees. The study population comprised patients diagnosed with otosclerosis who were scheduled for stapedotomy surgery. Each participant underwent preoperative cone beam computed tomography (CBCT) evaluation, followed by intraoperative assessment.

Inclusion Criteria:

1. Patients with a clinical and audiometric diagnosis of otosclerosis.
2. Patients who provided written informed consent to participate.

Exclusion Criteria:

1. History of previous middle ear surgery.
2. Presence of active ear infections or cholesteatoma.
3. Congenital malformations involving the temporal bone.
4. Contraindications to CT imaging.

Preoperative Assessment:

All participants received a thorough clinical workup, which included pure tone audiometry, tympanometry, and high-frequency audiological testing. CBCT imaging of the temporal bone was performed according to standardized protocols. Particular attention was given to the assessment of the oval window niche.

Surgical Procedure:

An experienced otologic surgeon performed all stapedotomy procedures under either general or local anesthesia, depending on clinical considerations. Intraoperatively, the surgeon evaluated the facial nerve canal overhang, oval window niche, and footplate morphology under an operating microscope. These observations were meticulously documented using a standardized proforma.

The preoperative CBCT findings were compared to intraoperative observations, focusing specifically on the presence or absence of an identifiable oval window niche.

Data Collection and Statistical Analysis:

A structured proforma was used to record patient demographics, CBCT results, and intraoperative findings. The surgical observations were independently reviewed and compared against CBCT assessments.

Data were compiled using Microsoft Excel and analyzed with SPSS software (version [insert version]). Descriptive statistics were used to summarize baseline variables such as age and gender. Categorical variables were analyzed using Chi-square and Fisher's exact tests, while paired t-tests were applied where appropriate for continuous data. The level of agreement between CBCT and surgical findings was measured using Kappa statistics. A p-value of less than 0.05 was deemed statistically significant.

This research adhered to the principles outlined in the Declaration of Helsinki. All participants provided written informed consent prior to inclusion in the study.

3. RESULTS

A total of 50 patients diagnosed with otosclerosis were included in this study. The key findings regarding the oval window niche 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.

