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Original Article

Role of Mastoid Pneumatization on the Success of Tympanoplasty Type- 1 Operation

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Abstract

Background: Mastoid pneumatization is an anatomical feature that can impact surgical outcomes in tympanoplasty Type 1 operations. The relationship between mastoid pneumatization and the success of tympanoplasty procedures is a topic of growing interest within the field of otolaryngology.

Aim: This study aimed to detect the role of mastoid pneumatization in predicting tympanoplasty type 1 operation success.

Subjects and Methods: Between February 2023 and February 2024, 40 patients attended in the otorhinolaryngology head and neck surgery department at Al-Azhar University Hospital [Damietta] participated in this prospective trial. Cases diagnosed with COM, medium-sized central tympanic membrane perforations, underwent CT scan for mastoid information, including pneumatization, and underwent endoscopic type I tympanoplasty with tragal cartilage graft.

Results: All patients diagnosed as mild conductive hearing loss with air-bone gap 20.0±5.58 dB underwent endoscopic tympanoplasty with tragal cartilage graft, resulting in a 90% success rate for graft taking and 10% failure graft taking. Utilizing a CT scan, we were able to determine that out of the 36 successful cases of tympanoplasty that we studied, 4 cases had failed following tympanoplasty. The success group showed a significant increase in longitudinal, transverse, surface area and total volume dimensions while the failure group did not.

Conclusion: Significant increases were observed in longitudinal, transverse, total volume, and surface area for the success group compared to the failure group.

Keywords: Mastoid; Mastoid Pneumatization, Tympanoplasty.

INTRODUCTION

With regard to the functional equilibrium of the middle ear, the mastoid air system is among the most substantial structures that are present in the ear. There is no change in the size of the mastoid bone amongst males and females when they reach adulthood. In addition, a number of studies discovered that there were no statistically substantial changes in mastoid pneumatization amongst the right and left sides of the body. In addition to being determined by genetics, the size of mastoid cells is also found to be influenced by environmental factors [1]. In order to reconstruct the tympanic membrane and improve hearing, a surgical procedure known as tympanoplasty is performed. The goal of this procedure is to prevent recurring otorrhea. A tympanic membrane perforation is typically the result of middle ear infections, trauma, or iatrogenic causes. It can also be caused by certain medical conditions [2].

There is a significant disparity between the stated success rates of tympanoplasty, which range from 56% to 94%. This disparity can be due to the fact that different selection criteria and definitions of success have been used at different times. The outcomes of surgical procedures such as tympanoplasty are determined by a number of factors, involving age, the size and location of the perforation, the type of graft, the condition of the opposite ear, the functional status of the Eustachian tube, the pneumatization of mastoid bone, the condition of the middle ear mucosa and the degree of pneumatization of mastoid air cells. These factors all play a role in determining this outcome [3]. In the field of imaging the structures of the ear, a substantial advancement has been made possible by the introduction of high-resolution thin section computed tomography. Computed tomography, on the other hand, has introduced an entirely new facet to the evaluation of the ear by making it possible to visualize the soft tissue components that are located within and adjacent to the temporal bone. Investigation into the impact that mastoid pneumatization has on the results of tympanoplasty has been made possible as a result of this. The bony components of the temporal bone are represented with resolutions that are roughly equivalent to those obtained using polytomography [4].

AIM OF THE WORK

The target of this research was to detect the role of mastoid pneumatization in predicting tympanoplasty type 1 operation success.

PATIENTS AND METHODS

The Otorhinolaryngology Head and Neck Surgery Department at Al-Azhar University Hospital [Damietta] were the participants in this prospective trial, which was carried out between February 2023 and February 2024. The investigation included forty cases who were treated there.

Sample size justification: This study based on study carried out by **Yegin *et al*.** [5]. Epi Info was used to calculate the sample size. By considering the following assumptions: 95% two-sided confidence level, with a power of 80% and α error of 5%, the sample size taken from the Epi- Info output was 32. Thus, the sample size was increased to 40 subjects to assume any drop out cases during follow up.

