Traumatic Incudostapedial Joint Disarticulation: Anatomical Reconstruction Versus Stapes Bypass

Original Article

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ABSTRACT

Objectives: To outline two surgical strategies for managing traumatic incudostapedial joint disarticulation (ISJD) with intact tympanic membrane (TM), aiming for improving the stability and the functional outcomes of the procedure.

Patients and Methods: This randomized controlled clinical trial was performed on 27 ears of 27 patients with isolated traumatic ISJD with intact tympanic membrane. The study was conducted in the Otorhinolaryngology Department, Mansoura University Hospitals, Egypt. Patients were randomly assigned into two groups: anatomical reconstruction group (n=14), and stapes bypass group (using a Teflon piston) (n=13). Air and bone conduction thresholds at frequencies 500–4000 Hz, were determined pre- and postoperatively.

Results: The postoperative pure-tone average and mean air-bone gap (ABG) were statistically significantly different ($p < 0.001$). The mean postoperative gain of air conduction (AC) threshold and consequently the mean postoperative ABG closure were significantly better with the stapes bypass group compared to the bone cement one. ABG closure to within 10 dB in the stapes bypass group was found in 11ears (84.6%), while in bone cement group, closure to within 10 dB was found in 10 (71.4%) and to within 20 dB in 14.2%. The cochlear function remained stable postoperatively in both groups ($p=0.422$). No complications were reported, and no patient had a postoperative ABG greater than 30 dB.

Conclusion: When the ISJ is dislocated, two options exist for ossicular reconstruction: bypassing the stapes using Teflon piston (stapedotomy) and anatomical reconstruction using ionomeric bone cement. Both techniques are successful with no statistically significant difference regarding hearing outcomes.

Key Words: Bone cement, ossiculoplasty, teflon piston, traumatic conductive hearing loss.

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INTRODUCTION

Ossicular chain lesions is suspected in cases of conductive hearing loss (CHL) that persists few months following head trauma, with air-bone gap (ABG) larger than 30 dB, in presence of an intact tympanic membrane (TM) and in absence of hemotympanum[1, 2].

Head trauma, with or without fracture of the temporal bone, can result in various ossicular chain lesions[2-5]. The most common post-traumatic ossicular lesions are the incudo-stapedial joint disarticulation (ISJD), incus dislocation and stapes lesion[6-8]. However, the isolated malleus and incus fractures are rare. This is because of the loose suspension of the incus between the firmly attached malleus and stapes. Among these lesions, it is generally believed that the incudo-stapedial joint (ISJ) is the most frequently injured site.

Many treatment options are available for reconstruction of the ISJD. These include replacement of the ISJ or the incus entirely using partial ossicular replacement prosthesis (PORP), as well as the incus interposition. Unfortunately, these options may be complicated by prosthesis extrusion or graft migration, respectively[9, 10].

Tissue adhesive, cartilage and bone were utilized to manage the ISJD while maintaining the normal anatomy. For the same purpose, the bone cement was more recently introduced as an excellent alternative to the currently accepted methods[11-16].

The goal of this study is to outline two surgical strategies for managing post-traumatic ISJD, with an intact TM, aiming for improving the stability and the functional outcomes of the procedure.

PATIENTS AND METHODS:

This randomized controlled clinical trial was performed on 27 ears of 27 patients with conductive hearing loss due to isolated traumatic ISJD with intact tympanic membrane.

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The study was conducted over 2 years (June 2017 - June 2019), in the otology and neurotology unit in the Otorhinolaryngology Department, Mansoura University Hospitals, Egypt. Informed written consents were obtained from all patients. The study was approved by the Mansoura Faculty of Medicine Institutional Research Board (MFM-IRB: MD.18.03.14).

Patients of the study were randomly assigned into two groups: anatomical reconstruction group (n=14), and stapes bypass group (n=13). Randomization was performed based on a computer-generated list of random numbers. The diagnosis of the ISJD in this study was made mainly according to the intraoperative findings. The cause of ISJD was head trauma in all patients of the study. At least six months should pass from the head trauma before any surgical intervention was considered. Patients with air bone gap less than 30 dB were excluded from the study.

