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Restoration of Columellar Effect Using a Teflon Piston in Otosclerosis Surgery: Anatomo-Clinical, Endoscopic and Radiological Correlation in a Case Report

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Abstract

Objective: To describe the anatomical, iconographic, and functional aspects of a case of otosclerosis surgery optimized under unconventional video-endoscopic control. **Clinical Observation:** A 27-year-old male patient was admitted for progressive unilateral right-sided conductive hearing loss of 5 years' duration, in the context of a normal tympanic membrane. Preoperative audiometry revealed a significant air-bone gap at conversational frequencies with preserved cochlear reserve. Impedance audiometry showed a slight decrease in tympano-ossicular system compliance with an absent stapedial reflex. Preoperative computed tomography revealed a stapes footplate thickening of approximately 0.7 mm associated with hypodensity of the antefenestram fissula on the right. A stapedotomy was performed endoscopically. The postoperative course was uneventful, with mild vertigo and transient tinnitus in the first 24 hours. There was no dysgeusia or facial paralysis. A postoperative audiometric examination performed after three months noted the closure of the air-bone gap (Air-Bone Gap) of less than 10 dB. Computed tomography (CT) of the temporal bones performed after 6 months shows perfect radio-opacity of the implant.

Keywords

Otosclerosis, Endoscopy, Tapedotomy

1. Introduction

Otosclerosis is a primary osteodystrophy of the otic capsule, characterized by focal and abnormal bone remodeling at the level of the oval window [1]. This metabolic process progressively leads to stapedovestibular ankylosis, interrupting the mechanical transmission of sound waves to the labyrinthine fluids and clinically manifesting as conductive hearing loss with a normal tympanic membrane [1]. The standard curative treatment is based on surgical restoration of the columellar effect, most often by stapedotomy [2].

Surgical technique: Approach and elevation of the tympanomeatal flap: The procedure is preferably performed via a retroauricular, endaural (or strictly transcanal approach depending on the anatomy of the external auditory canal) approach [3]. An arcuate incision is made using a Rosen scalpel, from 12 o'clock to 6 o'clock, approximately 6 to 7 mm from the annulus. Careful elevation of the skin flap with a flap lift allows advancement to the sulcus. The Gerlach ring is then gently retracted from its groove (sulcus), opening access to the middle ear cavity without breaching the tympanic membrane [1] [4].

Rosen's notch: To obtain optimal exposure of the stapedovesticular region, the incus, and the tympanic portion of the facial nerve, a Rosen's notch is routinely performed. This resection must be carried out carefully to preserve the chorda tympani, which is gently retracted. Exposure is considered satisfactory when the pyramid, the incudostapedial joint, and the tympanic portion of the facial canal are clearly visible [1]-[6].

Checking the stability and sectioning the stapes muscle tendon: Before any irreversible action, the stability of the footplate is confirmed by gentle micro-palpation of the ossicular chain, verifying the mobility of the incus and malleus in contrast to the immobility of the stapes. The incudostapedial joint is then sectioned, followed by sectioning the stapes muscle tendon. This separation protects the inner ear from sonic trauma during subsequent steps.

Crurotomy: Crurotomy is performed using microscissors, resulting in the fracture of the anterior and posterior rami of the stapes. It requires very high stability to avoid labyrinthine trauma and stapes footplate fractures. The stapes superstructure is then extracted from the stapedial cleft, leaving the footplate fixed in isolation at the oval window [1]-[8].

Calibrated platinotomy: A central or postero-inferior micro-perforation (area of least risk for the saccule) is made using a trephine.

The diameter of the calibration is adjusted (usually 0.5 to 0.6 mm) according to the diameter of the chosen Teflon or titanium piston, in order to ensure optimal sealing while avoiding excessive friction.

Piston measurement and placement: The distance between the outer face of the descending branch of the incus and the footplate is precisely measured using a graduated gauge. 0.25 mm is usually added to ensure that the tip of the piston penetrates just far enough into the vestibule without damaging the underlying membranous structures [4].

The piston is then lowered, inserted into the platinotomy, and its ring is crimped onto the long apophysis of the incus.