Inclusion criteria: Both sexual encounters with A type I tympanoplasty procedure is scheduled for individuals who are at least 12 years old & have COM with central perforation, normal middle ear mucosa, a dry middle ear cavity, & an intact ossicular chain. The Eustachian tube function of all cases who are included in the study should be normal [Eustachian tube function was also assessed preoperatively using Valsalva maneuver. It was assured that Eustachian tube function was normal in all cases], & their hearing level should correlate to the size and location of the TM hole. A deficiency in the ossicular chain or any other type of disease should not be assumed to be present.

Exclusion criteria: The presence of active ear discharge, a history of past middle ear operations, individuals who have undergone any form of mastoidectomy or revision tympanoplasty, & individuals who are not eager to have surgery are all indicators of infection at the time of operation. Attico-antral Chronic suppurative otitis media [CSOM], tympanosclerosis, cholesteatoma, individuals who have suspected ossicular pathology with an air-bone gap greater than 40 decibels, individuals with sensorineural hearing loss [SNHL], cases with a history of radiotherapy to the neck & head region, & patients who refuse to participate in the study are all individuals who are not eligible for the study.

Counseling and consent: After providing individuals with an explanation of the goal of the research & obtaining signed consent from each patient or his guardian, a comprehensive description of the procedure was then provided to the individuals. During the immediate postoperative period, the cases were given instructions to keep their ears that had been operated on dry and was instructed to return to the clinic if they saw any signs of wound infection, such as pain or discharge.

All patients were subjected to the following:

Preoperative evaluation: History taking including: Past history, Present history, Personal history, Family history and history of previous surgeries, general examination, full ENT examination including: nasal examination, ear examination otoscopic, Oropharyngeal examination, and endoscopic, and neck examination.

Laboratory investigations: Pure tone audiometry and audiological assessment [Figures 1,2]. Radiological assessment by CT scan [Figures 3 to 6] of the coronal cuts and temporal bone axial for all patients.

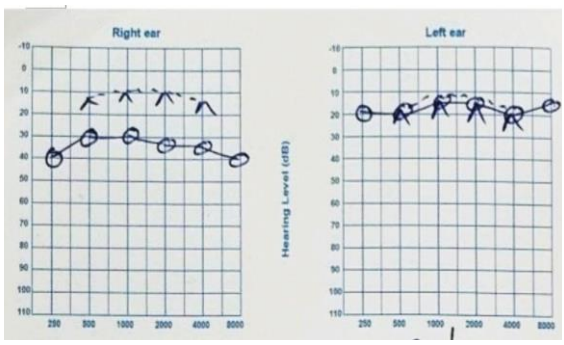

Figure [1]: Pure tone audiometer [PTA] showing right mild conductive hearing loss.

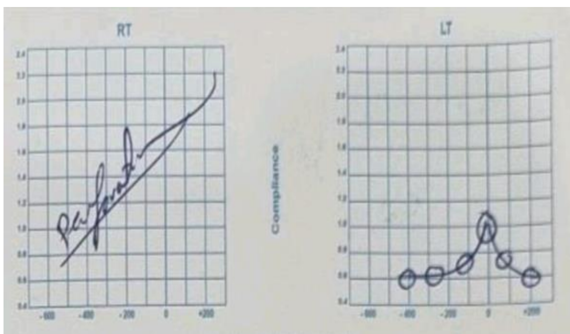

Figure [2]: Tympanometry Showing RT Tympanic membrane perforation.

