

Combined Heermann and Tos (CHAT) technique in cholesteatoma surgery: surgical technique and preliminary results

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Abstract

The combined Heermann and Tos (CHAT) technique is the combination of Heermann's 'cartilage palisade tympanoplasty' and Tos's 'modified combined approach tympanoplasty = modified intact canal wall mastoidectomy'. The first author (Cem Uzun) performed the CHAT technique as a one-stage operation in 15 ears of 15 patients with cholesteatoma. Two patients (one with a follow up of less than six months and one who did not show up at the final re-evaluation) were excluded from the study. Median age in the remaining 13 patients was 37 years (range: 14–57 years). Cholesteatoma type was attic, sinus (Tos tensa type 1) and tensa retraction (Tos tensa type 2) in six, five and two ears, respectively. Cholesteatoma stage was Saleh and Mills stage 1, 2, 3, 4 and 5 in one, three, four, four and one ear, respectively. The eustachian tube was not involved with cholesteatoma in any ear. After drilling of the superoposterior bony annulus, transcanal atticotomy with preservation of thin bridge and cortical mastoidectomy with intact canal wall, the cholesteatoma was removed, and the eardrum and atticotomy were reconstructed with palisades of auricular cartilage. Type I tympanoplasty was performed in two ears, type II in nine ears and type III (stapes absent) in two ears, with either autologous incus (eight cases), cortical bone (two) or auricular cartilage (one). No complication occurred before, during or after surgery. Oto-microscopy and audiometry were done before and at a median of 13 months after surgery (mean 14 months, range 7–30 months). There was no sign of residual or recurrent cholesteatoma in any patient during the follow-up period. At the final examination, all ears were dry and had an intact eardrum except one with a small, central hole, which had been seen since the early post-operative period. Clean and stable attic retraction with a wide access was observed in two ears. Post-operative hearing at the final evaluation was better (change > 10 dB) than the pre-operative one in nine ears and did not change in the remaining four. Pre- and post-operative mean hearing values were, pure-tone average 47 and 35 dB ($p = 0.01$) and air-bone gap 30 and 20 dB ($p = 0.02$), respectively. With the CHAT technique, cholesteatoma can be completely and safely removed from the middle ear, and a durable and resistant reconstruction of the middle ear with reasonable hearing can be achieved. However, a further study should analyse long-term results of a larger patient group.

Key words: Cholesteatoma; Surgical Procedures; Hearing Loss

Introduction

Important goals in cholesteatoma surgery are to completely remove the disease without leaving residual cholesteatoma, to restore the ear anatomy properly in order to prevent recurrent cholesteatoma and to improve the quality of life of the patient (good hearing and no cavity problems). A technique that allows a surgeon to reach these goals would be ideal for cholesteatoma surgery.

In order to avoid recidivism, a surgical technique should provide good visualization of the common places of residual cholesteatoma. The most frequent places of residual cholesteatoma are the sinus tympani and anterior attic.^{1–4}

Post-operative eardrum retraction is a common complication in eardrums reconstructed with fascia after cholesteatoma surgery.⁵ This is an important reason for recurrent cholesteatoma.^{2,6}

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It has long been believed that complete eradication of cholesteatoma was impossible without the destruction of the canal walls; it is now known to be possible, however, and even represents the best method for the prevention of recurrence.⁷ In addition, canal wall up techniques may provide better hearing results and quality of life than canal wall down techniques.⁸ Canal wall down mastoidectomy can have a negative impact on a patient's lifestyle and wellbeing and carries an intrinsic morbidity, resulting in a long-term attendance in the out-patient clinic.^{9,10}

Therefore, a combination of a canal wall up mastoidectomy technique, which provides good visualization of the sinus tympani and anterior attic, with a reconstruction technique that prevents post-operative eardrum retractions, seems to be ideal. The combined Heermann and Tos technique (CHAT),^{11,12} a combination of Heermann's 'cartilage palisade tympanoplasty'^{13,14} and Tos's 'modified combined approach tympanoplasty'^{15,16} (or 'modified intact canal wall mastoidectomy' (Figure 1), may be the ideal technique.¹¹ Tos's technique consists of 'otosclerosis drilling' of the posterior-superior bony annulus, transmeatal atticotomy with preservation of a thin bridge, and cortical mastoidectomy with preservation of a thin posterior bony ear canal wall.^{12,15-17} Although Tos's technique is a canal wall up technique, it provides as good exposure of the sinus tympani and anterior attic as the canal wall down mastoidectomy does, and better exposure than the classic canal wall up mastoidectomy.^{15,16,18} Besides, the 'palisade reconstruction technique' can effectively prevent post-operative re-perforations, retractions and cholesteatoma recurrence, and also provides good long-term hearing results.¹⁹⁻²⁶

Related literature and the background studies related with the first author, gave CU the idea to combine those two original techniques. CU first

introduced the CHAT technique in 2002.^{11,12} In the present study, the CHAT technique is described and the preliminary results of the technique are evaluated.