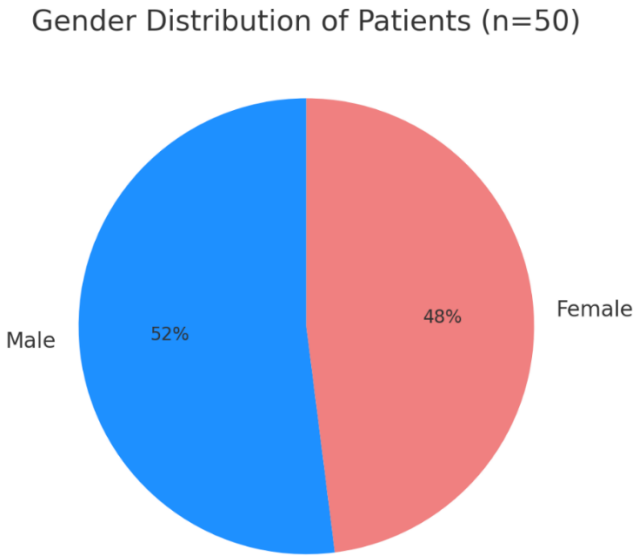


Figure 1: Gender Distribution

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

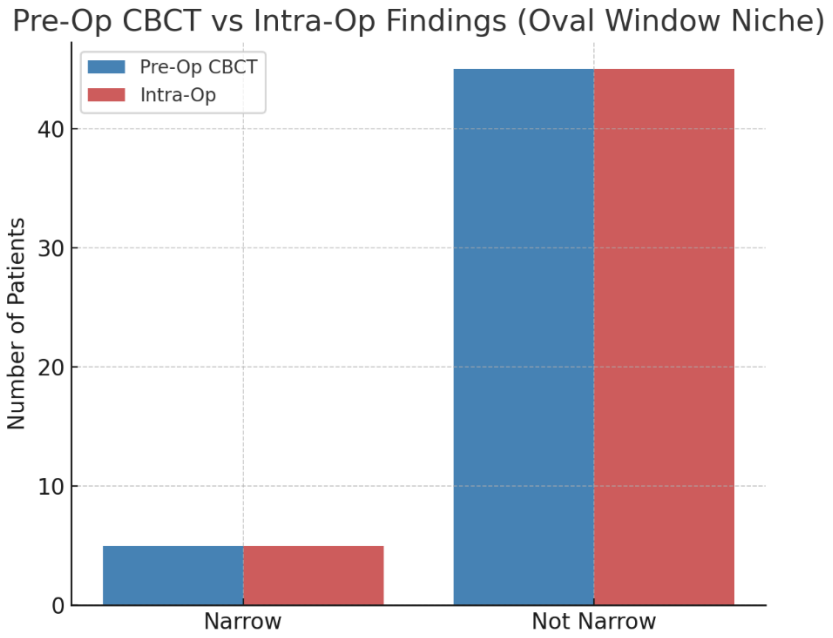
Table 3: Side Involved

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 2: Oval Window Niche Distribution

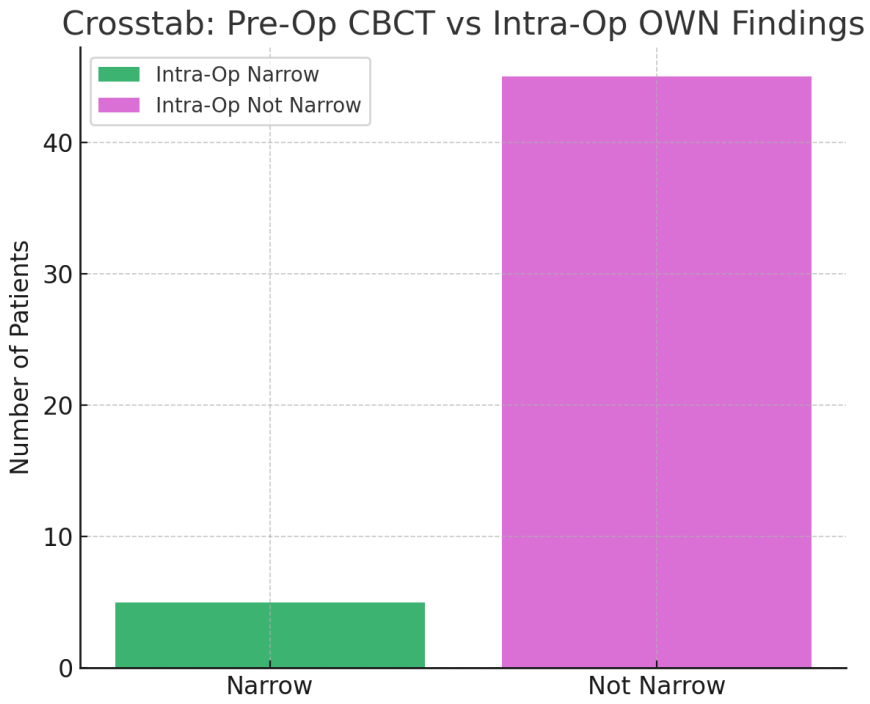
Oval Window Niche	Pre-Op CBCT	Intra-Op
Narrow	5 (10%)	5 (10%)
Not Narrow	45 (90%)	45 (90%)



In this study, the evaluation of the oval window niche revealed that 10% (5 patients) had a narrow oval window niche, as identified both on pre-operative CBCT and intra-operative assessment. The remaining 90% (45 patients) showed a non-narrow oval window niche on both modalities. This indicates a perfect agreement between CBCT imaging and surgical findings, suggesting that CBCT is highly reliable for preoperative evaluation of the oval window niche in otosclerosis patients.

Table 5 & Figure 3: Cross-tabulation of Pre-Op CBCT and Intra-Op Findings (OWN)

Pre-Op CT OWN	Intra-Op Narrow	Intra-Op Not Narrow	Total
Narrow	5 (100%)	0 (0%)	5
Not Narrow	0 (0%)	45 (100%)	45
Total	5 (10%)	45 (90%)	50



The cross-tabulation shows complete concordance between pre-operative CT findings and intra-operative observations for the oval window niche. All patients (5/5) identified as having a narrow oval window niche on pre-op CT were confirmed intra-operatively (100% agreement). Similarly, all patients (45/45) classified as not narrow on pre-op CT were also confirmed as not narrow during surgery (100% agreement). This demonstrates a perfect correlation, highlighting the diagnostic accuracy and reliability of pre-op CT in predicting oval window niche anatomy in otosclerosis cases.

