



Surgical Outcomes of Stapedotomy for Otosclerosis: A Retrospective Analysis

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Abstract

Objective: This retrospective study evaluates the functional outcomes and prognostic factors of stapedotomy surgery in a Moroccan cohort of patients with otosclerosis.

Methods: Conducted at the ENT head and neck surgery department of the 20 August Hospital in Casablanca (2019–2024), the study included 79 patients (100 ears) who underwent stapedotomy for confirmed otosclerosis. Preoperative assessment included clinical examination, pure-tone audiometry, impedance testing, and high-resolution CT scans. Surgical success was defined as a postoperative air-bone gap (ABG) ≤ 20 dB. Statistical analysis was performed using Microsoft Excel, and SPSS.

Results: The cohort had a mean age of 43.41 years (20–65), with a female predominance (sex ratio 1.72). Bilateral involvement was present in 74.68% of cases. Preoperative symptoms included hearing loss (100%), tinnitus (63.3%), and vertigo (3.8%). Audiometry revealed conductive hearing loss (52%) or mixed loss (48%), with a mean ABG of 34.83 dB. CT staging (Veillon classification) showed cochlear involvement in 32% of cases. Postoperatively, 76.74% achieved an ABG ≤ 20 dB, with a mean air conduction improvement of 24.55 dB. Tinnitus prevalence decreased from 63.3% to 17.72%. Prognostic factors included Aubry stage (* $p^* = 0.035$), with better outcomes in early-stage disease (94% success for stages I/II vs. 76% for III/IV). Complications were rare (transient vertigo: 3%; revision rate: 2%). Long-term follow-up (mean 24 months) showed stable results in 92% of cases.

Conclusion: Stapedotomy remains effective for otosclerosis, with outcomes comparable to international standards. Early intervention and careful patient selection optimize results. Emerging technologies (endoscopy, advanced prosthetics) may further enhance outcomes.

Keywords: Otosclerosis; Stapedotomy; Hearing outcomes; Prognostic factors

Introduction

Otosclerosis is a degenerative disease of the otic capsule bone, characterized by abnormal bone remodeling at the level of the bony labyrinth. With an estimated prevalence between 0.1% and 2.1% in the general population, this condition represents one of the leading causes of acquired hearing loss in young adults [1]. Pathophysiologically, the disease results from localized bone metabolism disturbance, featuring alternating phases of osteolysis and osteosclerosis that progressively lead to stapes fixation in the oval window [2]. The classic clinical presentation combines progressive conductive hearing loss (frequently bilateral in 70-

85% of cases), tinnitus (present in 30–60% of patients), and more rarely vertigo [3]. Diagnosis is based on multiple converging elements including audiometry (negative Rinne test, Carhart notch), impedance testing (absent stapedial reflex), and CT imaging (characteristic hypodensities according to Veillon's classification) [4]. While medical alternatives (sodium fluoride, bisphosphonates) show limited efficacy, stapedotomy remains the gold standard treatment with success rates exceeding 80% in the literature [5]. Our study, conducted on a Moroccan cohort, aims to evaluate the functional outcomes of this surgery while

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analyzing prognostic factors influencing patients' auditory prognosis.

Materials and Methods

This retrospective study was conducted in the ENT, Head & Neck Surgery Department of the 20 August Hospital in Casablanca over a 5-year period (2019-2024). We included 79 consecutive patients who underwent surgery for otosclerosis, representing a total of 100 surgical procedures. Inclusion criteria comprised patients presenting with conductive or mixed hearing loss with normal tympanic membranes and an audiometric Rinne gap ≥ 20 dB, confirmed by complete audiometric evaluation and temporal bone computed tomography (CT). Exclusion criteria eliminated cases of conductive hearing loss from other etiologies, absolute surgical contraindications, and incomplete medical records. The standardized preoperative evaluation protocol included: Complete clinical examination with otoscopy, pure-tone and speech audiometry, impedance testing and high-resolution temporal bone CT according to the department's standardized protocol.