Material and methods

Patients

Between July 2001 and September 2003, we performed the CHAT technique in 15 ears of 15 patients with cholesteatoma, under general anaesthesia. None of the patients had an intracranial or extracranial complication due to cholesteatoma. Two patients (one with a follow up of less than six months and one who did not show up at the final re-evaluation) were excluded from the study. Median age at operation in the remaining 13 patients was 37 years (range 14-57 years). Four of them were female and nine were male.

Otoscopic findings and cholesteatoma type

Pre-operatively, nine ears had total or subtotal perforation. Despite pre-operative medical treatment, persistent otorrhoea was present in eight ears at the time of operation. Tos's otoscopic classification²⁷⁻²⁹ was used to classify the cholesteatoma. Using this system, cholesteatomas are classified according to their site of origin as attic cholesteatoma, developing from Shrapnell's membrane, or tensa cholesteatoma, originating in the pars tensa. The tensa cholesteatoma is further subdivided into sinus cholesteatoma (Tos's tensa type I), developing from a postero-superior retraction and spreading toward the stapes and the tympanic sinuses, as well as medially to the incudal body and the malleus head up toward the attic and aditus, and tensa retraction cholesteatoma (Tos's tensa type II) involving the retraction of the entire pars tensa, extending into the hypotympanum or tubal orifice, as well as the posterior tympanum or medially to the incus and malleus up towards the attic and aditus.²⁷⁻²⁹ Accordingly, cholesteatoma type was attic, sinus and tensa retraction (tensa) in six, five and two ears, respectively (Table I).

The extent of cholesteatoma was defined according to the farthest involved site, as tympanic cavity, attic, antrum and mastoid process.³⁰ In addition, the extent of cholesteatoma was also graded using a staging system proposed by Saleh and Mills.³¹ In this staging, the extent of disease is defined by the number of sites involved with cholesteatoma. If the disease is confined to the site of origin, it is considered as stage 1. If the cholesteatoma spreads to another site (attic, antrum, tympanic cavity, mastoid cavity, eustachian tube, labyrinth and middle fossa), it is considered stage 2, and so on up to 5.³¹

Surgical technique

First, after the initial endaural (Tos incision)¹⁶ and retroauricular incisions, the posterior tympanomeatal flap along with the fibrous annulus was elevated and the posterior-superior bony annulus was drilled ('otosclerosis drilling').¹⁵

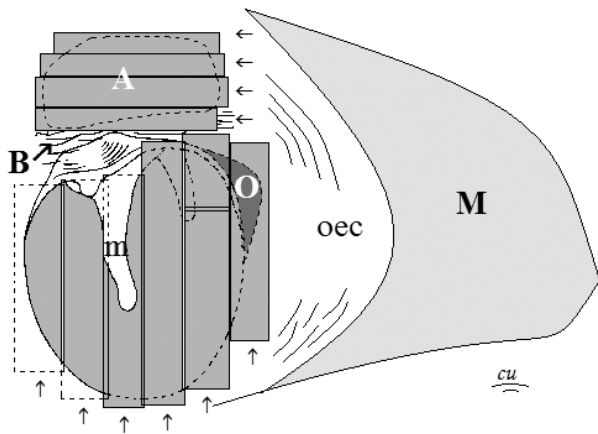


FIG. 1

Schematic view of the combined Heermann and Tos (CHAT) operation from the top of the outer-ear canal (oec). In the CHAT technique, the eardrum and atticotomy (A) opening is reconstructed with cartilage palisades (arrows) after drilling of the lateral wall of facial recess ('otosclerosis drilling' = O), transmeatal atticotomy with intact bridge (B) and cortical mastoidectomy (M) with intact canal wall. Palisades are placed parallel to manubrium (m) for the reconstruction of eardrum and anteroposteriorly for covering the atticotomy.