Audiological evaluation was carried out using a clinical audiometer (Model OB 822; Madsen, Taastrup, Denmark). Air and bone conduction thresholds at frequencies500–3000 Hz were reviewed before and after operations (1 month, 3 months, 6 months and 1 year), and at the last available follow-up. Minimal follow-up period was 12 months (12 – 36 months).

Results were reported in accordance with the American Academy of Otolaryngology- Head and Neck Surgery Committee on Hearing and Equilibrium guidelines for evaluation of the results of treatment of conductive hearing loss[17].

2.1 Surgical techniques:

All surgeries were performed by the senior author (MRG), to ensure standardization of the surgical techniques for all patients. Patients were placed in supine position with the head is in the classic otologic position (flat on the bed with no head rest). The ear was then sterilized and draped in the standard fashion. Local anesthesia is preferred by the senior author whenever possible, and it was applied in 24 patients. On the other hand, in uncooperative patients (n=3), general anesthesia was applied.

Exploration of the middle ear was done via the trans-canal approach (stapedectomy approach). The status and the mobility of the ossicular chain status were examined, and the diagnosis of isolated ISJD was made. When any other ossicular chain lesions were found upon exploration, the patient were excluded from the study.

Two main treatment modalities were used. In the anatomical reconstruction group, ossicular reconstruction was performed by bone cement. On the other hand, in the stapes bypass group, traditional stapedotomy was performed bypassing the incudo-stapedial joint and the stapes.

2.2 Anatomical reconstruction group (n=14):

All Ionomeric bone cement (Hrarvard Ionoglas Cem, Harvard Dental International GmbH, Hoppegarten, Germany) was used to reconstruct the ISJ and to anatomically restore the integrity of ossicular chain (Figure 1, 2 ,3, 4).

2.3 Stapes bypass group (n=13):

Traditional stapedotomy was performed and a Teflon piston (0.6 mm diameter, Gyrus Inc., Bartlett, TN, USA) was used to bypass the ISD and the stapes and transmit the sound from the incus to the inner ear directly. The proper length of the piston was adjusted, and a classic pin hole stapedotomy was performed. A drop of bone cement was applied as an adjuvant, to add a more firm and secure connection between the piston and the incus (Figure 5A 5B).

Using the Statistical Package (SPSS, ver. 20), a paired t-test was used to compare the preoperative and postoperative hearing results. $P<0.05$ was accepted as statistically significant and closure of the ABG to within 20 dB was considered successful.

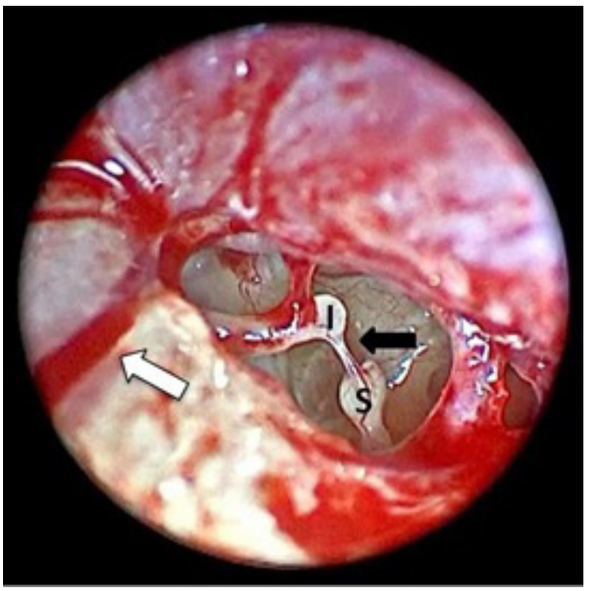

Fig.1: Endoscopic view of the right middle ear with incudostapedial joint dislocation (black arrow), incus (I), stapes head (s) and a fracture line (white arrow).

