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Correlation Between Pre-Operative Cone Beam CT and Intraoperative Findings of the Footplate Thickness in Otosclerosis

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KEYWORDS

Otosclerosis,

Cone Beam CT, Footplate Thickness, Stapedotomy, Temporal Bone Imaging,

Preoperative Assessment

ABSTRACT:

Introduction:

Otosclerosis is a progressive disorder of abnormal bone remodeling in the otic capsule, often resulting in stapes footplate fixation and conductive hearing loss. Accurate assessment of footplate morphology is essential for surgical planning, particularly to identify cases with thick or obliterated footplates. Cone Beam Computed Tomography (CBCT) has emerged as a promising imaging modality for detailed visualization of the temporal bone. This study aims to evaluate the correlation between pre-operative CBCT findings and intraoperative observations of footplate thickness in patients undergoing stapedotomy for otosclerosis.

Materials and Methods:

A prospective comparative study was conducted over one year at Bharath Medical College Hospital & Research Institute, Chennai, involving 60 patients diagnosed with otosclerosis. All participants underwent comprehensive clinical and audiological evaluation, followed by CBCT imaging of the temporal bone. During surgery, footplate morphology was assessed using an operating microscope and documented systematically. The pre-operative CBCT findings were then compared with intraoperative observations. Data were statistically analyzed using SPSS Version 26.0, employing chi-square test, Fisher's exact test, and kappa statistics, with a p-value of <0.05 considered significant.

Results:

CBCT identified thin footplates in 41 patients (68.3%), while intraoperative findings confirmed thin footplates in 43 patients (71.7%). Among the 41 CBCT-predicted thin footplates, 36 were confirmed intraoperatively, yielding a sensitivity of 83.7%, specificity of 70.6%, positive predictive value of 87.8%, negative predictive value of 63.2%, and an overall diagnostic accuracy of 80.0%. The correlation between CBCT and intraoperative findings was statistically significant ($p = 0.001$), indicating a strong agreement between modalities.

Conclusion:

CBCT demonstrates high diagnostic accuracy in predicting footplate thickness in otosclerosis and serves as a valuable tool for preoperative surgical planning. Its use can help anticipate anatomical variations, minimize intraoperative complications, and guide appropriate surgical technique selection.

Introduction

Otosclerosis is a progressive primary osteodystrophy of the otic capsule, characterized by abnormal bone remodeling in the temporal bone, often leading to fixation of the stapes footplate and subsequent conductive hearing loss [1]. The condition typically involves the fissula ante fenestram and may extend to involve the oval window and cochlear capsule in more advanced stages [2]. Clinically, patients present with slowly progressive hearing impairment, often in the second to fourth decades of life, and the diagnosis is confirmed through audiometry and radiologic imaging.

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Among the pathological changes in otosclerosis, thickening of the stapes footplate plays a critical role in determining the technical complexity and success rate of stapes surgery. A thickened or obliterated footplate is often associated with an increased risk of intraoperative complications such as footplate fracture, perilymph gusher, or incomplete fenestration, potentially compromising hearing outcomes [3,4]. Furthermore, the variability in footplate morphology—from thin and pliable to thick and sclerotic—has implications for the choice of surgical approach (e.g., stapedotomy vs. stapedectomy) and prosthesis selection [5]. Hence, preoperative assessment of footplate thickness is of great significance in surgical planning and patient counseling.

Traditionally, intraoperative evaluation during surgery has been the only reliable method to assess the thickness and consistency of the stapes footplate. However, with advancements in imaging, Cone Beam Computed Tomography (CBCT) has emerged as a valuable non-invasive tool for high-resolution visualization of bony structures in the temporal bone [6]. CBCT provides excellent spatial resolution with isotropic voxels and a lower radiation dose compared to conventional high-resolution computed tomography (HRCT), making it ideal for otologic imaging [7]. It allows detailed assessment of the stapes footplate, oval window niche, and surrounding anatomy, including the presence of facial nerve canal overhang, which may also affect surgical access [8].