TABLE I

AGE, SEX, FOLLOW-UP TIME, CHOLESTEATOMA AND TYMpanoplasty TYPE OF THE PATIENTS OPERATED ON USING THE COMBINED HEERMANN AND TOS (CHAT) TECHNIQUE

No.	Patient		Follow-up time (months)	Type ^{27,28}	Cholesteatoma		Tympanoplasty type
	Age	Sex			Extent ³⁰	Stage ³¹	
1	40	M	9	Attic	Antrum	3	II
2	37	F	13	Sinus	Tympanic cavity	1	II
3	17	M	11	Tensa*	Mastoid process	4	II
4	42	M	11	Attic	Mastoid process	5	II
5	42	M	14	Sinus	External ear	2	I
6	57	M	8	Tensa*	Attic	2	II
7	52	M	11	Sinus	Mastoid process	4	III
8	14	M	17	Sinus	Antrum	3	II
9	28	F	7	Attic	Mastoid process	4	II
10	37	F	30	Sinus	Mastoid process	4	III
11	42	F	17	Attic	Tympanic cavity	2	II
12	22	M	19	Attic	Antrum	3	II
13	25	M	19	Attic	Mastoid process	3	II

retraction cholesteatoma

I*Tensa = Tens

Transmeatal atticotomy with preservation of a thin bridge and cortical mastoidectomy with intact and thin canal wall were performed (Figure 1).^{12,15-17} Large cholesteatomas involving ossicles, all but one extending into the attic (or from the attic to tympanic cavity), antrum, mastoid process or external ear canal, were removed.

When the ossicular chain was intact, a type I tympanoplasty was done, when the long process of the incus was defective but with an intact stapes suprastructure, a type II was done, and when the stapes was absent, a type III tympanoplasty was done. The eardrum and atticotomy were then reconstructed with palisades of auricular cartilage, as previously described (Figure 1).^{25,32} The cartilage was most often taken from the scapha-crural part of auricula, rarely from tragus or concha. The perichondrium was preserved on one side of the cartilage, and thin palisades (approximately 0.5 to 1 mm) were cut with a scalpel blade.

In ears with total perforation, after elevation of the tympanomeatal flap and the fibrous annulus, the first palisade was placed far anterior in the tubal entrance, medial to the bony annulus; the next one was also placed under the bony annulus. The third palisade had close contact with the malleus handle. The next palisades were placed posteriorly to the malleus handle but on the top of the bony annulus. The most posterior palisade was placed with its posterior edge on top of the posterior bony annulus (Figures 1 and 2).^{12,14,20,25,32} If the perforation was small and the inferior part of the drum was intact, the inferior ends of the palisades were usually placed under the remaining eardrum, without contact with the bony annulus.^{20,25,32} In ears with ossiculoplasty, the placement of the palisades was adapted to the placement of the interposed ossicle. Usually, shorter palisades were placed on the ossicle or between the ossicle and the bony annulus (Figures 1 and 2).^{12,20,25,32} This may have facilitated the mobility of the tympanic membrane and ossicular chain, and influenced the hearing results.

Palisades, which were placed parallel to manibrium mallei and beneath the fibrous annulus, should carefully cover the posterior bony annulus and

otosclerosis drilling, and the palisades, which were placed anteroposteriorly over the atticotomy, should carefully cover the lateral attic wall (Figure 1). Tympanomeatal and skin flaps, and fascia (if used) were replaced,¹² to cover the palisades with fascia was not necessary for the ones used for tympanic membrane reconstruction. However, we usually used fascia to cover and support the palisades over the atticotomy (Figure 2).

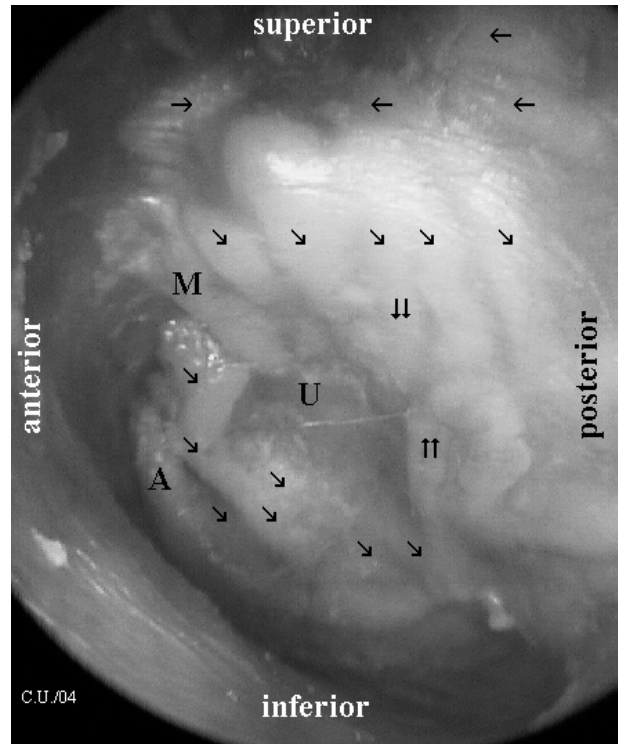


FIG. 2.