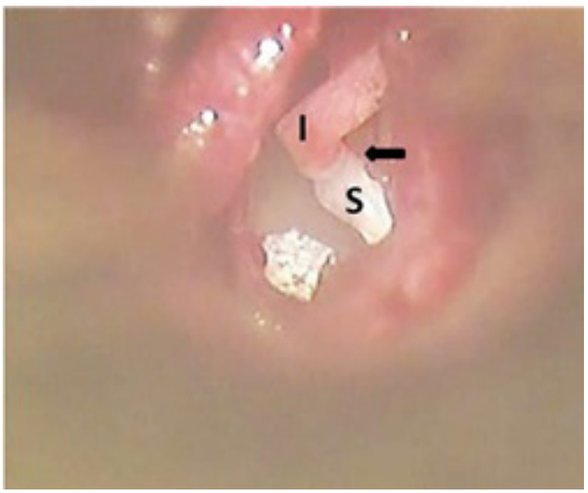

Fig. 2: Microscopic view of the left middle ear with incudostapedial joint dislocation (black arrow), incus (I) and stapes head (s).

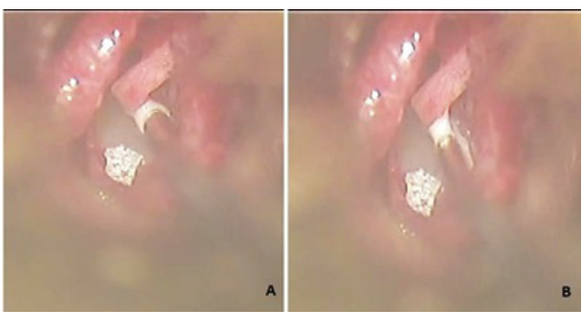

Fig. 3 (A&B): Application of bone cement by a needle to bridge the gap and restore the integrity of ISJ anatomically.

Fig.4: Restored incudostapedial joint.

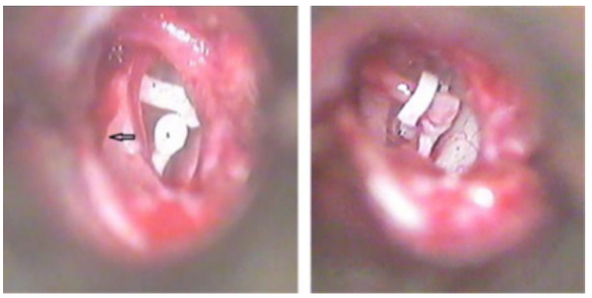

Fig.5: (A) Incudostapedial dislocation: incus (I), stapes head (S) and fracture line (black arrow). (B) Shows Teflon piston between incus and footplate.

RESULTS:

The study was conducted on 27 ears of 27 male patients. The mean age was 26± 12.1 years, and the range of the ages was 12-47 years. The mean duration between the onset to the surgical intervention was 9.5 ± 5.2 years, and the range was 8 months to 16 years. Regarding the mean duration from the onset of the trauma to the surgical intervention, there was no significant difference between the two groups. The stapes bypass group had mean duration of 9.1 ± 4.3 years, while it was 10.2 ± 5.9 years in the anatomical reconstruction group. The deafness was left sided in 25 ears (92.5%) and right sided in 2 ears (7.4%). Traffic accident was the commonest cause of the ossicular chain discontinuity in 23 ears (85.2%), while blunt head trauma was the cause in 4 ears (14.8%). Six ears had fracture lines of the posterior and the postero-superior meatal wall.

The mean preoperative air conduction (AC) and bone conduction (BC) thresholds were 54.5 ±12.7 dB and 15.45 ± 5.2 dB, respectively. The mean postoperative AC and BC thresholds were 17.12 ± 8.89 dB and 13.96 ± 5.009dB, respectively. The mean pre and postoperative ABGs were 39.04 ± 10.11 and 3.16± 6.46 dB (Table 1). The postoperative improvement of the pure-tone average by 40.7 dB was statistically significant ($p < 0.001$). The cochlear function remained stable postoperatively, there were no significant changes ($p=0.422$).

