Mrmc Neo Surgical Ventilating Port and Neo Attic Malleo-Incudal Complex in Endoscopic Management of Limited Attico-Antral Cholesteatoma

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Abstract To study functional outcome of the endoscopic management of limited attico-antral cholesteatoma in terms of visualization of sac, cholesteatoma disease clearance, ABG closure improvement, preservation of residual anatomy and recurrence of disease. It is a prospective study done during Feb 2016 to March 2017 done on 20 pts with limited attico-antral cholesteatoma with CT confirmation. Endoscopic management of limited attico-antral cholesteatoma with complete removal of sac, infected discharge and granulations along with creation of MRMC Neo surgical ventilating port (joining Anterior & posterior isthmuses) done in cases where residual attic anatomy was present to establish physiological attic ventilation and drainage. Whereas in cases of attic and ossicular erosion, ossiculoplasty along with neo attic malleo-incudal complex (with composite tragal cartilage with perichondrium graft) for lateral attic wall reconstruction was done to prevent attic retraction. Patients had mean pre op ABG of 36.29 ± 6.29 and mean post op ABG closure of 16.33 ± 6.50 with no recurrence of cholesteatoma at 6 months of follow up. Patient showed significant (55%) improvement in hearing with all having graft uptake in which four cases having mild pars tensa retraction which recovered later without any intervention. Thus creation of new MRMC Neo surgical ventilating port or neo attic malleo-incudal complex with endoscopic approach allows better visual access to clear the limited attico-antral disease with sparing of normal residual attic anatomy along with physiological ventilation and drainage having better hearing results and outcome.

Keywords Attico-antral cholesteatoma · Endoscopic ear surgery · Middle ear mucosal folds · Spaces · Ventilation

Introduction

Cholesteatoma is known for its ruthless spread into the middle ear cleft for which modified radical mastoidectomy has been a time tested procedure to eradicate and exteriorise the extensive cholesteatoma presenting in various regions of the attic and the mastoid. The radicality of this procedure affects the normal anatomy and physiology of the attic and antrum when considered as a treating tool for a limited attico-antral cholesteatoma; which can be treated by minimally invasive techniques, yet preserving the anatomy and physiology of this region.

Starting in the 1990s, operative endoscopy was introduced in otologic surgery, and significantly changed not only surgical concepts but also anatomical view of middle ear and physiologically achieved better hearing results, which has popularised it during the last 25 years [1, 2].

Since the introduction of this instrument, the concept of a minimally invasive approach in middle ear surgery is changing. The wide and varied view of the endoscopes allows for a minimally invasive transcanal access to the attic, providing complete removal of limited disease without the need for a postauricular or canal wall down approach.

Materials and Methods

Study was conducted between February 2016 to January 2017 at Department of ENT, Basweshwara Teaching and General Hospital, attached to M. R. Medical College

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(MRMC) Kalaburagi. Patients were selected on the basis of inclusion and exclusion criteria. Only subjects affected by limited attico-antral cholesteatoma with a minimal posterior involvement of the antrum and a minimal inferior involvement up to the second genu of the facial nerve were included. Subjects affected by middle ear cholesteatoma extending to the mastoid cells except antrum, mesotympanic or protympanic area were excluded. Patients affected by petrous temporal bone cholesteatoma, iatrogenic cholesteatoma and congenital cholesteatoma were also excluded.

Preoperative Evaluation

Patients underwent traditional microscopic examination and audiometric studies. In addition, an office-based endoscopic ear examination and Computed Tomography (CT) scanning of the temporal bone was done mainly to decide the pathological extent and hearing loss to fulfil the criteria of limited attico-antral disease.