Otoendoscopic view of the left ear of a patient 20 months after a successful CHAT operation. The perichondrium, which was kept on one side of the cartilage palisades, fused with the perichondrium of the adjacent palisades, whereby the new eardrum was formed, supported by the cartilage palisades (arrows). Palisades over atticotomy (upper horizontal arrows) are not visible enough because of the fascia cover. Note the shorter palisades (double arrows) over and between the repositioned incus and superior and inferior bony annulus. M = manibrium; A = annulus; U = umbo.

A ventilation tube, 3 to 5 mm in diameter, was placed in the mastoidectomy cavity through a separate incision behind the skin incision and removed together with the ear canal pack, after three weeks. The ear canal was filled with gelfoam balls to secure the ear canal skin flaps, as well as a 1 cm wide strip of gauze moistened with oxytetracycline and hydrocortisone ointment. If pre-operative Valsalva's manoeuvre was negative, the patient performed the manoeuvre twice a day from the first week.^{12,16,17}

All patients were operated on by one of the authors (CU) in one stage via a retroauricular approach. We did not plan or perform a second stage or a second look operation, but instead closely followed the patients and intervened if symptoms occurred. Per-operative endoscopy was performed and all operations were recorded on videotapes.

Outcome measures

Oto-microscopy, pure-tone and speech audiometry (speech reception threshold, SRT, and speech discrimination score, SDS) were performed pre-operatively and at follow up at a median of 13 months after surgery (mean 14 months, range 7–30 months) (Table I). Pure-tone average was an average of thresholds at 0.5, 1, 2, and 3 kHz (the four-tone pure-tone average).³³ When threshold at 3 kHz was not available, a mean of 2 and 4 kHz was taken as an estimated threshold at 3 kHz.³³ Air-bone gap was the four-tone pure-tone average for air conduction minus the same average for bone conduction. In addition, the pre-operative minus the post-operative high pure-tone bone-conduction average at 1, 2, and 4 kHz was calculated as a measure of operative damage to hearing.³³ Differences between pre-operative and post-operative hearing results were analysed with Wilcoxon signed ranks test. A *p* value below 0.05 was considered statistically significant.

Results and analysis

Per-operative findings

Cholesteatoma was localized in the tympanic cavity in one ear only, and extended into the attic from the tympanic cavity in one ear, or from the attic to the tympanic cavity in another ear, into antrum in three ears, up to the mastoid process in six ears or external ear canal in one ear (Table I). The sinus tympani was involved in 10 ears, anterior attic in seven, posterior crus in four and around ossicles in 11 ears by cholesteatoma. Cholesteatoma stage was stage 1, 2, 3, 4 and 5 in one, three, four, four and one ear, respectively (Table I). Cholesteatoma at tubal orifice was not seen in any ear.

Type I tympanoplasty was performed in two ears, type II in nine ears and type III (stapes absent) in two ears (Table I) with either autologous incus (eight cases), cortical bone (two cases) or auricular cartilage (one case).

In one ear with mastoid process involvement, a 1.5 cm-wide dural defect at tegmen and a 2 mm-wide bony defect on the horizontal semicircular canal

were observed and repaired by using cartilage plate and bone wax, respectively. No complication occurred during or after surgery.

Otosopic findings

All ears were dry. All the patients had an intact eardrum except one with a small, central hole, which had been seen since the early post-operative period. Clean and stable attic retraction with a wide access was observed in two ears. There was no sign of residual or recurrent cholesteatoma (e.g. persistent otorrhoea, hearing deterioration, bulging or lateralization of the palisades) in any patient during the follow-up period or at the final examination.

Hearing results

Post-operative hearing at the final evaluation was better (change > 10 dB) than at the pre-operative one in nine ears and did not change in the remaining four (change < 10 dB). Pre- and post-operative mean hearing values were, pure tone average 47 and 35 dB (*p* = 0.01) and air-bone gap 30 and 20 dB (*p* = 0.02), respectively. Of the seven patients' results available, pre- and post-operative mean SRT were 46 and 31 dB (*p* = 0.115), and SDS was 80 and 93 per cent (*p* = 0.027), respectively (Table II).