The mean ABG has significantly improved from 39.04 dB preoperatively, to 3.16 dB postoperatively ($p<0.001$). The ABG closure to within 10 dB occurred in 21 ears (77.8%), and to within 20 dB in 5 ears (18.5%). The ABG was greater than 20 dB (mean 22 dB) in 2 ears (7.4%). No intraoperative or postoperative complications were reported in the study. No patient had a postoperative ABG greater than 30 dB.

Table 2 shows the results of both treatment modalities. The mean postoperative gain of AC threshold in the Teflon group was 45.93 dB. The mean AC threshold has significantly improved from 62.94 dB preoperatively to 19.01dB postoperatively ($p=0.001$). In comparison, the bone cement group showed a 31.65 dB gain of AC, from 47.11 dB to 15.46 dB (0.001). Accordingly, this accounted

for a non-statistically significant difference between both groups (*P=0.02*).

The mean postoperative ABG closure was non significantly better in the Teflon group in comparison with the bone cement group (*p<0.056*). (Table 3).

The ABG closure to within 10 dB was achieved in 11/13 (84.6%) and within 20 dB in 2/13 ears (15.4%) in the Teflon group. In the Bone Cement group, the ABG closure Within 10 dB occurred in 10/14 ears (71.42%) and within 20 dB in 2/14 ears(14.3%) and in 2 ears the ABG closure above 20 dB in 2/14 ears (14.3%) with a mean of 22.5 dB. (Table 4). The cochlear function remained stable postoperatively in both groups, there were no significant changes (*p=0.112*).

Table 1: Comparison between preoperative and postoperative mean AC, BC and ABG

Total groups (n=27)	Preoperative	Postoperative	*P-value*
Mean air conduction (AC)	54.5 ±12.7 dB	17.12 ± 8.89 dB	<0.001*
Mean bone conduction (BC)	15.45 ± 5.2 dB	13.96 ± 5.009dB	0.422
Mean air bone gap (ABG)	39.04 ± 10.11	3.16± 6.46 dB	<0.001*

Table 2: Comparison between both Bone cement and Teflon groups as regard mean preoperative and postoperative AC.

	Bone cement (n=14)	Teflon (n=13)	*P-value*
Mean preoperative air conduction (AC)	47.109±12.98	62.95±4.77	
Mean postoperative air conduction (AC)	15.47±10.51	19.01±6.45	0.02
P value	(<0.001*)	(<0.001*)	

Table 3: Comparison between Bone cement and Teflon groups regarding ABG pre and post

ABG	Bone cement (n=14)	Teflon (n=13)	Wilcoxon signed *P-value*
Preoperative air bone gap (ABG)	33.28+8.46	45.62+7.60	
Postoperative air bone gap (ABG)	2.65+7.2	3.75+5.69	P 056
Wilcoxon signed *P value*	(<0.001)	(<0.001)	

Table 4: ABG closure in both Teflon and bone cement groups.

Air bone gap closure	Bone cement (n=14)	Teflon (n=13)	*P-value*
Within 10 dB	10 (71.42%)	11 (84.6%)	
Within 20 dB	2 (14.2%)	2 (15.4%)	0.281
Above 20 dB	2 (14.2%)	0 (0%)	

DISCUSSION

In this study, the main cause of ISJD was head trauma due to traffic accident. The same cause was reported by other studies[3, 6, 7, 18]. Two options were used for ossicular reconstruction of ISJD. Anatomical reconstruction using ionomeric bone cement represented an option for the management. On the other hand, bypassing the stapes, by inserting Teflon piston, from the incus to inner ear, has offered the second option for managing such conditions.