Recent studies have suggested that CBCT can visualize subtle changes in footplate morphology, including thickening and obliteration, which are often predictive of intraoperative findings [9]. However, there remains a paucity of studies directly correlating CBCT-based measurements of stapes footplate thickness with intraoperative assessments during stapedotomy. Establishing such a correlation could enhance surgical preparedness, reduce intraoperative risks, and allow for more individualized treatment strategies in patients with otosclerosis.

Therefore, the present study aims to evaluate the correlation between preoperative CBCT findings and intraoperative observations of footplate thickness in patients undergoing surgery for otosclerosis. This investigation seeks to validate the utility of CBCT as a reliable diagnostic modality in the preoperative assessment of stapedial pathology, with a specific focus on footplate thickness and its implications for surgical outcomes.

Materials and Methods

The present study is designed as a prospective, comparative study conducted at Bharath Medical College Hospital & Research Institute, Chennai, Tamil Nadu, India. The research is carried out over one year, following approval from the Institutional Scientific and Ethics Committees. The study includes patients with a clinical and audiological diagnosis of otosclerosis who are scheduled to undergo stapedotomy surgery.

Inclusion Criteria

1. Patients with clinically and audiometrically confirmed otosclerosis.
2. Patients who provide written informed consent for participation.

Exclusion Criteria

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

Preoperative Evaluation

All eligible patients undergo a comprehensive preoperative assessment, including clinical otologic examination, pure tone audiometry, tympanometry, and high-frequency audiological testing. Subsequently, each patient undergoes Cone Beam Computed Tomography (CBCT) of the temporal bone using a standardized imaging protocol. The

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CBCT scans are reviewed to assess specific anatomical parameters, particularly to find the Footplate Thickness in Otosclerosis.

Surgical Procedure

All patients undergo standard stapedotomy under either general or local anesthesia, based on their medical status and the anesthesiologist's recommendation. A single experienced otologic surgeon performs all surgeries. Intraoperative evaluation is conducted using an operating microscope to visualize the stapes footplate morphology. Findings are documented in a predesigned, standardized surgical proforma.

Table 1: Types of Stapedial Otosclerosis

Type	Description	Clinical Features	Footplate Status
Histologic Otosclerosis	Microscopic foci in otic capsule without symptoms	Asymptomatic; incidental finding	Mobile
Fenestral (Clinical)	Lesion around oval window and stapes footplate	Conductive hearing loss; bilateral, gradual	Fixed
Cochlear Otosclerosis	Extension of lesion to cochlea (retrofenestral)	Sensorineural hearing loss	May or may not be fixed
Mixed Otosclerosis	Combination of fenestral and cochlear involvement	Mixed hearing loss (conductive + SNHL)	Partially or fully fixed
Obliterative Otosclerosis	Advanced disease; complete obliteration of oval window	Severe conductive or mixed hearing loss	Fully fixed and thickened

Data Collection and Comparison

This study adheres to the ethical principles outlined in the Declaration of Helsinki. All participants provide written informed consent prior to enrolment. Patient demographics, preoperative CBCT findings, and intraoperative observations are recorded in a structured study proforma. The primary focus of analysis is the correlation between CBCT and intraoperative findings, specifically regarding the stapes footplate thickness morphology.

Statistical Analysis

Data are entered into Microsoft Excel and analysed using SPSS software Version 26.0. Descriptive statistics are used to summarize baseline characteristics, such as age and gender. Chi-square test and Fisher's exact test are applied to assess associations between categorical variables. Paired sample t-tests are used where applicable for continuous variables. Kappa statistics are employed to evaluate the level of agreement between CBCT and intraoperative findings. A p-value of <0.05 is considered statistically significant.