High-tone bone-conduction level did not show a significant change after the operation (*p* = 0.506). No patient had a high-tone bone-conduction hearing impairment more than 10 dB (Table II).

Discussion

Especially in ears with poor middle-ear aeration, 80 per cent of the fascia grafts and almost half of the perichondrium grafts atrophy in the following years post-operatively, and middle-ear atelectasis recurs.³⁴ In the late 1950s and the beginning of the 1960s, Heermann used cartilage plates for tympanoplasty to prevent eardrum retractions.³⁵ He first introduced the palisade technique in 1962.¹³ Heermann *et al.* found that with the use of palisades of conchal or tragal cartilage placed parallel to the malleus handle, twisting of cartilage, which was the case with larger cartilage plates, was avoided.¹⁴ In recent years, use of cartilage and cartilage palisades in middle-ear surgery is increasing.^{19–26} This may be the reason for the excellent post-operative results obtained after cartilage palisade tympanoplasty. Recently, it has been shown that cartilage palisade tympanoplasty after one-stage surgery of tensa cholesteatoma in children effectively prevents post-operative retraction,²⁰ a common complication in eardrums reconstructed with fascia.^{5,36,37} It has also been shown that cartilage palisade tympanoplasty provides as good hearing results as tympanoplasty with fascia,³⁶ with comparable tympanometric findings.³⁷ In ears with poor tubal function, which is a common situation in cholesteatomatous chronic otitis media disease before and even long after the operation, cartilage palisade tympanoplasty provides better late treatment results compared to fascia grafting.^{36,38} Cartilage palisades seem to be able to withstand the negative pressure

TABLE II

PRE-OPERATIVE (PREOP) AND POST-OPERATIVE (POSTOP) HEARING RESULTS AT A MEDIAN OF 13 MONTHS AFTER A CHAT OPERATION

Patient No.	PTA (dB)		ABG (dB)		SRT (dB)		SDS (%)		HPTBCA (dB)	
	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
1	60	31	45	27	65	35	72	92	18	18
2	45	21	35	11	40	20	80	96	13	13
3	35	23	33	20	–	–	–	–	2	5
4	40	28	20	14	–	–	–	–	23	15
5	40	48	30	28	30	55	72	96	13	22
6	38	47	23	26	–	–	–	–	18	27
7	62	43	42	22	60	30	80	88	23	20
8	30	37	21	25	35	30	88	100	7	7
9	28	17	20	9	25	25	92	92	12	10
10	54	58	24	39	–	–	–	–	30	20
11	68	26	42	10	65	25	76	88	25	20
12	70	50	20	15	–	–	–	–	7	10
13	45	25	39	15	–	–	–	–	53	43
Mean	47	35	30	20	46	31	80	93	19	18
SD	14	13	10	9	17	11	8	4	13	10
Range	28–70	17–58	20–45	9–39	25–65	20–55	72–92	88–100	2–53	5–43
<i>p</i> *	0.013		0.023		0.115		0.027		0.506	

PTA = pure-tone average; ABG = air-bone gap; SRT = speech reception threshold; SDS = speech discrimination score; HPTBCA = high pure-tone bone-conduction average; SD = standard deviation; * = Wilcoxon signed ranks test; – = not available

resultant in tubal dysfunction, which subsequently prevents retraction, consequential pre-cholesteatoma formation with hyperkeratosis epithelium and cholesteatoma recurrence, while still providing good long-term functional hearing results.^{26,38}

In the present study, the stiffness of the cartilage palisades failed to adversely affect the functional hearing results; on the contrary they provided good post-operative results in the majority of patients (Table II). Sometimes, small groves may develop between the palisades^{20,25,39} and these thin parts of the drum could serve as a suitable place for later paracenteses, if necessary, as well as allowing spontaneous perforation in acute otitis media.²⁰ However, if a deep retraction occurs, it may lead in the long term to recurrent cholesteatoma.^{6,20} Careful long-term observation of such suspected cases is recommended.²⁰