The overall postoperative results were statistically significantly different, regarding the pure-tone average, mean ABG and ABG closure, in the studied groups. The cochlear function remained stable postoperatively, reflecting the safety and the feasibility of both lines of management, in the experienced hands. No complications were encountered in the study population. All the patients had ABG less than 30 dB postoperatively, a finding that can be used in counselling and assuring the potential future patients undergoing an exploratory tympanotomy for persistent posttraumatic CHL.

The outcomes of the studied groups - namely the mean postoperative gain of AC thresholds, significantly improved in both groups as regards the preoperative thresholds with non-significant differences between groups. The mean postoperative ABG and the postoperative ABG closure were non-significantly better in the stapes bypass group. A possible explanation can be that the delayed surgical intervention might lead to some sort of stapes fixation. Despite having a more or less similar mean duration of delay in the intervention after the onset of trauma (9.5 ± 5.2 years), the Teflon group could give better outcomes, after bypassing the assumed subtle stapes fixation.

In our previous study[19], thirteen patients with ISJD underwent stapes bypass surgery and 14 patients underwent anatomical reconstruction with ionomeric bone cement, by the senior author (MRG). However, in those patients the Teflon piston was to fit from the incus to rest over the footplate, after proper readjustment of the length of the prosthesis. The mean short-term postoperative AC was improved from 62.95 dB to 19.02 dB with closure of the ABG to within 10 dB in

84.6% of cases. The mean long-term postoperative air-conduction was 17.12 dB with closure of the ABG to within 10 dB in 71.4% of cases. In the current Teflon group, stapedotomy was performed to adapt and stabilize the prosthesis and consequently bypassing the assumed stapes fixation, thereby enhancing the acoustic effect. The latter modification in the technique was associated with superior outcomes over one-year follow-up at least. The mean gain of AC thresholds improved from 64.9 dB to 16 dB and the ABG closure to within 10 dB could be achieved in 11/11 ears (100%).

Interestingly, the authors of this work noticed improvement in the bone conduction after surgery, as the mean preoperative BC thresholds was 15.45 ± 5.2 dB and the mean postoperative BC thresholds was 13.96 ± 5.009dB. However, this improvement was statistically not significant (*p=0.422*). A possible explanation of this is that when sound is applied to skull, it is transmitted not only via skull bones but also via the external auditory canal and ossicular chain. Thus, in ossicular chain disruption, the contribution of the ossicular chain to the bone conduction process is lost, and after successful ossiculoplasty, BC thresholds may improve. Similarly, Bauer[20] noticed improvement in the BC thresholds after ossiculoplasty.

It seems impractical to compare the outcomes of ossicular reconstruction due to traumatic lesions with other causes as chronic otitis media and cholesteatoma. Reconstructing the defects of the ISJ may be accomplished by several means. The ISJD or a minor erosion of the lenticular process of the incus may be treated by using tragal cartilage or cortical bone, leaving the incus in situ[11, 20].

ISJ rebridging ossiculoplasty by reconstructing the missing part of the long process of the incus or ISJD with liquid ionomeric bone cement has the advantages of precise hearing results, cost effectiveness, and ease of application[13]. Ozer *et al*,[14] found that of 15 patients, 9 (60%) achieved a successful hearing result (an ABG to within 20 dB). Baglam *et al*, [12] had reported a postoperative ABG of less than 20 dB in 81.6 percent after one year using incudostapedial rebridging ossiculoplasty with ionomeric bone cement during tympanoplasty surgery. In our study (bone cement group), ABG closure to within 20 dB was found in 6/9 ears (66.7 %).

CONCLUSION

This Few months after head trauma, ossicular lesion is suspected in cases with persistent ABGs greater than 30 dB with an intact TM. Traffic accident is the commonest cause of ossicular lesions. When the ISJ is dislocated, two options exist for ossicular reconstruction: bypassing the stapes using Teflon piston (stapedotomy) and anatomical reconstruction using ionomeric bone cement. Both techniques are successful with no statistically significant difference regarding hearing outcomes.

CONFLICT OF INTEREST

There are no conflicts of interest.

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