



Original Article

Revision Stapedectomy with Necrosis of the Long Process of the Incus: Does the Degree of Necrosis Matter? A Retrospective Clinical Study

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OBJECTIVE: To discuss the different modalities for managing necrosis of the long process of the incus in revision stapedectomy on the basis of the degree of necrosis and compare the results with those reported in the literature.

MATERIALS and METHODS: Thirty-six patients underwent revision stapedectomy with the necrosis of the long process of the incus from 2009 to 2016. The patients were divided into three groups on the basis of the degree of necrosis. For group A (minimal necrosis), augmentation technique with bone cement was performed. For group B (partial necrosis), the cement plug technique was performed. For group C (sever necrosis), malleus relocation with malleovestibulopexy was performed using reshaped necrosed incus. Air and bone conduction thresholds at frequencies of 500–3000 Hz were reviewed pre- and postoperatively using conventional audiometry. The air–bone gap (ABG) and bone conduction thresholds were measured.

RESULTS: Postoperative ABG was reduced to <10 dB in 28 cases (77.8%) and <20 dB in all cases (100%). There was no significant change in postoperative bone conduction thresholds. The mean patient follow-up duration was 23 (range, 18–36) months. The cement plug technique was used in 75% of cases.

CONCLUSION: Managing necrosis of the long process of the incus in revision stapedectomy should be considered according to the degree of necrosis. The cement plug technique is considered to be a reasonable option in most cases. Malleus relocation with malleovestibulopexy is an effective alternative to prosthesis.

Keywords: Long process of incus, revision stapedectomy, malleus relocation, hearing results

INTRODUCTION

Stapedectomy has been established as a safe and reliable surgical management for otosclerosis. Successful air–bone gap (ABG) closure within 10 dB is predictable after surgery^[1–3]. However, there is an incidence of surgical failure that necessitates revision stapedectomy^[4,5]. Failure may occur in cases of persistent preoperative ABG or reopening of ABG, sensory neural hearing loss (SNHL), and dizziness^[6]. Common findings during revision stapedectomy include necrosis of the long process of the incus (LPI), lateralization or displacement of prosthesis, loosening of the connection between the prosthesis and incus, and closure of the fenestra in the oval window. The incidence of LPI necrosis in revision stapedectomy ranges from 5%^[7] to 25%^[3], and in some studies, it was the first cause of failure^[8], which may occur owing to the popular use of piston prostheses connected to LPI, which leads to its necrosis^[9].

Revision stapedectomy with LPI necrosis is challenging. Results of ABG closure are less satisfactory than those of primary surgery^[10]. Various surgical techniques have been described such as bypassing the LPI necrosis with TORP, malleovestibular prosthesis^[11], or recent use of reconstruction of LPI with bone cement, which allows the reconstruction of the natural incus–oval window interface^[5].

This study aimed to discuss the different modalities for managing LPI necrosis in revision stapedectomy on the basis of the degree of necrosis and to perform a literature review.

MATERIALS and METHODS

Ethical Consideration

This study fulfilled the requirements of the ethical committee of Otolaryngology Department and was approved by the Institutional Research Board of the Faculty of Medicine. Informed written consent was obtained from all patients.

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This retrospective clinical study included patients who underwent revision stapedectomy from 2009 to 2016. Thirty-six patients with LPI necrosis were included.

Surgical technique

A senior surgeon operated on all patients via the transcanal approach under local anesthesia. After exploring the middle ear, the prosthesis was freed and removed. The old stapedotomy was evaluated and revised if required. According to the degree of LPI necrosis (Figure 1), the patients were divided into three groups: group A, minimal necrosis (LPI still in continuity); group B, partial necrosis (LPI crosses the margin of the oval window); and group C, severe necrosis (LPI does not reach the margin of the oval window).

For group A, the augmentation technique was performed, wherein LPI was augmented with glass ionomer bone cement, followed by the reinsertion of the Teflon piston prosthesis (Figure 2). For group B, the cement plug technique was performed; the prosthesis was reinserted first to the remaining LPI and then fixed to LPI using the cement plug (Figure 3). During cement application, pieces of gel-foam were used to cover the facial nerve and footplate and were removed after the cement hardened. For group C, malleus relocation with malleovestibulopexy was performed using reshaped necrosed incus. The malleus was completely dissected from the tympanic membrane, after which the incus was removed. The tensor tympani tendon was cut, and the malleus was posteriorly retracted till it was directly placed above the oval window. To avoid possible malleus anterior retraction, the anterior malleal ligament was overstretched. The distance between the relocated malleus and footplate was measured using a measuring rod. The remaining incus was then reshaped to fit into the hole in the footplate (one tapered end) and to accommodate the handle of the malleus (grooved other end) (Figure 4). The oval window was sealed using a small piece of fascia^[12]. The tympanic membrane was returned to its position, and the external ear canal was packed with gelfoam that was soaked with an antibiotic ointment.