The atticotomy opening can be covered either with fascia, cartilage, or a piece of cortical bone. Tos preferred to use fascia to cover the atticotomy and through this opening could detect any residual cholesteatoma.^{4,15,16} To cover the lateral attic wall, cartilage palisades are sometimes preferred.^{12,40,41} However, this reconstruction can compromise the discovery of a cholesteatoma recurrence or growth of a residue because of the opacity of the cartilage palisades.³⁶ This is the main disadvantage of the palisade grafting technique.³⁶ Compared to the cartilage plate grafting technique, however, the palisade reconstruction may allow any residual cholesteatoma growth to be recognized, because of outward bulging. When lateralization of the palisade occurs in the attic region or when the posterior–superior canal wall appears to be ‘hanging’ down over the graft, recurrent cholesteatoma should be suspected.¹⁹ In addition, when performing one-stage and/or closed technique surgery, patients have to be followed up closely for a long period.³⁶ If we are not sure about the availability of post-operative follow up of a patient, we do not perform a closed technique.

Tos modified the combined-approach tympanoplasty in 1970, mainly to avoid second look operations and revisions, which usually end in a canal wall down procedure.¹⁵ The principle of this modified technique is to create such conditions in the attic that the retraction does not necessarily lead to recurrent cholesteatoma requiring re-operation, but most often to a peaceful, small cavity with an acceptably wide access.^{4,15} Although we used cartilage palisades to cover the atticotomy, we observed attic retraction in two ears; these have been clean and stable up to now and had a wide access. Even covering the attic cavity with bone or cartilage may not prevent the development of retractions, but they are usually dry and unproblematic in most cases.^{16,42} However, these retractions should be closely followed by an otologist because they may lead to a recurrent cholesteatoma even after many years.⁴³ This may also be due to a technical fault, for example the palisades might have slid down during the replacement of skin flaps or fascia. Surgeons should therefore also be very careful at the end of surgery, during replacement of the flaps and when filling the ear canal pack. Otherwise close follow up with frequent re-examinations or revision surgery may be needed.

Cholesteatoma surgery should be individualized according to the prevailing pathoanatomy, as there is no technique that is superior in all cases.¹⁵ We therefore do not perform the CHAT technique in every ear with cholesteatoma. In ears with severe middle-ear pathology like cholesteatoma in the tubal orifice, a canal wall down technique is preferred.^{8,12,25} In contrast, in ears with limited disease (i.e. stage 1 or 2 cholesteatoma), we prefer tympanoplasty alone or with an atticotomy.²⁵ However, in the current study, there were four cases that had relatively limited cholesteatoma (Table I). But these ears required a Tos technique for the removal of cholesteatoma as we could not remove all pathology without a mastoidectomy because of extensive granulation tissue. In the Tos technique, removal of cholesteatoma

from the tympanic sinus is safer and easier after otosclerosis drilling, and atticotomy provides an opportunity for a direct survey of the anterior attic.^{16,18,44} If it is properly done,¹⁶ transmeatal atticotomy should not damage bone-conduction hearing. In their study on 273 patients with attic cholesteatoma, Lau and Tos found that recurrence and re-operation rates were almost the same in the Tos and the canal wall down techniques.⁸ Hearing in the canal wall down group was slightly poorer than in the Tos technique group. Moreover, cavity problems and tympanic membrane pathologies were more common in the canal wall down group.⁸

- **The combined Heermann and Tos (CHAT) technique for cholesteatoma surgery involves drilling of the superior-posterior bony annulus, transcanal atticotomy with preservation of a thin bridge, cortical mastoidectomy and palisade cartilage reconstruction**
- **Evaluation at a median of 13 months following surgery revealed no evidence of residual or recurrent cholesteatoma in the 13 patients studied**
- **The technical details of this method of treatment are discussed**

It is therefore logical to combine Heermann's and Tos's techniques for the surgical treatment of cholesteatoma. The CHAT technique may provide good eradication of the disease, good post-operative hearing and good quality of life for patients. The mean observation time in the present study is 14 months, which is acceptable for reporting a surgical technique and its preliminary results.³³ An increase in the recurrence rate of cholesteatoma might be seen with increasing observation time⁴² and thus, a further study should analyse the long-term results of a larger patient group; comparison with other techniques should be performed for a more objective outcome. Patients should be closely followed after closed techniques like the CHAT technique. When hearing deteriorates, or persistent otorrhoea is present, if there is lateralization of the palisades, or residual or recurrent cholesteatoma is detected, re-operation will be necessary.

Conclusions

With the CHAT technique, cholesteatoma can be completely and safely removed from the middle ear, and a durable and resistant reconstruction of the middle ear with reasonable hearing can be achieved. However, long-term follow-up results of a larger patient group should be analysed.

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