Surgical Technique

Local anaesthesia with intravenous sedation was preferable but were given the option of general anaesthesia. The ear canal was infiltrated with xylocaine 2% with 1:80,000 epinephrine. The whole ear procedure was performed solely with the endoscope (20 cm length, 4 mm wide angle, 0° and 30° sinoscope with 3 chip camera and LED light source attached). A wide posterior tympanomeatal flap was elevated. As the annulus is elevated and the middle ear is entered, the cholesteatoma sac is elevated off the middle ear structures, in continuity with the flap when possible. The sac is then pursued and dissected from the attic and antral area with cotton ball, microear pointed pick and ball probe under direct vision, with the bony rim curetted using differently sized bone curettes to view the posterior extent into the antral and the anterior attic area under continuous monitoring with the endoscope. The mucosal folds with body of the incus and the head of malleus were preserved or removed if eroded on the basis of the extent and location of disease. After assuring the complete removal of cholesteatoma sac with excision, appropriate ossicular chain work (ossiculoplasty) was performed when ossicles were eroded. When all ossicles were intact with oedematous attic mucosal folds and purulent discharge in attic spaces which indicated both tympanic isthmuses block; the disease clearance was done by allowing the drain of the inspissated purulent attic discharge by creating wide *MRMC Neo surgical ventilating port* ensuing complete attico-antral ventilation and drainage. This was done by perforating through the medial incudal fold (Fig. 1) joining both the isthmus establishing a

wide ventilating port termed as *MRMC Neo surgical ventilating port* (i.e. from tensor tympani tendon anteriorly to bony pyramid and posterior incudal ligament posteriorly) ventilating from mesotympanum to the attic. When completely the attic mucosal folds and ossicles were eroded the attic defect was measured and closed using a composite tragal graft representing as *neo attic malleo-incudus complex* of the attic guarding the lateral attic wall with excess perichondrium to prevent later retraction around the graft (Fig. 2). The tympanic membrane defect is reconstructed using an underlay temporalis fascia graft. The tympanomeatal flap is then repositioned, and the ear canal then packed with gelfoam. The time taken for each procedure was recorded. Continuous office based endoscopic ear examination and pure tone audiometry was done in the follow up period up to 6 month and results noted down.

Results

Twenty patients were included. There were 12 males and 8 females. The youngest patient was 16 years old, and the oldest was 51. Endoscopic OPD-based examination was incorporated into all routine evaluation along with preoperative CT scan of the temporal bone was performed in all ears, and it was suggestive of a limited attico antral cholesteatoma in which 14 cases had opacification of both attic and aditus while remaining 6 had involvement of only the attic. Pure tone Audiologic testing showed a mean air–bone gap of 36.29 ± 6.29 dB (average of air–bone gap at 500, 1000, 2000, 4000 Hz) in 20 ears. Bone thresholds were stable. A transcanal endoscopic approach was adequate for complete intact elevation and removal of cholesteatoma sac in continuation of tympanomeatal flap elevation from attic to antrum with good visualisation of anatomical attic

Fig. 1 Inferior view of Mrmcneo surgical ventilating port 1 and 2 after removal of intraossicular fold between handle of malleus 3 and long process of incus 4 (exposing Anterior isthmus-1) and removal of medial incudal fold between incus short process and stapedius tendon 6 (Widening Posterior Isthmus & joining with Anterior Isthmus with 0.8 mm ball probe & seen as 1 & 2), 7 pyramidal eminence, 8 round window niche, 9 promontory, 10 tympanomeatal flap

Fig. 2 Reconstruction of lateral attic wall with composite tragal cartilage 1 tragal cartilage with perichondrium (as neo attic incudo-malleal complex), 2 oval window, 3 round window, 4 promontory, 5 horizontal part of facial nerve

spaces and mucosal folds with removal of pathological sac, purulent discharge, granulation, ossicular erosion with varying degree using angled scopes in all cases.

In six cases the disease was confined to attic with all ossicles intact with edematous attic mucosal folds with purulent discharge, the disease clearance with draining of attic discharge was done along with establishment of the ventilation to the attic from mesotympanum was ensued by a large *MRMC Neo surgical ventilating port* to the attic. At the end of 6 month follow up showed a mean air–bone gap closure of 11.77 ± 2.61 dB (Table 1).

