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Main Article

Predictive role of Carhart's notch in pre-operative assessment for middle-ear surgery

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Abstract

Objectives: To evaluate the predictive role of the audiometric Carhart's notch for the assessment of middle-ear pathology prior to surgical intervention.

Method: In this retrospective analysis, a total of 315 operated ears of 305 patients were evaluated regarding their pre-operative pure tone audiograms and peri-operative findings. The probable relationship between the middle-ear pathologies found and the Carhart's notch found on pre-operative pure tone audiometry was investigated. Patients with conductive hearing loss who obtained at least a 10 dB improvement (at 1 and 2 kHz frequencies) in their bone conduction threshold post-operatively were included in the Carhart's notch group. The pathologies underlying Carhart's notch were compared.

Results: Three hundred and fifteen ears of 305 consecutive patients with conductive hearing loss were operated on due to middle-ear pathology. In patients with otosclerosis and tympanosclerosis, a Carhart's notch was seen at 2 kHz in 28 (93 per cent) patients but at 1 kHz in only two (7 per cent). However, in patients with chronic otitis media, a Carhart's notch was seen at 1 kHz in 10 (55 per cent) patients and at 2 kHz in eight (45 per cent) patients.

Conclusions: Otitis media with effusion, tympanosclerosis and congenital malformations should be considered in the differential diagnosis of a patient with a Carhart's notch seen on pure tone audiometry. A Carhart's notch at 2 kHz indicates stapes footplate fixation, whereas one at 1 kHz indicates a mobile stapes footplate; the footplate mobility can thus be predicted pre-operatively.

Key words: Hearing Loss, Conductive; Audiometry, Pure Tone; Otosclerosis; Otologic Surgical Procedures

Introduction

The false elevation of bone conduction thresholds at 2–4 kHz is referred to as Carhart's notch. A similar threshold elevation may also be seen at 1 kHz, and this can also be referred to as Carhart's notch. An improvement in bone conduction thresholds follows successful otologic surgery.[1,2] The presence of Carhart's notch in the pure tone audiograms of patients with otosclerosis, primary malleus fixation and otitis media with effusion (OME) has been reported previously.[2–4]

This study aimed to investigate a possible relationship between the audiometric presence of Carhart's notch and the nature of middle-ear pathology detected peri-operatively.

Patients and methods

Three hundred and fifteen operated ears of 305 consecutive patients with conductive hearing loss were retrospectively enrolled in this study.

Audiometric data, expressed as decibel hearing level, obtained three days pre- and 12 weeks post-operatively, were evaluated retrospectively. All measurements were performed in a soundproof room using an Amplaid A 315 audiometer (Amplifon, Milan, Italia) which was calibrated twice a year. Air conduction thresholds were measured at 250 and 500 Hz and at 1, 2, 4 and 8 kHz and bone conduction thresholds at 0.5, 1, 2 and 4 kHz.

Data collected from both ears of one patient were treated independently and analysed separately.

The following information was collected from the files of each patient: pre-operative diagnosis, mobility of stapes footplate, presence of Carhart's notch in pure tone audiogram, improvement of hearing loss and disappearance of Carhart's notch. Ears were included in the Carhart's notch group if a depression of bone conduction threshold of at least 10 dB was observed at 0.5–4 kHz frequencies, which improved following a successful operation.

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TABLE I

DISTRIBUTION OF CARHART'S NOTCH (CN), BY MIDDLE-EAR PATHOLOGY

Pathology	Mean age (years)	Total ears (*n*)	CN at 1 kHz (*n*)	CN at 2 kHz (*n*)	Total CN (*n*)
Cholesteatoma	–	23	–	–	–
TM perforation	–	25	1	1	2
Ossicular defect	–	47	1	1	2
Granulation otitis	–	52	8	6	14
Chronic otitis media	32.7 ± 14.4	147	10	8	18
Otosclerosis	43.6 ± 12.5	26	1	17	18
Middle-ear effusion	19.5 ± 19.4	70	1	4	5
Tympanosclerosis	23.3 ± 7.1	61	1	11	12
Others*	31.5 ± 13.7	11	1	1	2
Total	29.3 ± 16.5	315	14	41	55

Others* = 4 stapes anomalies, 7 traumatic tympanic membrane (TM) perforations.

Unsuccessfully operated ears (i.e. >20 dB air–bone gap, graft failure or operative complications) were excluded from the study. Ears displaying a Carhart's notch at ≥4 kHz were also excluded from the study, to eliminate the probability of noise-induced hearing loss. The peri-operative middle-ear pathologies of patients with Carhart's notch were recorded, in order to establish the mechanism and/or meaning of Carhart's notch.

Results

The study involved 315 ears of 305 consecutive patients (152 males, 15 females; mean age 29.35 ± 16.56 years; range 6–71 years) who had been suffering from conductive hearing loss due to various types of middle-ear pathology. Patient's pre- and post-operative audiologic assessments (the latter recorded 12 weeks post-operatively) and peri-operative middle-ear findings were recorded from their files.

Peri-operative diagnoses were as follows: 147 cases of chronic otitis media, 61 of tympanosclerosis, 61 of middle-ear effusion (70 ears), 25 of otosclerosis (26 ears), seven of traumatic tympanic membrane perforation and four of congenital ossicular anomalies. Patients with chronic otitis media were classified as: 52 cases of chronic otitis media with granulation tissue, 23 of chronic otitis media with cholesteatoma, 47 of osssicular defect secondary to chronic otitis media (dry ear) and 25 of dry ear without ossicular defect. The last group was treated with myringoplasty only.