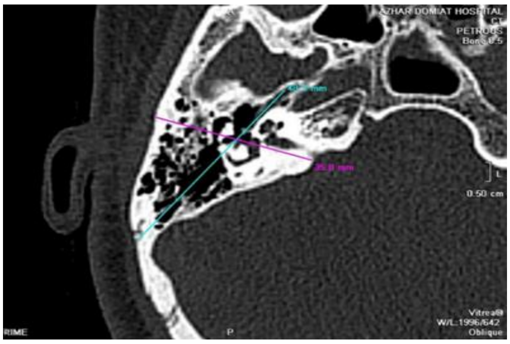

Figure [3]: CT Temporal Bone Axial view

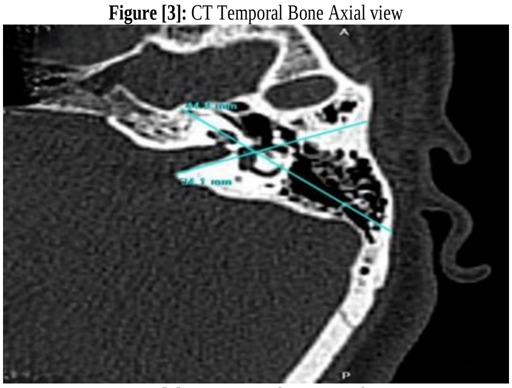
Figure [4]: CT Temporal Bone Axial view

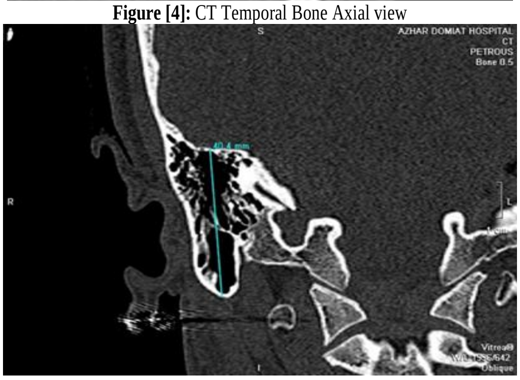

Figure [5]: CT Temporal bone coronal view

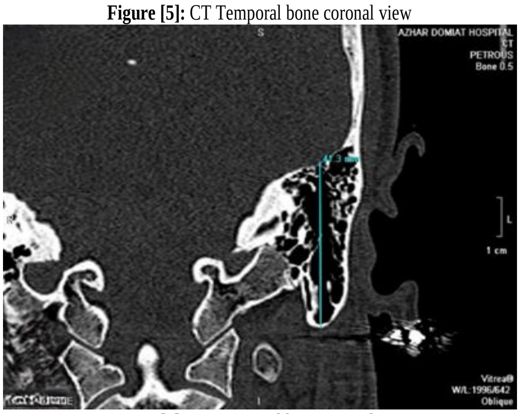

Figure [6]: CT Temporal bone coronal view

Computed Tomography Images Measurement and Analysis: Through CT Imaging: Using a 160-row multi-detector CT scanner [TOSHIBA Aquilion prime], an axial volume scan with coronal and sagittal reformations [0.67 mm] parallel to and perpendicular to the lateral semi-circular canal was conducted [120,000 kV, section thickness of 0.67 mm]. Using specialized software [Vitrea fX 6.7.4, Vital Images], the images were post-processed on a workstation. A semiautomatic algorithm is used to define a Hounsfield unit threshold amongst adjacent structures. This threshold is chosen by the user. The lower limit of the intrapetrous carotid artery, the anterior wall of the internal auditory canal, the cochlea, the medial limit of the petrous apex and the semicircular canals were among the sites used for measurements at the malleus-incus level. The width, height, anteroposterior length, and total width of both mastoids were measured as the linear dimensions of the mastoid air cells. The area of every air cell [cm^2] and the perimeter [cm] of each image were measured, highlighted, and added together for each image. The results of this multiplication were the mastoid surface area [cm^2] and volume [ml], respectively, after a section interval of 0.25 cm. Every axial CT scan was used to measure the area of each mastoid air cell in each ear, which was then multiplied by the thickness of the slice. The mastoid bone's volume was determined by adding up all the measurements.

Operative procedure: A general anesthetic was administered during the surgical procedures. All surgical treatments that are carried out through the utilization of endoscopic method and tragal cartilage graft will be conducted.

Surgical technique [Figures 7-10]: In addition to cleaning and inspecting the ear canal, tests were performed to determine the health of the perforation and the middle ear mucosa. An injection of a local anesthetic, which contained epinephrine at a concentration of one hundred thousand, was administered into each of the four quadrants of the outer ear canal. De-epithelization of the perforation edges as well as harvesting of the ipsilateral tragal cartilage graft [Figure 7] were both performed. Transcanal incisions, which are created in the external ear canal, are a useful method for gaining access to the middle ear. These incisions elevate the tympanomeatal flap alongside the annulus. Following the examination of the continuity and movements of the ossicles as well as the integrity of the middle ear, the malleus was dissociated from the tympanic membrane by means of a pick. The prepared graft was then positioned lateral to the malleus and medial [over-underlay] to the remnant of the membrane. Finally, sponges were inserted into both the middle ear and the outer ear canal in order to finish the operation.