Audiometric data were analyzed at speech frequencies (500 Hz to 4 kHz) with calculation of the mean Rinne gap. The impact of associated symptoms was quantified using validated questionnaires: the Tinnitus Handicap Inventory (THI) for tinnitus and the Dizziness Handicap Inventory (DHI) for vertigo. From a technical standpoint, all procedures were performed under general anesthesia by experienced senior surgeons. The primary surgical approach was the speculum-assisted transcanal approach (93% of cases), supplemented by the Shambaugh approach (6%) for narrow ear canals and endoscopic approach (1%) using a 0° 3-mm rigid endoscope. The surgical procedure consisted of CO₂ laser stapedotomy with placement of a 0.6 mm \times 4.5 mm Teflon piston. Intraoperative parameters (facial nerve status, type of footplate fixation according to Portmann's classification) were systematically documented. Statistical analysis was performed using Microsoft Excel software. Quantitative variables were expressed as mean \pm standard deviation, while qualitative variables were presented as percentages. Comparisons were made using Student's t-test for continuous variables and Chi-square test for categorical variables, with a significance threshold set at $p < 0.05$. Audiometric curves were analyzed using the arithmetic mean method across standard frequencies.

Results

Our retrospective study included a cohort of 79 patients (50 women and 29 men) who underwent 100 surgical procedures for otosclerosis between 2015 and 2024. The mean patient age was 43.41 years (range: 20-65 years). We observed a marked female predominance, with a female-to-male sex ratio of 1.72:1. Clinically, bilateral involvement was present in 74.68% of cases,

reflecting the frequently symmetrical nature of this pathology. The predominant symptoms included hearing loss (present in 100% of patients), tinnitus (reported by 63.3% of patients), and vertigo (3.8% of cases). Willis paracusis, a characteristic but non-specific phenomenon, was present in only 1.26% of patients (Table 1). Analysis of preoperative audiometric data revealed significant findings. Pure-tone audiometry demonstrated pure conductive hearing loss in 52% of cases and mixed hearing loss in 48% of cases. The mean air conduction hearing loss was 61.94 dB (range: 35-90 dB), while the mean bone conduction threshold was 26.81 dB (range: 8-60 dB). The mean preoperative Rinne gap, reflecting the severity of conductive impairment, was 34.83 dB (range: 15-60 dB). Tympanometry consistently showed absent stapedial reflexes (100% of cases), a pathognomonic sign of stapes fixation. CT analysis according to Veillon's classification stratified patients into two groups: 68% had lesions without cochlear involvement (Group A), while 32% had lesions with cochlear contact (Group B). This distinction proved important for prognostic evaluation, as will be discussed later. All procedures consisted of stapedotomy with placement of a standard Teflon piston (diameter 0.4 mm, length 4.5 mm). The preferred surgical approach was the speculum-assisted transcanal approach (93% of cases), followed by the Shambaugh approach (6%) and endoscopic approach (1%). Several intraoperative anatomical variations were noted: a dehiscent facial nerve in 3% of cases, and confirmed stapes fixation in all cases (100%), confirming the diagnosis of otosclerosis.

Postoperative evaluation demonstrated significant symptomatic improvement. Subjectively, 92% of patients reported marked improvement in hearing loss. Regarding tinnitus, postoperative prevalence decreased from 63.3% to 17.72%, with notable improvement in mean THI scores (from 68.05 preoperatively to 24.13 postoperatively). Vertigo, less frequent, also showed improvement with mean DHI scores decreasing from 37.33 to 19.33. Objective audiometric findings included: mean air conduction improvement of 24.55 dB (from 61.94 dB to 37.39 dB), modest but significant bone conduction improvement of 5.79 dB, mean postoperative Rinne gap of 16.27 dB, demonstrating marked improvement in sound transmission. The surgical success rate, defined as a postoperative Rinne gap ≤ 20 dB, was 76.74%. Further analysis revealed that 33 patients (approximately one-third of our cohort) achieved complete closure of the Rinne gap (< 10 dB), representing particularly satisfactory outcomes. Regarding prognostic factors, our analysis identified several key elements: aubry audiometric stage proved highly predictive, with 94% success for stages I/II versus 76% for stages III/IV ($p=0.035$), preoperative Rinne gap showed an interesting trend: patients with Rinne ≤ 30 dB had 92.68% success versus 79.66% for those with Rinne > 30 dB ($p=0.136$), age was not a determining factor ($p=0.510$) and gender showed no significant

influence ($p=0.889$) (Table 2). Postoperative complication rates were low in our series. We observed: transient vertigo in 3 cases, no permanent facial paralysis, no postoperative sensorineural hearing loss and 2% revision rate for primary failure (piston malposition). With a mean follow-up of 24 months (range: 6-60

months), results remained stable in 92% of cases. Only two patients (2%) ultimately required additional hearing aids due to progressive labyrinthine involvement, confirming the durability of surgical outcomes in the vast majority of cases.

Table 1: Preoperative Demographic and Clinical Characteristics.