Hearing evaluation

Pre- and postoperative (≥ 1 year) pure tone audiometry was performed for all cases. Air conduction (AC) threshold, bone conduction (BC) threshold, and ABG were documented. Hearing results were reported according to the American Academy of Otolaryngology Head and Neck Surgery Committee of Hearing and Equilibrium guidelines for the evaluation of results of conductive hearing loss treatment. ABG was analyzed at 0.5, 1, 2, and 3 kHz. Successful hearing was defined as a postoperative ABG of ≤ 20 dB^[13].

Statistical analysis was performed using a statistical software (SPSS, ver. 20, IBM, Corp.; Armonk, NY, USA). Paired Student's t-test was used to compare the means of the pre- and postoperative hearing results. P values of <0.05 were considered to be statistically significant.

RESULTS

The study included 36 patients. The mean age was $41.2 (\pm 6.36)$; range, 30–56 years. Group A included five cases (13.9%), group B included 27 cases (75%), and group C included four cases (11.1%). The mean postoperative follow-up period was 23 (range, 18–36) months.

Hearing results are presented in Table 1. The mean preoperative AC threshold was $54.7 (\pm 4.8)$ dB, $47.8 (\pm 3.8)$ dB, $55.8 (\pm 4.1)$ dB, and $55.6 (\pm 4.1)$ dB for all cases, group A, group B, and group C, respectively. While the mean postoperative AC threshold was $26.8 (\pm 4)$ dB ($p < 0.001$), $27 (\pm 6.8)$ dB ($p = 0.009$), $26.4 (\pm 3.4)$ dB ($p < 0.001$), and $29 (\pm 3.5)$ dB ($p = 0.003$), respectively. There was a significant improvement in the mean postoperative AC threshold of all groups.

The mean preoperative BC threshold was $17.1 (\pm 1.8)$ dB, $16.8 (\pm 1.7)$ dB, $17.2 (\pm 1.9)$ dB, and $17.3 (\pm 1.7)$ dB for all cases, group A, group B, and group C, respectively. While the mean postoperative BC threshold was $17 (\pm 1.9)$ dB ($p = 0.226$), $16.4 (\pm 1.8)$ dB ($p = 0.178$), $17.1 (\pm 2.1)$ dB ($p = 0.593$), and $17 (\pm 1.4)$ dB ($p = 0.215$), respectively. There was no significant change in the mean postoperative BC threshold of all groups.

The mean postoperative ABG improved from $37.5 (\pm 5.3)$ to $9.5 (\pm 3.1)$ dB for all cases ($p < 0.001$), from $31 (\pm 4.9)$ to $9 (\pm 2.3)$ dB in group A ($p = 0.002$), from $38.6 (\pm 4.8)$ to $9.3 (\pm 3)$ dB in group B ($p < 0.001$), and from $38.2 (\pm 2.3)$ to $12 (\pm 4)$ dB in group C ($p = 0.003$). In all groups, there was a significant improvement in the mean postoperative ABG.

The postoperative ABG reduced to <10 dB in 28 cases (77.8%) and <20 dB in all cases (100%). In group A, it reduced to <10 dB in four cases (80%); in group B, it reduced to <10 dB in 22 cases (81.5%); and in group C, it reduced to <10 dB in two cases (50%). There were no cases with postoperative SNHL. There were no complications reported in any patient in relation to the use of bone cement as tympanic membrane perforation, otorrhea or granulations.

DISCUSSION

Management of LPI necrosis in revision stapedectomy is challenging. In many earlier series, malleovestibulopexy (connecting malleus to the vestibule) was the technique of choice, using either prosthesis (as Fisch malleostapedotomy, malleus grip prostheses of Schuknecht, Kurz titanium malleovestibulopexy clip piston, and Gyrus Nitinol

Table 1. Hearing results

Cases	Air Conduction (dB)			Bone Conduction (dB)			Air–Bone Gap (dB)			Air–Bone Gap Closure	
	Pre	Post	Sig.	Pre	Post	Sig.	Pre	Post	Sig.	<10 dB	10–20 dB
All (n=36)	54.7 \pm 4.8	26.8 \pm 4.0	0.000	17.1 \pm 1.8	17 \pm 1.9	0.226	37.5 \pm 5.3	9.5 \pm 3.1	0.000	28 (77.8%)	8 (22.2%)
Group A (n=5)	47.8 \pm 3.8	27 \pm 6.8	0.009	16.8 \pm 1.7	16.4 \pm 1.8	0.178	31 \pm 4.9	9 \pm 2.3	0.002	4 (80%)	1 (20%)
Group B (n=27)	55.8 \pm 4.1	26.4 \pm 3.4	0.000	17.2 \pm 1.9	17.1 \pm 2.1	0.593	38.6 \pm 4.8	9.3 \pm 3.0	0.000	22 (81.5%)	5 (18.5%)
Group C (n=4)	55.6 \pm 4.1	29 \pm 3.5	0.003	17.3 \pm 1.7	17 \pm 1.4	0.215	38.2 \pm 2.3	12 \pm 4.0	0.003	2 (50%)	2 (50%)