In 14 cases had involvement of both attic and antrum, of which 10 of these having malleus, incus and stapes supra structure eroded, the attic was reconstructed by using a composite tragal cartilage with perichondrial graft as a *neo attic malleo-incudus complex* (Fig. 2) for attic support and type 4 tympanoplasty was done by stapes foot plate augmentation by cartilage and in four cases long process of incus was eroded, the malleus and the remnant of incus were preserved for attic support after thorough clearance of

retraction from attic and antrum with establishment of *MRMC Neo ventilating port* and then followed by type 3 tympanoplasty augmenting stapes by cartilage. These 14 cases showed a mean air–bone gap closure of 19.33 ± 6.55 dB at the end of 6 month follow up. Combined mean air–bone gap closure was 16.33 ± 6.50 , with 55% improved hearing in all 20 cases at the end of 6 month of follow up (Table 1).

All cases had graft uptake. Mild to Moderate retraction in pars tensa was evident in four cases; which recovered and did not required further intervention. The average time taken for each procedure was 2 h 15 min.

Discussion

The tympanic diaphragm divides the attic from mesotympanum, this along with other mucosal folds and ligaments carry blood vessels just like mesentery suspending and holding ossicles [3] in the attic and dividing it into different compartmental spaces, (i.e.) (a) the posterior compartment (medial and lateral incudal space), (b) Prussak's space, just medial to pars flaccida and lateral to the head and neck of the malleus; (c) the anterior attic space anterior to the malleus head (Fig. 3), making the attic a busiest place resisting cholesteatoma formation. But the weak fibrous layer of pars flaccid under negative middle ear pressure forms retraction pocket in prussack's space and allowing it to spread via 2 routes—one commonest being from posterior pouch of von troeltsch to posterior attic space to aditus and antrum or middle ear, next least being from anterior pouch of von troeltsch if present to anterior attic space and middle ear spread. The attic is ventilated by anterior and posterior isthmus (1–3 mm) [4] openings in

Table 1 Functional hearing results during follow up period

	Mean pre operative ABG (mean $\pm$ SD)		ABG (mean $\pm$ SD)	Improvement (=pre–post Op ABG)	% Of improvement (%)
MRMC neo surgical ventilation port with intact ossicular chain	34.75 ± 5.10	Improvement at 3 month	12.59 ± 2.66	22.16 ± 4.87	62
		Improvement at 6 month	11.77 ± 2.61	23.18 ± 4.75	65
Types 3 and 4 tympanoplasty with attic reconstruction or MRMC neo surgical ventilating port	37.85 ± 6.34	Improvement at 3 month	23.22 ± 7.75	14.63 ± 4.34	36
		Improvement at 6 month	19.33 ± 6.55	18.08 ± 5.04	47
Combined hearing results	36.29 ± 6.29	Improvement at 3 month	18.64 ± 6.01	17.6	47
		Improvement at 6 month	16.33 ± 6.50	19.95	55

Fig. 3 1 Anterior malleolar fold, 2 lateral malleolar fold (below this Prussak's space), 3 lateral incudomalleal fold, 4 medial incudal fold, 5 plica stapedis, 6 obturatoria stapedis, 7 tensor tympani fold, 8 superior malleal fold incomplete medially communicating to anterior attic space anteriorly to this fold, 9 superior incudal fold, incomplete posteriorly and communicating laterally to lateral incudal space with an anterior opening viz posterior pouch of von troeltsch communicating to Prussak's space, medial to this fold is medial incudal space with two important openings 14 anterior isthmus and 15 posterior isthmus, ventilating all the attic compartments from mesotympanum shown in red arrows, 10 superior malleal ligament, 11 anterior malleal ligament, 12 posterior incudal ligament, 13 stapedioid muscle, 16 pyramidal eminence, 17 posterior pouch of von troeltsch, 18 malleus head, 19 incus body and short process, 20 stapes, 21 incudostapedial joint, 22 to Aditus-ad-antrum