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Results

Table 2: Age Distribution Table (n = 60)

Age Group (Years)	Number of Patients	Percentage (%)
21–30	8	13.3%
31–40	18	30.0%
41–50	14	23.3%
51–60	16	26.7%
61–70	4	6.7%
Total	60	100%

In the present study, the age of patients ranged from 21 to 70 years, with a mean age of 43.58 years and a standard deviation of 11.91. The most commonly affected age group was 31–40 years, accounting for 30% of the total study population. This was followed by the 51–60 years group (26.7%) and 41–50 years group (23.3%). Younger patients aged 21–30 years constituted 13.3% of the cases, while only 6.7% were in the 61–70 years group. These findings are consistent with the known clinical pattern of otosclerosis, which typically manifests in the third to fifth decades of life, reflecting the peak age range for disease presentation.

Table 3: Gender distribution

Sex	Number of Patients	Percentage (%)
Male	31	51.7%
Female	29	48.3%
Total	**60**	**100%**

Among the 60 patients included in the study, 31 (51.7%) were male and 29 (48.3%) were female, showing a slight male predominance. While some previous studies report a female predominance in otosclerosis, the near-equal gender distribution in the current study suggests that both sexes are almost equally susceptible in this population. The minimal difference observed may be due to regional, genetic, or sampling variations. Regardless, the findings highlight that otosclerosis is not gender-exclusive and requires a uniform diagnostic approach across both sexes.

Table 4: Distribution of Footplate Thickness Based on CBCT and Intraoperative Findings (n = 60)

Assessment Method	Thin Footplate	Not Thin Footplate
Pre-operative CBCT	41 (68.3%)	19 (31.7%)
Intraoperative Findings	43 (71.7%)	17 (28.3%)

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In this study, 60 patients diagnosed with otosclerosis and undergoing stapedotomy were assessed to evaluate the correlation between pre-operative Cone Beam CT (CBCT) findings and intraoperative footplate thickness. On pre-operative CBCT imaging, 41 patients (68.3%) were reported to have a thin footplate, and 19 patients (31.7%) were reported as not thin.

Intraoperative assessment confirmed 43 patients (71.7%) had a thin footplate, while 17 patients (28.3%) had a not thin footplate.

Table 5: Pre-Operative CBCT and Intraoperative Footplate Thickness (n = 60)

CBCT Finding	Intraoperative: Thin	Intraoperative: Not Thin	Total	P value
Thin	36 (60.0%)	5 (8.3%)	41 (68.3%)	0.001
Not Thin	7 (11.7%)	12 (20.0%)	19 (31.7%)	
Total	43 (71.7%)	17 (28.3%)	60 (100.0%)	

The comparison between pre-operative CBCT findings and intraoperative footplate thickness in 60 patients revealed a strong correlation. Among the 41 patients identified as having a thin footplate on CBCT, 36 (60.0%) were confirmed intraoperatively, while 5 (8.3%) had a not thin footplate. Of the 19 patients assessed as not thin on CBCT, 7 (11.7%) were intraoperatively thin, and 12 (20.0%) were correctly identified. The observed correlation was statistically significant, with a p-value of 0.001, indicating that CBCT is a reliable preoperative tool for predicting footplate morphology in patients with otosclerosis.

Table 6: Diagnostic Performance of CBCT

Parameter	Value
Sensitivity	83.7%
Specificity	70.6%
Positive Predictive Value (PPV)	87.8%
Negative Predictive Value (NPV)	63.2%
Overall Diagnostic Accuracy	80.0%

The diagnostic performance of pre-operative Cone Beam CT (CBCT) in predicting intraoperative footplate thickness demonstrated high accuracy. The sensitivity of 83.7% indicates CBCT effectively identifies patients with thin footplates, while a specificity of 70.6% shows reasonable ability to detect those without thin footplates. The positive predictive value (PPV) was 87.8%, reflecting a high probability that a thin footplate on CBCT corresponds to intraoperative confirmation. The negative predictive value (NPV) was 63.2%, suggesting moderate reliability in ruling out thin footplates. Overall, the diagnostic accuracy of 80.0% supports the use of CBCT as a dependable preoperative imaging modality for evaluating footplate morphology in otosclerosis.