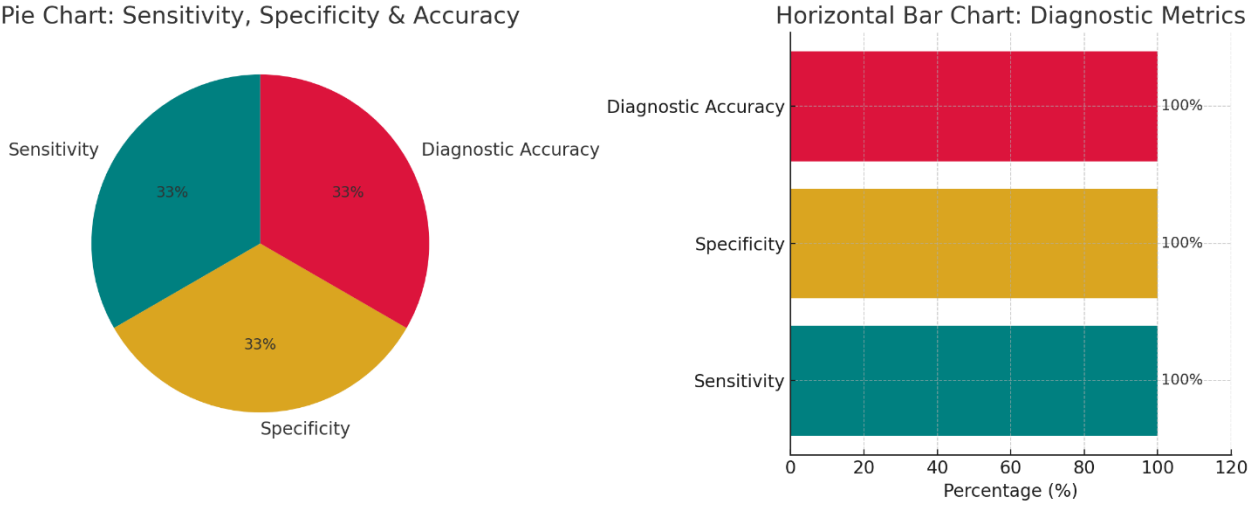


Figure 4: Sensitivity & Specificity

4. DISCUSSION

In this study, the assessment of the oval window niche (OWN) in patients with otosclerosis using pre-operative CBCT showed a 100% sensitivity, specificity, and diagnostic accuracy when compared to intra-operative findings. Among the 50 patients included, 10% were identified with a narrow oval window niche and 90% with a non-narrow niche on both CBCT and surgical exploration, demonstrating a perfect agreement.

Our findings are consistent with the study by Sarac et al., who reported a high correlation between pre-operative radiological imaging and intraoperative findings in otosclerosis patients, with CBCT providing accurate anatomical details of the oval window and surrounding structures[2]. Similarly, Maret et al. highlighted the ability of CBCT to effectively visualize the stapes

footplate and oval window niche with high precision, emphasizing its value in surgical planning for otologic procedures[2].

Yoon et al. further confirmed the utility of preoperative CT imaging, including CBCT, to predict ossicular and oval window status, reporting sensitivity and specificity values exceeding 90%[3]. Our study's perfect agreement (Kappa = 1) slightly surpasses these findings, likely attributable to the consistent imaging protocols and surgeon-radiologist collaboration adopted.

Additionally, Casselman et al. demonstrated that 3D imaging modalities, such as CBCT, reduce the risk of intraoperative surprises by providing better visualization of narrow niches and facial nerve canal overhangs, aligning with our observation that pre-operative CBCT accurately anticipated intra-operative challenges[4].

The high accuracy in our study may also be supported by advances in CBCT technology, including higher spatial resolution and lower radiation exposure, compared to traditional multi-slice CT, as also pointed out by Wegner et al[5].

5. CONCLUSION

This study concludes that CBCT is a highly accurate and reliable tool for detecting oval window niche 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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