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The effect of chronic otitis media with effusion on temporal auditory processing disorders: a randomized case-control study

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Abstract

Introduction: Chronic Otitis Media with Effusion (OME) is a chronic inflammatory disorder of the middle ear cleft defined by middle ear fluid collection and an intact tympanic membrane. Numerous authors have highlighted the correlation between OME and central auditory processing disorders, particularly, temporal processing capabilities.

Aim of this study: Using both PPS and GIN tests, this study aims to investigate the influence of persistent conductive hearing loss caused by OME on auditory temporal processing in children.

Subjects and Methods: a randomized case-control study was implemented in which 80 children were split up into two groups. The Control group consisted of forty children known to be OME-free. The case group consisted of 40 children with chronic OME.

Results: A statistically significantly lower mean pitch pattern score and a statistically significantly higher mean of gap detection thresholds were detected in cases.

Conclusion: Comparing children with chronic OME to those with normal hearing, temporal ordering, and resolution were found to be diminished. Either the long duration of disease or the low hearing thresholds were correlated with a significantly greater degree of impairment.

Keywords: Chronic Otitis Media with Effusion; Temporal Auditory; Hearing Loss.

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1. Introduction

Chronic Otitis Media with Effusion (OME) is a chronic inflammatory disease of the middle ear cleft characterized by fluid buildup in the middle ear and an intact tympanic membrane. The presence of fluid in the middle ear for more than three months or six or more times per year is diagnostic of chronic OME. Depending on the type of fluid or effusion (serous or mucous), variable degrees of conductive hearing loss frequently occur [1]. The pathophysiology is complicated with the malfunction of the eustachian tube, which accounted for the majority of cases [2]. In response to the lack of auditory input caused by OME-related long-term conductive hearing loss, abnormal auditory pathways form in the brain [3].

The peripheral auditory system detects and decodes sound waves produced by the

environment [4]. Central auditory processing encompasses a variety of auditory system mechanisms accountable for the ensuing behavioral phenomena: Localization and lateralization of sound; auditory discrimination; recognition of the auditory patterns; temporal components of audition, and auditory penetrance [5].

The auditory temporal processing is the capacity to discriminate between differences in a sound wave of the temporal order. That involved the quick alteration of time-dependent acoustic features, which enables the detection of a brief pause between two sounds. To sense such variations, the auditory system must be able to recognize abrupt changes in sound intensity and spectrum shifts [6].

The Pith Pattern Sequence (PPS) was developed to evaluate the identification of frequency variations and temporal ordering tasks involving inputs through both hemispheres [4]. The gaps in noise (GIN) test were created to determine the temporal resolution with which the gap detection threshold is generated [6].

So, many authors have highlighted the correlation between OME and central auditory processing disorders, in particular, temporal processing abilities, which are highly essential to auditory, speech, language, and educational development of children and are dependent on high-fidelity sound transmission [6-7]. That study employed PPS and GIN tests to explore the effect of persistent conductive hearing loss caused by OME on children's temporal auditory processing.

2. Subjects and methods

2.1. Subjects

From December 2020 to July 2021, the Fayoum University Otolaryngology department, Audio-vestibular unit, undertook randomized case-control research. That included two groups of 80 children. Forty children who were known to be OME-free formed the Control group. The case group composed of 40 children with chronic OME.

Inclusion criteria

Participants ages ranged between 9-12 years for both genders were recruited. Patients in the case group were diagnosed with chronic OME in both ears, as recommended by the American Academy of Otolaryngology-Head and Neck Surgery Foundation (ASHA) [8]. The standard development stated that the average academic performance and language growth; absence of attention problems.

Exclusion criteria

Participants with significant neurological or psychiatric disorders, any form of attention disorder, or otological disorders were excluded.

2.2. Ethical Approval

The Research Ethical Committee of Faculty of Medicine, Fayoum University, Fayoum, Egypt, approved the current study

following the guiltiness of Helsinki Declaration (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/). Detailed consents were approved and collected by the parents of children participated in the study.