Functional verification and sealing: The proper tolerance and dynamics of the assembly are tested by applying micro-pressure to the hammer handle, verifying the transmission of movement throughout the reconstruction up to the piston. A perfect seal of the platinotomy around the piston is ensured, if necessary, by the interposition of micro-fragments of connective tissue or fat harvested from the lobule, thus preventing any perilymphatic fistula.

Closure: The tympanomeatal flap is repositioned in its initial anatomical position, ensuring perfect alignment of the skin edges. The canal is calibrated using absorbable gauze or compresses soaked in antibiotic/corticosteroid solution to maintain the flap during the initial healing phase.

The recent integration of intraoperative endoscopy offers excellent wide-angle visualization of the structures of the middle ear cavity and ensures the precision of microsurgical procedures. This work reports the anatomical, iconographic, and functional aspects of a case of otosclerosis surgery optimized under video-endoscopic guidance.

2. Clinical Observation

A 27-year-old male patient was admitted for progressive unilateral right-sided conductive hearing loss that had been developing for 5 years, in the context of a completely normal tympanic membrane on otoscopy, initially suggesting otosclerosis. Preoperative audiometric testing revealed an air-bone gap. A significant air-bone gap was observed at conversational frequencies with preservation of cochlear reserve (**Figure 1**). Impedance audiometry noted a slight decrease in the compliance of the tympanoossicular system with abolition of the stapedial reflex. Preoperative computed tomography revealed a stapes footplate thickening of approximately 0.7 mm associated with hypodensity of the antefenestram fissula on the right, classified as Symons and Fanning stage (**Figure 2**). Exploration and reconstruction were performed under direct endoscopic guidance. Intraoperative endoscopic examination allowed optimal exposure of the oval window niche, the tympanic segment of the facial nerve, and the incudostapedial joint (**Figures 3-7**). After sectioning the stapedius muscle tendon, excising the ramus superstructure, and creating a calibrated microfenestration of the stapes foot (stapedotomy), a Teflon piston was inserted. Direct endoscopic visualization confirmed the ideal positioning of the prosthesis: the superior loop was perfectly crimped around the long process of the incus, ensuring absolute mechanical stability without any unwanted micromobility, while the distal stem plunged perpendicularly to the center of the stapedotomy (**Figure 8**). The postoperative course was uneventful, with mild vertigo and transient tinnitus in the first 24 hours. There was no dysgeusia or facial paralysis. A postoperative audiometric examination performed three months later showed closure of the postoperative air-bone gap to less than 10 dB (**Figure 9**). Computed tomography (CT) of the temporal bones. A thin coronal section image, taken after 6 months, demonstrates the perfect radiopacity of the implant. It confirms the absence of secondary displacement and validates the axis of the prosthesis, whose distal end gently touches the vestibule without excessive penetration, thus limiting any risk of direct trauma to the underlying membranous structures or perilymph leakage (**Figure 10**).

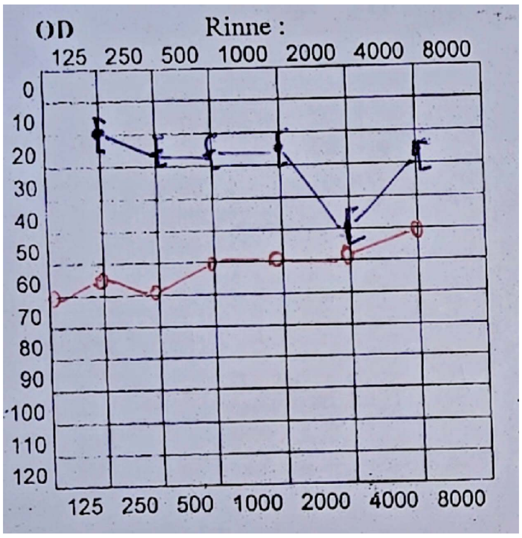

Figure 1. Preoperative audiometry.