Postoperative follow up: At one month and three months, otoscopic and endoscopic ear examinations were used to evaluate the outcomes of the procedure [Figures 11 and 12]. The following results were observed during the endoscopic examinations performed at the first and third months after the surgery: the size and location of the tympanic membrane perforation, as well as the postoperative graft status.


Figure [7]: Harvested tragal cartilage graft.

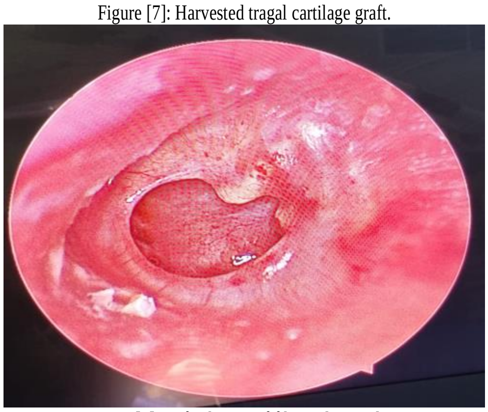
Figure [8]: Refreshment of fibrosed TM edges

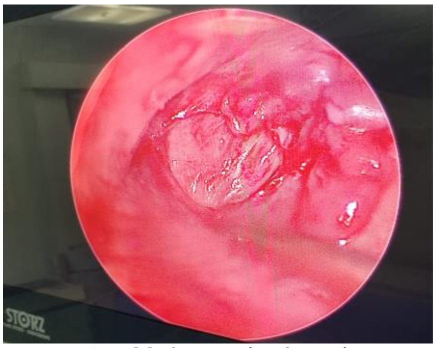

Figure [9]: Placement of cartilage graft.

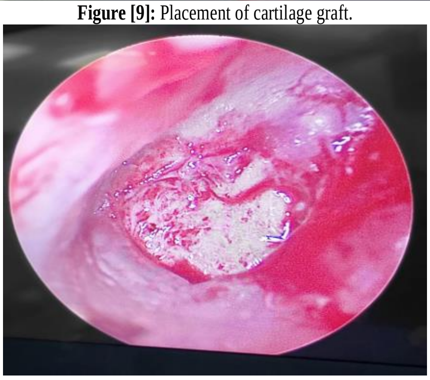

Figure [10]: Placement of Gell foam

Figure [11]: Follow up after 1 month.

Figure [12]: Follow up after 3 months

RESULTS

The age of the average of the participants was 19.88 years, 27.5% of the subjects were male, while 72.5% were female, 32.5% were married, and 67.5% were not married, 22.5% of the subjects lived in urban areas, & 77.5% in rural areas [Table 1]. One-hundred percent of cases with central tympanic membrane perforation underwent endoscopic tympanoplasty with tragal cartilage graft resulting in a 90% success rate for graft taking, and 10% failure graft taking [Table 2]. Outlines pure tone audiometry for the same subjects, revealing conductive hearing loss in 100%. The hearing loss degree was mild, with ABG of 20 ± 5.58 dB [Table 3].

Age showed, a significant decrease in the success group p=0.0302 [18.75 ± 8.14 years] compared to the failed group [30 ± 16.06 years] [Table 4]. The success group demonstrated a substantial increase in longitudinal dimensions and transverse dimensions compared to the failure group p= 0.0255, 0.0232 respectively. However, depth measurements decreased in the success group p=0.0223. The overall volume increased significantly in the success group p=0.0373, while the surface area was significantly higher in the success group p=0.0229 [Table 5]

Table [1]: Demographic data and basal characteristics of included subjects

		Value [N = 40]
Age [Years]		19.88 ± 9.96
Gender [n,%]	Male	11 [27.5%]
	Female	29 [72.5%]
Residence [n,%]	Urban	9 [22.5%]
	Rural	31 [77.5%]

Table [2]: Disease evaluation among included subjects

		Value [N = 40]
Diagnosis	Medium size central tympanic membrane perforation	40 [100%]
COM SIDE	Right	27 [67.5%]
	Left	13 [32.5%]
Operation [Endoscopic tympanoplasty]		40 [100%]
Tragal cartilage graft		40 [100%]
Result of graft	Taken = success cases	36 [90%]
	Failed = failed cases	4 [10%]