2.3. Study design

After obtaining a detailed auditory history of the participating children from their parents, an otoscopic examination and essential audiological evaluation were performed as follows:

Tympanometry, acoustic reflex: Using a 226 Hz tympanometer (Interacoustic AT235h).

Tympanogram interpretation [9]:

- Normal (A) tympanometric curve [10].

- A (B) (flat) tympanogram indicates OME [11]. Acoustic reflexes to ipsilateral 500, 1000, 2000, and 4000 Hz stimulation.

Pure tone audiometry used Inter acoustics AC40 clinical audiometers. Phonetically balanced Arabic word sets are used for children's speech audiometry [12, 13]. The test materials were delivered through a P. C. C. D. player linked to an audiometer to headphones in a sound-treated room at a 35–50 dB sensation level (SL) in reference to the patient's (SRT) or at the listener's most comfortable level (MCL) [14].

Pitch pattern sequence test (PPS):

The (PPS) (Musiek Version) [15] has sixty sequences, each with three tones, two of which are always the same and one of which varies. 1.430 Hz is a high-pitched or "thin" tone; 880 Hz is low-pitched or "thick". Each 200-ms sequence is separated by a 7-second interval. If a patient rrecognizes14 of the first 15, the examination may end. If 15 questions are wrong, 30 must be answered. Sixty items are unneeded. (Appendix A)

Gaps In Noise Test (GIN):

(GIN) by Musiek [14] measures temporal resolution. Six-second white noise segments repeat. Each section may have 0-3 quiet gaps of 2 to 20 milliseconds.

The GIN exam consists of four lists, each with 60 gaps per list. Randomly presenting one list in each ear prevented a training effect from occurring if testing always began in the same ear. Sample test list (Appendix B). The estimated gap detection threshold (GDT) is the shortest silence gap identified four out of six times (67%). The percentage of correct responses (Total recognized gaps/total detected gaps) x 100.

Clinic's normative data were:

(GDT) = 4-6 milliseconds, GIN = 65-85%.

2.4. Analytical Statistics:

Using the Statistical Package for Social Science (SPSS) software, the data was analyzed for quantitative parametric data: One-Sample Kolmogorov-Smirnov test & Independent samples t-test between two independent groups. Bivariate Pearson correlation test to determine connections between factors for qualitative data.

3. Results

That study engaged 80 youngsters, who were divided into two groups of 40 each. No statistically significant differences in age or gender distribution were detected. 47 boys (60%) and 33 girls (40%) participated. The course of the condition ranged from 6 to 42 months (Table 1). Tympanometry revealed that controls had type (A) tympanogram with retained acoustic reflexes, while patients had type (B) tympanograms with lost acoustic reflexes.

Table 1: Description of disease duration among cases.

Parameters	Disease duration (m.)
Minimum	6
Maximum	42
Mean ±SD	19.3±10.6

Regarding hearing evaluations (Table 2), Air conduction thresholds revealed a statistically significant higher mean air conduction threshold in both ears among patients (40.9) compared to controls (17.8) with a mean air-bone gap of 22.3.

Table 2: PTA thresholds among cases and controls.

PTA Threshold (dBHL)	Variables	Participants		*P-value*
		Cases (n=40)	Control (n=40)	
Air-conduction	Right ear	40.9±8.6	17.8±2.8	<0.001*
	Left ear	39.9±9.3	17.4±2.7	<0.001*
Air bone gap	Right ear	22.3±7.9	0	<0.001*
	Left ear	21.8±8.2	0	<0.001*

* Significant *P-value*.

For evaluating problems in temporal auditory processing, results revealed a statistically significant difference in the mean PPS in both ears between patients (49.9± 7.3) and controls (68.3± 6.1) (Table 3). A statistically significant difference between the mean GDT in both ears (8.07±1.5) between patients and controls (Table 4). GIN score showed that 54% of patients had statistically substantially lower means than controls (73%) (Table 5).