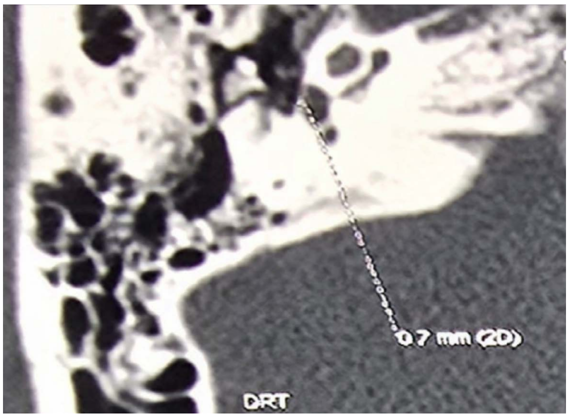

Figure 2. CT scan of the right petrous bone: 0.7 mm squamous plate thickening associated with hypodensity of the antefenestram fussula.

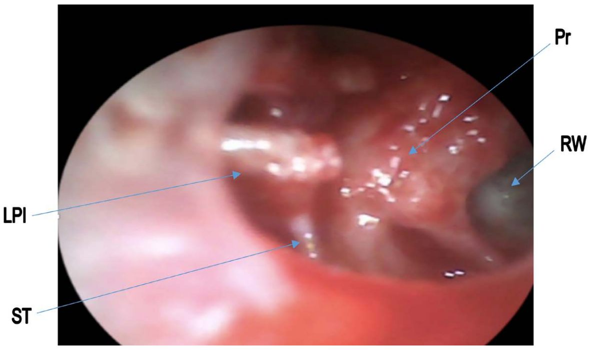

Figure 3. Exposure of the middle ear cavity.

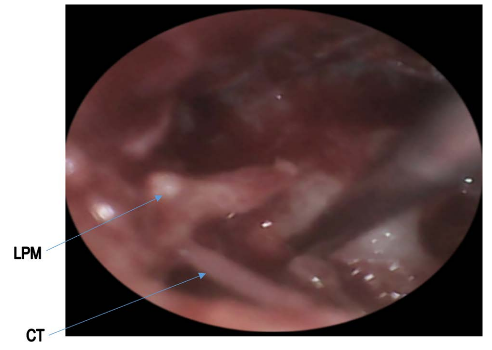

Figure 4. Dissection and preservation of the chorda tympani.

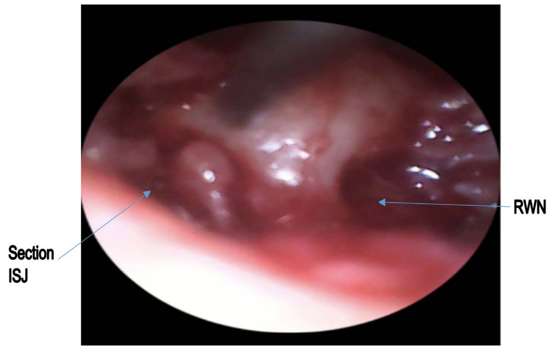

Figure 5. Incudostapedial disarticulation.

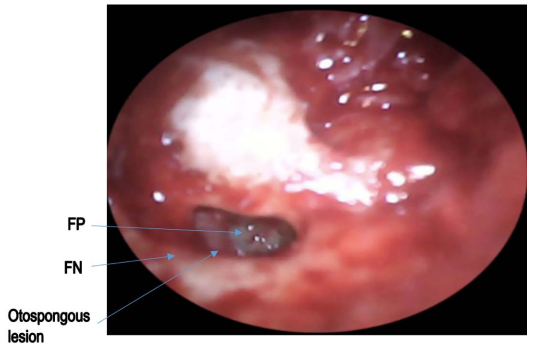

Figure 6. Endoscopic view of the stapes footplate and the otosclerotic lesion.

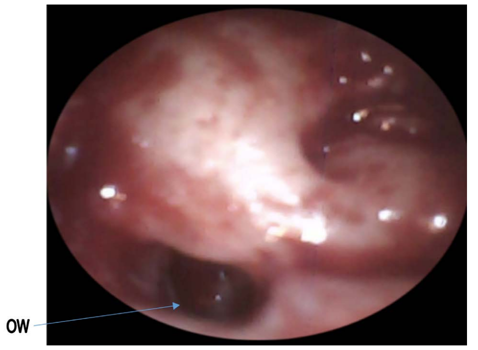

Figure 7. Endoscopic view of the oval window niche after stapedotomy.