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Discussion

The present study assessed the diagnostic value of Cone Beam Computed Tomography (CBCT) in evaluating footplate thickness preoperatively and comparing it with intraoperative findings in patients undergoing stapedotomy for otosclerosis. In our study of 60 patients, CBCT detected thin footplates in 68.3% of cases, while intraoperative confirmation was noted in 71.7% of cases. The sensitivity, specificity, PPV, NPV, and overall accuracy of CBCT for detecting thin footplate were 83.7%, 70.6%, 87.8%, 63.2%, and 80.0%, respectively.

Our findings align with those of Ajitha K et al., who reported similar diagnostic values—sensitivity of 83.3%, specificity of 71.4%, and accuracy of 80%—in their prospective study of 50 patients with otosclerosis. This reinforces the clinical reliability of CBCT as a preoperative tool in assessing temporal bone anatomy and planning surgery accordingly.

Casselman et al. demonstrated that CBCT provides superior spatial resolution in the evaluation of middle and inner ear structures, including the stapes footplate, with lower radiation exposure compared to multi-slice CT. Their work emphasizes CBCT's value in detailed morphological assessment, which supports its use in preoperative planning for otosclerosis surgery.

Similarly, Wegner et al. conducted a comparative study between high-resolution CT (HRCT) and CBCT and concluded that CBCT was not only effective in identifying otosclerotic foci but also more sensitive in detecting changes such as footplate thickening and obliteration. They suggested that CBCT offers higher diagnostic confidence when assessing subtle bone abnormalities associated with otosclerosis.

Rudic et al., in a review of imaging modalities in otosclerosis, also highlighted the importance of preoperative imaging for identifying surgical risks, including thickened footplates and facial nerve overhang. They advocated the routine use of advanced imaging like CBCT in complex otologic surgeries to minimize intraoperative surprises and improve patient safety.

Furthermore, our study's PPV of 87.8% and accuracy of 80% suggest that CBCT is a reliable predictor of intraoperative footplate status, particularly in identifying thin footplates. The relatively lower NPV (63.2%) indicates some limitations in excluding thick footplates based on CBCT alone, likely due to overlapping radiodensities or limitations in interpreting borderline cases.

Overall, the findings from our study and corroborating evidence from the literature underscore the clinical utility of CBCT in otosclerosis. It provides surgeons with crucial anatomical insights, reduces intraoperative complications, and helps tailor surgical techniques, especially in cases where abnormal footplate morphology is suspected.

Limitations

However, the study has certain limitations. It was conducted at a single tertiary care centre, which may affect the generalizability of the results. Interpretation of CBCT findings may vary depending on radiological expertise, and the relatively modest sample size could be expanded in future studies. Additionally, CBCT may have limited ability to differentiate borderline cases of footplate thickening, impacting its negative predictive value. The study also did not evaluate the correlation between footplate morphology and postoperative hearing outcomes, which could offer further clinical insights. Despite these limitations, the findings support the integration of CBCT into routine preoperative evaluation for otosclerosis surgery.

Conclusion

This prospective study demonstrates that Cone Beam Computed Tomography (CBCT) is a reliable and effective imaging modality for the preoperative evaluation of footplate thickness in patients with otosclerosis. With high sensitivity (83.7%), specificity (70.6%), and overall diagnostic accuracy (80%), CBCT findings showed a statistically significant correlation with intraoperative surgical

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observations. These findings highlight CBCT's utility in surgical planning, particularly in anticipating anatomical variations such as a thick or obliterated footplate, which can influence operative strategy and reduce intraoperative complications. The high positive predictive value (87.8%) further reinforces its role in confirming cases with thin footplates, thus assisting in improving surgical outcomes.

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