Carhart's notch was found in the audiograms of 18 patients with otosclerosis (73 per cent), 12 patients with tympanosclerosis (19.6 per cent), 18 patients with chronic otitis media (12.4 per cent), five patients with OME (7.1 per cent) and two patients with ossicular anomaly (50 per cent). In patients with otosclerosis, a Carhart's notch was seen at 1 kHz in one patient and at 2 kHz in 17 patients. In patients with chronic otitis media, a Carhart's notch was seen at 1 kHz in 10 patients and at 2 kHz in eight patients. In patients with OME, a Carhart's notch was seen at 1 kHz in one patient and at 2 kHz in four patients. In patients with tympanosclerosis, a Carhart's notch was seen at 1 kHz in one patient and at 2 kHz in 11 patients (Table I). Stapes footplate fixation was seen in two of the 11 patients with a Carhart's notch at 1 kHz and in 32 of the 37 patients with a Carhart's notch at 2 kHz (Table II). The mean magnitude of Carhart's notch was 16.44 ± 4.35 dB, ranging from 10 to 25 dB. There was no specific relationship between the magnitude of Carhart's notch and the middle-ear pathology observed.

Discussion

Sound applied to the skull is not transmitted solely via the bone to the cochlea; an almost equal component is transmitted via the external auditory canal and the ossicular chain to the inner ear. In individuals with a conductive hearing impairment this second mode of transmission is not so prominent. The measurements of bone conduction thresholds are not the same thing as in the normal individuals.[5]

Carhart's notch is a bone conduction artefact seen in pure tone audiometry. In a study conducted by Conijn *et al.*,[4] a good correlation was found between the conductive loss evident in the pure tone audiogram and the conductive loss as estimated by brain evoked response audiometry, for all frequencies except for 2 kHz. This bone conduction artefact at 2 kHz has been thought to result from stapes fixation in otosclerosis, and it has also been reported in other middle-ear pathologies, such as primary malleus fixation and OME.[2–4] The presence of a Carhart's notch in the audiograms of patients with OME was thought to result from impedance to sound transmission caused by viscous middle-ear fluid and oedema of the middle-ear mucosa.[6] When the ossicles are fixed to the skull, as in ankylosis of the stapes, they cannot vibrate independently of the skull and hence are subject to a decreased transmission of sound at the resonant frequency of the skull, which is approximately 2 kHz.

Yi *et al.*[7] demonstrated bilateral, symmetric Carhart's notches in two family members diagnosed

TABLE II

DISTRIBUTION OF CARHART'S NOTCH (CN), BY STAPES FOOTPLATE MOBILITY

Stapes footplate	CN at 1 kHz (*n*)	CN at 2 kHz (*n*)	Total (*n*)
Fixed	2	32	34
Mobile	11	7	18

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with congenital absence of the stapes and oval window. Carhart's notch is known to be present in patients with a fixed footplate and/or nonfunctioning oval window. However, in our study, a Carhart's notch at 1 kHz was mostly seen in patients with a mobile stapes footplate, whereas a Carhart's notch at 2 kHz was mostly seen in patients with stapes footplate fixation. The frequency at which Carhart's notch appears seems to be an indicator of stapes footplate mobility; a Carhart's notch at 1 kHz or 2 kHz may be a predictive factor in determining the mobility or fixation of the stapes footplate, respectively.

- **The presence of a Carhart's notch in the pure tone audiogram of patients with otosclerosis, primary malleus fixation and otitis media with effusion has been reported previously**
- **In this study of 315 ears with conductive deafness, a Carhart's notch was not seen solely at 2 kHz**
- **A Carhart's notch at 1 kHz or 2 kHz may be a predictive factor in determining the mobility or fixation of the stapes footplate, respectively**

Conclusions

In our study, Carhart's notch was not seen solely at 2 kHz but also at 1 kHz. While Carhart's notch is supposed to be specific for otosclerosis, it has also been seen in some other disorders such as OME, tympanosclerosis and congenital ossicular anomalies. Differential diagnosis of the patient with Carhart's notch should be carefully considered. A Carhart's notch at 1 kHz or 2 kHz may be a predictive factor in determining the mobility or fixation of stapes footplate, respectively. This finding could be used in preoperative estimation of stapes footplate mobility.

References

1 Carhart R. The clinical application of bone conduction audiometry. *Arch Otolaryngol* 1950;**51**:798–808
2 Ahmad I, Pahor AL. Carhart's notch: a finding in otitis media with effusion. *Int J Pediat Otorhinolaryngol* 2002;**64**: 165–70
3 Moon CN, Hahn MJ. Primary malleus fixation: diagnosis and treatment. *Laryngoscope* 1981;**91**:1298–307
4 Conijn EA, Van der Drift JF, Brocaar MP, van Zanten GA. Conductive hearing loss assessment in children with otitis media with effusion. A comparison of pure tone and BERA results. *Clin Otolaryngol* 1989;**14**:115–20
5 Browning GG, Gatehouse S. Hearing in chronic suppurative otitis media. *Ann Otol Rhinol Laryngol* 1989;**98**:245–50
6 Kumar M, Maheshwar A, Mahendran S, Oluwasamni A. Could the presence of a Carhart notch predict the presence of glue at myringotomy? *Clin Otolaryngol* 2003;**28**: 183–6
7 Yi Z, Yang J, Li Z, Zhou A, Lin Y. Bilateral congenital absence of stapes and oval window in two members of a family: etiology and management. *Otolaryngol Head Neck Surg* 2003;**128**:777–82

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