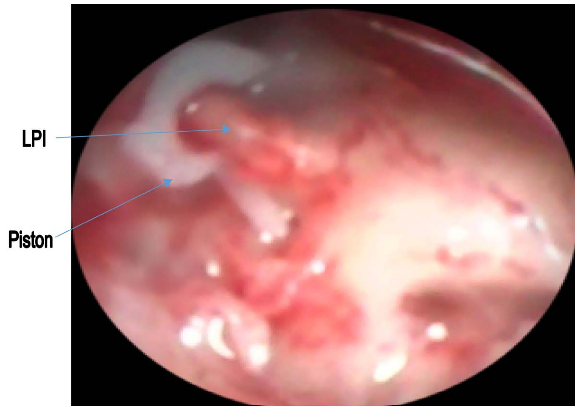

Figure 8. Endoscopic view of the piston attached to the long process of the incus.

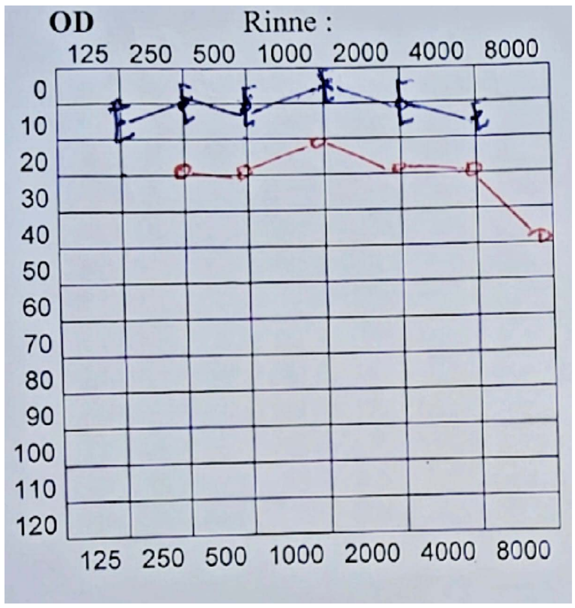

Figure 9. Postoperative audiometry results.

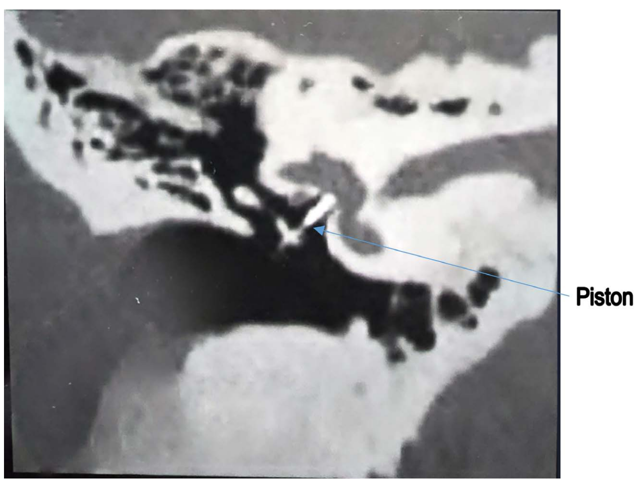

Figure 10. Postoperative frontal CT scan: piston in place.

3. Discussion

The surgical management of otosclerosis in our case was based on a standardized, rigorous approach, aimed at restoring the amplifying effect of the tympano-ossicular chain while minimizing labyrinthine risks.

Comparing our intraoperative and audiometric results with data from the literature highlights a perfect correlation with international standards, while also emphasizing the specificities of our practice at the Gabriel Touré University Hospital. Postoperative air-bone gap closure was less than or equal to 10 dB. These data are entirely comparable to large international series.