Table [3]: Pure Tone Audiometry of included subjects

		Value [N = 40]
Conductive Hearing loss		40 [100%]
Degree	Mild Conductive Hearing loss	40 [100%]
	ABG [dB]	20 ± 5.58

Table [4]: Comparison between Failed and Success cases regarding demographic data

		Failed [N = 4]	Success [N = 36]	P. Value
Age [year]		30 ± 16.06	18.75 ± 8.14	0.0302*
Gender [n,%]	Male	2 [50%]	9 [25%]	0.3002
	Female	2 [50%]	27 [75%]	0.3002
Residence	Urban	2 [50%]	7 [19.44%]	0.1735
	Rural	2 [50%]	29 [80.56%]	0.1735

Table [5]: Comparison amongst Failed and Success cases regarding C.T Finding of mastoid pneumatization

	Failed [n = 4]	Success [n = 36]	P. Value
Longitudinal [cm]	1.58 ± 0.43	1.94 ± 0.27	0.0255*
Transverse [cm]	1.24 ± 0.19	1.57 ± 0.26	0.0232*
Depth [cm]	0.49 ± 0.08	0.44 ± 0.03	0.0223*
Total volume [ml]	0.95 ± 0.27	1.36 ± 0.36	0.0373*
Surface are [Cm^2]	2.04 ± 0.85	3.09 ± 0.82	0.0229*

* indicating significant difference

DISCUSSION

In order to repair the tympanic membrane and close any perforations that have developed in the tympanic membrane, a surgical method that is known as type 1 tympanoplasty is utilized [3]. Only the restoration of the tympanic membrane may be accomplished with this method." During this method, the ossicular chain is not damaged and retains its mobility. Additionally, there are no other surgical operations performed in the middle ear [6]. Among the structures that contribute to the functional equilibrium of the middle ear, the mastoid air system is among the most important among them. It is around 15 years of age for men and ten years of age for women before the development of the mastoid air cell system reaches its full maturity [1].

The main results of our study were as following:

A standard deviation of 9.96 years was found among the participants, with the average age of the participants being 19.88 years old. Gender distribution showed that 27.5% of the subjects were male, while 72.5% were female. Marital status indicated that 32.5% were married, and 67.5% were not married. Regarding residence, 22.5% of the subjects lived in urban areas, 77& 77.5% in rural areas. ***Metin et al.*** [7] who wanted to investigate the connection among mastoid air cell volumes and graft success after tympanoplasty, reported that out of the 57 individuals who participated in the investigation, 20 [35.09%] were male and 37 [64.91%] were female, with a mean age of 29.69 [range 12–56]. However, our findings were supported by their findings. **Marchioni *et al.*** [8] aimed to present the results that were obtained in their institution & describe what they consider to be the most advanced method for treating tympanic membrane perforations, they reported that a total of one hundred nine patients participated in their study. The ratio of males to females in their study was 0.72, with forty males and fifty-seven females each.

We found that all patients were diagnosed with central tympanic membrane perforation. All of them underwent endoscopic tympanoplasty with tragal cartilage graft, resulting in a 90% success rate for graft taking and 10% failure graft taking and all presented with medium-sized central tympanic membrane perforation. Our results agreed with **Sethi *et al.*** [9] who reported that all 50 cases diagnosed with central tympanic membrane perforation. Out of the remaining individuals, thirty-eight cases [76%] had effective graft take up, twelve cases [24%] experienced failure, & five cases [10%] had a tiny tympanic membrane hole.

A study conducted by **Yegin *et al.*** [10], aimed to determine the extent to which the degree of mastoid pneumatization influenced the success rate of cartilage type 1 tympanoplasty, also conducted a research with the same objective, they reported that all patients underwent cartilage type 1 tympanoplasty. In addition**, Aggarwal and Dev** [11] reported that the overall success rate was 89%.

Our current study showed regarding outlines pure tone audiometry for the studied subjects, conductive hearing loss was reported in 100%. The hearing loss degree was mild, with an ABG of 20 ± 5.58 dB [11]**.** In addition, **Marchioni *et al.*** [8] who reported that Prior to the operation, the average ABG was 27 ± 5 dB.