Pre: preoperative; Post: postoperative; Sig.: significant

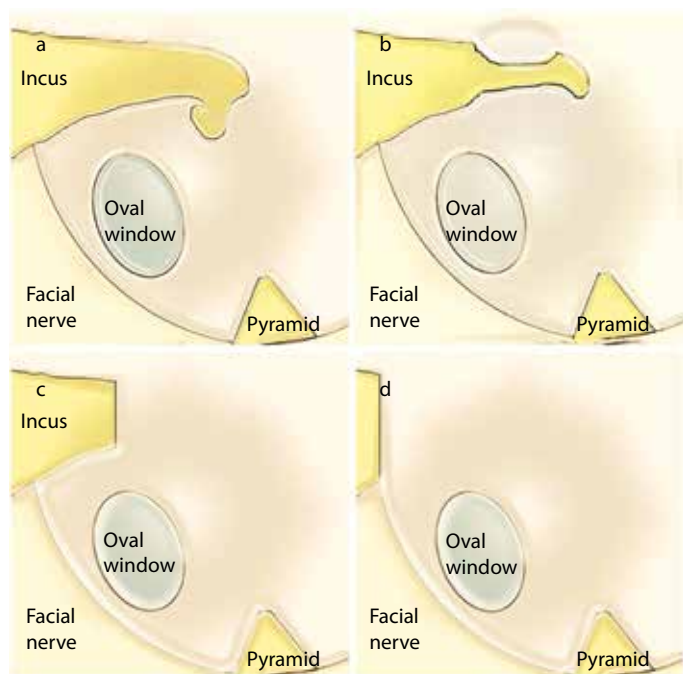


Figure 1. a-d. The degrees of the necrosis of the long process of the incus (LPI). (a) Intact LPI. (b) Group A, minimal necrosis (LPI still in continuity). (c) Group B, partial necrosis (LPI cross the margin of oval window). (d) Group C, severe necrosis (LPI does not reach the margin of the oval window).



Figure 2. a-c. The augmentation technique. (a) Group A: LPI, long process of the incus; F, facial nerve; FP, footplate. (b) LPI is augmented with glass ionomer bone cement. (c) The Teflon piston prosthesis is reinserted.

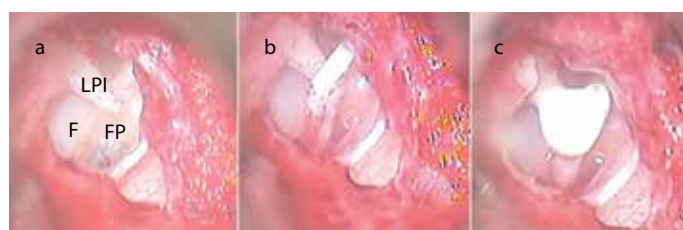


Figure 3. a-c. The cement plug technique. (a) Group B: LPI, long process of the incus; F, facial nerve; FP, footplate. (b) The prosthesis is reinserted to the remaining LPI. (c) The prosthesis fixed to LPI using the cement plug.

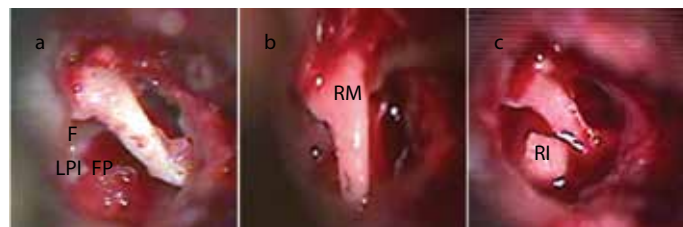


Figure 4. a-c. Malleus relocation with the malleovestibulopexy technique. (a) Group C: LPI, long process of the incus; F, facial nerve; FP, footplate. (b) The malleus is posteriorly retracted till it is directly placed above the footplate; RM, relocated malleus. (c) The LPI necrosis is reshaped to fit between the hole in the footplate and handle of malleus; RI, reshaped incus.

Teflon piston) or our previously published technique of malleus relocation with reshaped incus [6, 12]. However, prosthesis positioning is technically challenging and has a potentially higher incidence of vertigo and SNHL after surgery [14]. Thus, many surgeons, including us, have begun to use bone cements to reestablish the incus–prosthesis interface [15]. In the last years, bone cements have been presented as a cheap and physiological ossiculoplasty technique. Glass ionomer and hydroxyapatite bone cements have been also used to reconstruct LPI necrosis in revision stapedectomy [4].