Vincent *et al*., in a series of more than 3000 cases of calibrated platinotomy, reported functional success (Air-Bone Gap 10 dB) in 92% to 94% of cases [9].

Fisch *et al*., pioneers of the Teflon piston, as well as the "Causse" school, describe similar success rates ranging between 90% and 95% [10].

At the regional level in West Africa (particularly the series reported by Senegalese or Ivorian teams), the average prosthetic gain or the closure of the air-bone gap (Air-Bone Gap) at less than 15 dB oscillates between 85% and 90%. Our observed gain is in the upper range of these local statistics, confirming the learning curve and mastery of otological microsurgery in Mali [11].

From a technical point of view, our choice has systematically been "calibrated trephine platinotomy".

Historically, total or subtotal platinectomy (Shea technique) was the norm [12]. However, modern literature has largely demonstrated the superiority of platinotomy. Smyth *et al*. and Marquet proved that calibrated platinotomy (0.5 to 0.6 mm) significantly reduced intraoperative acoustic trauma and the rate of postoperative deafness (less than 0.5% in the literature versus nearly 2% for total platinectomies) [13] [14].

By limiting the opening of the labyrinth to the strict diameter of the piston, we agree with the conclusions of "Lesinski", who insists on the preservation of vestibular micro-mechanics and the drastic reduction of disabling rotatory vertigo in the first postoperative days [15].

Creating the Rosen notch is essential to exposing the oval window niche. In our study, morbidity related to stretching or sectioning of the chorda tympani (transient dysgeusia) did not occur.

In the literature, the incidence of transient taste disturbances after exclusion or reclusion of the chorda tympani varies from 10% to 30% according to the authors (Michael *et al*.) [16].

Our rigorous intraoperative approach to delicately releasing the cord before bone curettage explains this condition, resulting in an outcome comparable to the most conservative surgical series.

We have mostly used 0.6 mm diameter Teflon pistons.

Comparative studies by Shiao *et al*. showed no major long-term audiometric difference between pure Teflon and titanium at conversational frequencies [12]. However, Teflon offers the advantage of a flexible crimp on the descending branch of the incus, limiting the risk of incus necrosis (described at less than 1% in the world literature).

The connective tissue sealing we apply around the piston is a step validated by the French school of otological surgery. It prevents the development of perilymphatic fistulas and delayed open labyrinths, a formidable complication that has become exceptional in our practice.

The functional success and long-term viability of otosclerosis surgery depend on meticulous precision during prosthetic assembly. The choice of stem diameter, the depth of vestibulotopic penetration, and, above all, the quality of the loop's crimping onto the descending ramus of the incus are critical steps. A crimping that is too loose exposes the patient to mechanical play and erosion of the descending ramus of the incus due to friction, while a crimping that is too tight can induce aseptic necrosis of the incus. The contribution of intraoperative endoscopy proves crucial here: it offers superior angular clarity and depth of field compared to the conventional operating microscope, allowing for detailed inspection of the inner surface of the descending ramus of the incus without excessive tilting of the patient or the surgical platform. In our case, this perfect intraoperative technique resulted in a direct clinical benefit, demonstrating an immediate audiometric improvement of 10 dB. This gain signifies the effective closure of the air-bone gap (Air-Bone Gap) and validates the restoration of overall ossicular chain compliance.

4. Conclusion

This case report highlights the advantages of video-endoscopic control in the surgical management of otosclerosis. Achieving a functional gain of 10 dB demonstrates the precision and reproducibility of prosthetic fitting under endoscopy, establishing it as a valuable alternative or complement to traditional microsurgery.

Ethical Approval Statement: Informed Consent

It was a purely scientific work aimed at improving the grip of those in charge in the field of otology; the ethical standards were strictly followed for each study participant with their informed consent, and respect for anonymity.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations

LPM: Lateral Process of the Malleus; LPU: Long Process of the Incus; ISJ: Incudostapedial Joint; FN: Facial Nerve; CT: Chorda Tympani; ST: Stapedial Tendon; PE: Pyramidal Eminence; RWN: Round Window Niche; Pr: Promontory; OW: Oval Window.