tympanic diaphragm which forms an irregularly sloping floor of attic from tensor fold anteriorly to Medial Incudal fold & plica stapedioid posteriorly and also mucosal epithelium changes from ciliated columnar epithelium in Eustachian tube to cuboidal epithelium with thick subepithelial connective tissue in the mesotympanum to pavement epithelium with thinner subepithelial connective tissue in the attic, antrum, mastoid air cells [5] thus facilitating secretions of attic by sloping attic floor and gravity rather than by mucociliary clearance (through isthmus openings), any hindrance to this drainage leads to array of pathological changes (by keratoma, polyp, oedema preventing aeration of attic and mastoid air cells) in the local attic environment ultimately leading to retraction and cholesteatoma in presence of normal Eustachian tube. Palva et al. [6] observed the persistence of inflammatory materials and cholesterol granuloma in the superior attic despite the tympanostomy tube study on children of isthmus block, attributing it to attic cholesteatoma developing from a pocket retraction.

So the surgeon's aim, in presence of normal Eustachian tube should be to create a wide ventilating port connecting both the isthmuses to prevent the pathology of blocked isthmuses (similar to normal ethmoid infundibulum ventilating and its block leading to recurrent sinusitis addressed by widening blocked ostium of paranasal sinuses of nose [7]) which has been done through MRMC neo surgical ventilating port done in ten cases of isthmus block which was possible by the use of different angled endoscopes because of wide visual access than with microscope with limited access and reach especially to medial compartment

where ossicles have to sacrificed even to remove the cholesteatoma [8, 9] and canal wall down procedures which can be prevented by transcanal access and step by step removal of sac as it extends into the attic spaces and even shortening the operating time [10–12] where even Some authors have proposed different surgical approaches to visualize the tympanic diaphragm; otherwise, it is very difficult to observe this particular structure with a microscope [13, 14]. In cases where attic ossicles were eroded, even the lateral attic wall can be reconstructed by tragal cartilage perichondrium graft (neo malleo-incudal complex) done in 10 cases. All cases on follow up of 6 months showed graft uptake in which four cases had mild pars tensa retraction which also recovered during follow up period as compared to study by tarabichi who encountered recurrence in the follow up period (6 out of 69 cases) which could be probably because of not addressing the ventilation and not adding anatomical support to lateral attic reconstruction, which were improvised in our study through endoscope [15].

This improved endoscopic access facilitates

- Better preservation of the ossicles, attic folds and spaces while ensuring complete removal of the matrix from the attic spaces and antral area in toto while preserving the residual normal anatomy left.
- Providing an alternate route to physiologically ventilate; breaking the vicious cycle of edema and blockade by creating a *MRMC Neo surgical ventilating port* re-establishing ventilation and drainage to the attic in cases due to its block.
- Reconstructing the eroded lateral attic wall with composite tragal cartilage (*neo attic malleo-incudus complex*), preventing attic retraction in cases where there was bony attic wall with complete ossicular erosion due to the disease.

Our study showed better functional results with reduction of mean air–bone–gap from 36.3 ± 5.10 dB pre op to 15.5 ± 6.55 dB post op probably as compared to Daniele et al. study [16] where reduction of air–bone–gap was <25 dB (at 500, 1000, 2000 Hz) postoperatively from average air–bone–gap of 25 dB or more pre operatively probably due to *MRMC Neo surgical ventilating port* providing physiological ventilation and drainage of the attic. Good hearing result was also observed by Tarabichi in his study “limited attic cholesteatoma by endoscopic approach” [11, 15].

Conclusion

Endoscope gives a direct and wide visual access to remove in toto the attic and antral retraction and cholesteatoma preserving the residual normal attic anatomy where

possible with creation of *MRMC Neo surgical ventilating port* attaining good physiological attico-antral aeration with drainage and surgical reconstruction of lateral attic by composite tragal cartilage graft as *neo attic malleo-incudal complex* where the attic anatomy is distorted by the disease process preventing future retraction and cholesteatoma formation and ultimately achieving better outcome in terms of anatomical preservation, reconstruction as needed with good physiologically functioning middle ear along with overall better hearing results after tympanoplasty.

Compliance with Ethical Standards

Conflict of interest There was no conflict of interest and no funding was received for the research.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Prior approval from ethical committee of the institute was taken.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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