The literature review revealed that many studies described the management of LPI necrosis in revision stapedectomy. All described one of the techniques mentioned in this study, i.e., LPI tip augmentation, cement plug, or malleovestibulopexy. However, they did not specify the basis on which they selected their technique. Furthermore, they did not describe the degree of LPI necrosis or link it to their choice. Therefore, the question regarding which technique should be selected remains unanswered. What happened if LPI showed minimal or partial necrosis with the use of malleovestibulopexy prosthesis or if LPI showed severe necrosis with the use of cements? Only few studies have mentioned the shift from cement to prosthesis in severe LPI necrosis [15, 16]. We believe that in these cases, what really matters are how the technique should be performed and which technique should be selected. A simple and safe technique certainly would be ideal. According to this point of view, we categorized the surgery using the three techniques on the basis of the three possible degrees of LPI necrosis.

Hearing outcomes after revision stapedectomy using cements are variable, with a small number of cases and limited follow-up periods [4]. Some trials have described LPI tip augmentation with hydroxyapatite cement with the insertion of piston prosthesis on LPI. Van Rompaey et al. [15] compared this procedure with malleovestibulopexy. The results at 3 months were <10 dB in 20% and <20 dB in 80% for the cement, whereas they were <10 dB in 40% and <20 dB in 80% for malleovestibulopexy. With 37 cases of LPI necrosis, House et al. [4] reported that ABG was <10 dB in 81.1% and <20 dB in 89.2%. In group A of the present study, ABG was <10 dB in 80% of patients and <20 dB in all patients.

The cement plug technique has been described in other series. Chen and Arriaga [17] reported seven cases of LPI necrosis, where they performed this technique using glass ionomer cement. Their results showed four cases (57.1%) with ABG closure of <10 dB; in the remaining three cases, postoperative ABG was >20 dB. Goebel and Jacob [10] found that in the one patient in whom this technique was used with hydroxyapatite, the postoperative ABG was 15 dB. Hudson et al. [5] demonstrated significantly better hearing results with hydroxyapatite. ABG closure of <10 dB was observed in 77.8% of patients and <20 dB in 96.3% of patients. They considered the cement plug technique with hydroxyapatite to be a reasonable option for LPI necrosis in revision stapedectomy; these results were in agreement with our study results as 75% of our cases (Group B) were managed with it. In our study, ABG closure of <10 dB was observed in 81.5% of patients and <20 dB in all patients. If ionomer cements are used, footplate and facial nerve should be covered with pieces of gelfoam to protect them from potential reaction to the cement [17]. In this study, there were no complications reported with respect to the use of cement.

In contrast, malleovestibulopexy continues to have its own indication. That's in cases of severe LPI necrosis in which the other two techniques cannot manage. When summarizing the reported experience regarding malleovestibulopexy prosthesis (the number of cases varies between 5 and 187); ABG closure to <10 dB is detected in 18%–70% of patients and <20 dB in 67%–90% of patients. Postoperative SNHL was detected in 0%–8% of cases^[14,15]. In our previous series regarding revision stapedectomy with LPI necrosis using malleus relocation, we used reshaped incus instead of prosthesis. We resolved the problem of the presence of an anteriorly positioned malleus that makes malleovestibulopexy potentially difficult and unstable. We used the malleus relocation technique, which places the malleus over the axis of the footplate, thereby enabling better insertion of the reshaped incus between the footplate and the handle of the malleus. Moreover, the results were comparable with that reported in the literature. ABG was closed to <10 dB in seven cases (58.3%) and <20 dB in 10 cases (83.3%). A mild postoperative SNHL was observed in one patient^[12]. In group C of this study, ABG closure to <10 dB was observed in 50% patients and <20 dB in all patients.

CONCLUSION

Management of LPI necrosis in revision stapedectomy is challenging. The choice of technique should be considered according to the degree of necrosis. Techniques that utilize bone cements have been proved to be effective in minimal or partial LPI necrosis, whereas malleovestibulopexy has been indicated to be effective in severe LPI necrosis. The cement plug technique is considered to be a reasonable option for LPI necrosis in most revision stapedectomy cases. Malleus relocation with malleovestibulopexy using reshaped incus is also an effective, cheap, and safe alternative to prosthesis.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Mansoura Otolaryngology Department, Faculty of Medicine, Mansoura University.

Informed Consent: Written informed consent has been obtained from all participants.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - M.G.; Design - B.A.; Supervision - M.G.; Resources - Y.S.; Materials - Y.S.; Data Collection and/or Processing - M.S.; Analysis and/or Interpretation - M.S.; Literature Search - Y.S.; Writing Manuscript - B.A.; Critical Review M.G.

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