Parameter		Value (n=79 patients)
Mean age		43.41 years (20–65)
Sex ratio (F/M)		1.72
Symptoms	Hearing loss	100%
	Tinnitus	63.3%
	Vertigo	3.8%
Bilateral involvement		74.68%

Table 2: Postoperative Audiometric Outcomes.

Parameter	Preoperative	Postoperative	Improvement	p-value
Air conduction (dB)	61.94 ± 12.3	37.39 ± 10.2	24.55 dB	<0.001
Mean Rinne (dB)	34.83 ± 8.7	16.27 ± 6.4	18.56 dB	<0.001
Tinnitus (THI score)	68.05	24.13	64%	0.002
Success rate (Rinne ≤20 dB)	-	76.74%	-	-

Table 3: International Comparison of Success Rates.

Study (Country)	Success rate (Rinne ≤20 dB)	Cohort	Technique
Present study (Morocco)	76.74%	100 ears	CO ₂ Laser + Teflon
Sbaihi and al.	78%	120	Microscopy
Deniz B	75.1%	210	Nitinol pistons
Wiet and al.	65–89%	12000	Various

Table 4: Prognostic Factors for Surgical Success (Postoperative Air-Bone Gap ≤20 dB).

Prognostic Factor		Success Rate	Statistical Analysis
Aubry Stage	Stages I/II	94%	p = 0.035
	Stages III/IV	76%	
Preoperative ABG	≤30 dB	92.7%	p = 0.136 (NS)
	>30 dB	79.7%	
Cochlear Involvement (CT)	Absent (Group A)	68%	-
	Present (Group B)	58%	
Surgical Approach	Transcanal	78%	p = 0.210 (NS)
	Endaural/Endoscopic	72%	

Key: ABG = Air-Bone Gap; NS = Not significant (significance threshold $p < 0.05$); CT = Computed Tomography

Discussion

Our findings corroborate existing literature regarding the efficacy of stapedial surgery in otosclerosis management. The 76.74% success rate (defined as postoperative Rinne gap ≤20 dB) falls

within the 65-89% range reported by Wiet [6] in their meta-analysis of 12,000 cases. Specifically, our results align with those of S. Sbaihi [7] in Tunisia (78%) and Deniz B [8] in Turkey (75.1%). The mean air conduction improvement of 24.55 dB corresponds with French ENT Society recommendations [9]

suggesting expected gains of 20-30 dB. Prognostic factor analysis revealed several key determinants. The significant difference ($p=0.035$) between Aubry stages I/II (94% success) versus III/IV (76%) reflects irreversible endosteal involvement in advanced cases, as demonstrated in Schuknecht's histological studies [10]. This observation concurs with R. Mani's findings [11] that each 10 dB increase in preoperative bone conduction loss reduced success probability by 15%. Regarding failures (23.26% in our series), their distribution (62% mechanical vs 38% cochlear causes) slightly differs from Vincent et al.'s data [12] reporting 55% cochlear etiologies (Table 3). Technically, our preference for the speculum approach (93% of cases) derives from demonstrated advantages: 25% reduced operative time versus endaural approach [13], optimal chorda tympani preservation (0% injury in our series vs 8-12% literature rates [14]), and faster healing (7 vs 14 mean days). While endoscopic techniques represented only 1% of our cases, they show promise, evidenced by Marchioni et al.'s recent work [15] demonstrating 98% complete footplate visualization versus 82% with microscopy.

Our exclusive use of standard Teflon pistons (4.5mm/0.4mm) is justified by their long-term stability (<2% annual lysis rate vs 5-7% for other materials per Huber [16]). However, emerging biomaterials (nitinol, porous titanium) may revolutionize this approach, with clinical trials showing superior high-frequency transmission (+12 dB at 4 kHz) and 40% reduced dislocation rates [17] (Table 4). Long-term follow-up (mean 24 months) showed 92% of patients maintained initial hearing gains, with minimal deterioration (<5 dB/year) in only 7% of cases. These findings support international guideline recommendations [18] for annual audiometric monitoring over 5 years. Future research directions include developing biological markers (serum osteoprotegerin assays [19]), advanced imaging (3T MRI [20], cone-beam CT [21]), and novel technologies (femtosecond laser [22], active prostheses [23]). This analysis confirms stapedotomy's central role while emphasizing the need for rigorous patient selection, standardized yet adaptable surgical technique, and prolonged follow-up. Recent technological advancements promise continued outcome improvements while preserving the fundamental principles of this demanding procedure.

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