On comparison of demographic data between failed [N = 4] and successful [n=36] cases, our results findings revealed that age demonstrated a substantial decrease in the success group [18.75 ± 8.14 years] compared to the failed group [30 ± 16.06 years]. In terms of gender &residence, was observed no statistically substantial variance amongst the groups who were successful & those that were unsuccessful. Our results agreed with **Abd Elnaem *et al.*** [12] who reported that was observed statistically substantial variance amongst successful & failed groups regarding age.

In addition, **Yegin *et al.*** [10]**, & Costa *et al.*** [13] reported that was noted no statistically substantial variance amongst successful and failed groups regarding gender. Otherwise, was observed statistically significant difference regarding age.

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Regarding clinical evaluation, our results demonstrated that all patients had medium sized central tympanic membrane perforation, COM side [Right or Left], operation [Endoscopic tympanoplasty], tragal cartilage graft, result of graft [Taken, Failed]. With relation to the existence of COM in the contralateral ear, **Costa *et al*.** [13] concluded that was observed no statistically substantial variance amongst the two groups that were studied in terms of the perforation side or type. Additionally, **ElBeltagy *et al*.** [14] found no statistically substantial variance in the success rate of tympanoplasty amongst the pneumatized & non-pneumatized groups, despite the fact that the pneumatized group demonstrated better graft uptake rate than the non-pneumatized group. The researchers aimed to compare the effect of pneumatized & non-pneumatized mastoid on the success of tympanoplasty in terms of rate of graft uptake & air-bone gap improvement.

The current study showed that audio-logical assessment revealed a significant decrease in conductive hearing loss [10% to 90%] in the success group compared to the failed group. Neither of the two groups exhibited any discernible differences, according to the ABG. In accordance with the findings of **Toros *et al.*** [15] who stated that the variance in ABG closure amongst the groups was not statistically substantial [$p > 0.05$], our findings were corroborated by their findings. Aside from that, was observed no statistically substantial variance amongst the two groups in terms of hearing gain.

Regarding computed tomography [C.T] findings for mastoid pneumatization in all 40 subjects. Significant increases were observed in longitudinal [1.89 ± 0.35 cm], transverse [1.53 ± 0.31 cm], total volume [1.29 ± 0.43 ml], and surface area [2.9 ± 0.98 cm^2]. In the present study, we present a comparison between cases of failed and successful mastoid pneumatization based on computed tomography [CT] findings. The failed group consisted of 4 cases, while the successful group comprised 36 cases. Regarding longitudinal dimensions, there was a substantial increase observed in the success group [1.94 ± 0.27 cm] compared to the failed group [1.58 ± 0.43 cm] [p = 0.0255*]. Similarly, the transverse dimensions showed a significant increase in the success group [1.57 ± 0.26 cm] compared to the failed group [1.24 ± 0.19 cm] [p = 0.0232*]. Depth measurements also exhibited a significant decrease in the success group [0.44 ± 0.03 cm] compared to the failed group [0.49 ± 0.08 cm] [p = 0.0223*]. Furthermore, there was a significant increase in the total volume observed in the success group [1.36 ± 0.36 ml] compared to the failed group [0.95 ± 0.27 ml] [p = 0.0373*]. Surface area measurements displayed a significant increase in the success group [3.09 ± 0.82 cm^2] compared to the failed group [2.04 ± 0.85 cm^2] [p = 0.0229*].

In line with these results, **Amer *et al.*** [16] who reported that the mean transverse diameter was 1.44 cm in successful instances & 0.833 cm in unsuccessful instances with a substantial variance [P = 0.0476], found that there was a statistically substantial variance amongst successful cases & unsuccessful cases in terms of the mean mastoid surface area [**P** = 0.0087]. Both of these findings are supported by our findings. It was stated that the mean longitudinal diameter of the mastoid was determined to be 2.35 centimeters in successful instances & 1.43 centimeters in unsuccessful instances, with a variance that was nearly substantial [P = 0.0636].

Conclusion: Significant increases were observed in longitudinal, transverse, total volume, and surface area for the success group compared to the failure group.

Financial and non-financial relationships and activities of Interest: None

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