Table 3: PPS scores among cases and controls.

Variables	Participants		*P-value*
	Cases (n=40)	Control (n=40)	
Right ear % Correct	49.9±7.3	68.3±6.1	<0.001*
Left ear % Correct	49.5±6.8	68.2±6.4	<0.001*

* Significant *P-value*.

Table 4: GDT among cases and controls.

Variables	Participants		*P-value*
	Cases (n=40)	Control (n=40)	
Right ear	8.07±1.5	5.8±5.8	<0.001*
Left ear	8±1.6	5.7±5.7	<0.001*

* Significant *P-value*.

Table 5: GIN scores among cases and controls.

Variables	Participants		*P-value*
	Cases (n=40)	Control (n=40)	
Right ear	54±7.5	73±4.5	<0.001*
Left ear	53.1±6.8	73.6±4.7	<0.001*

* Significant *P-value*.

The results of the case group were used to conduct correlational research between the severity of temporal auditory processing abnormalities, the duration of disease, and the degree of hearing loss. A statistically significant negative correlation was found between disease duration and PPS scores, suggesting that an increase in disease duration is related to a reduction in PPS scores (Figure1).

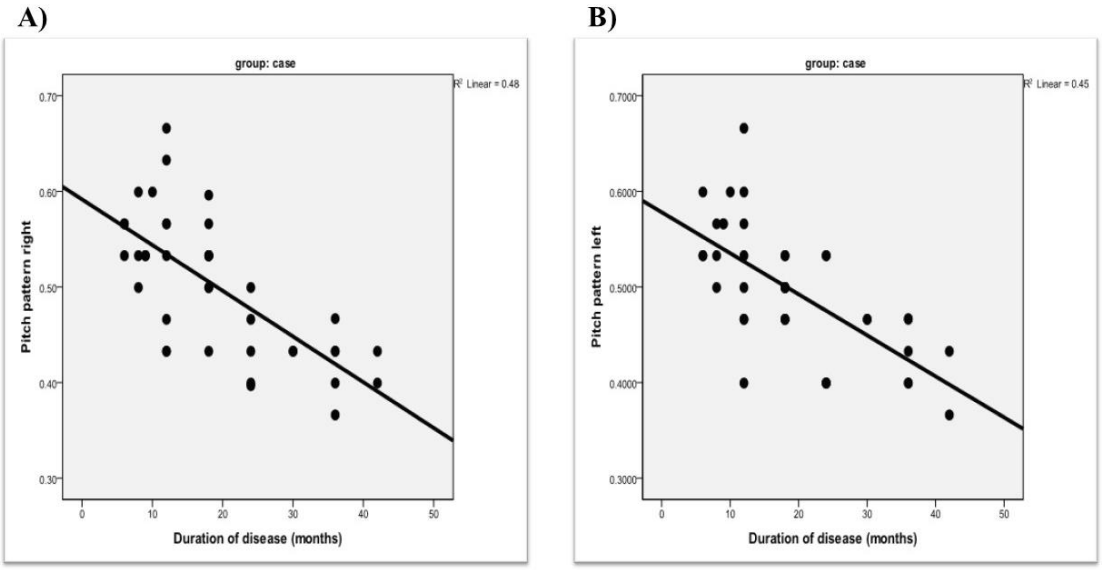

Figure 1: Chart illustrating the relation between duration of disease and PPS in A) right ear and B) Left ear; within cases.

Another Correlational investigation between disease length and GIN scores revealed a statistically significant negative correlation between disease duration and GIN scores, suggesting that an increase in disease duration is associated with a decrease in GIN scores figure (Figure 2). There was a statistically significant negative correlation between the air-bone gap and PPS scores, revealing that a larger air-bone gap is associated with a lower PPS score (Figure 3).

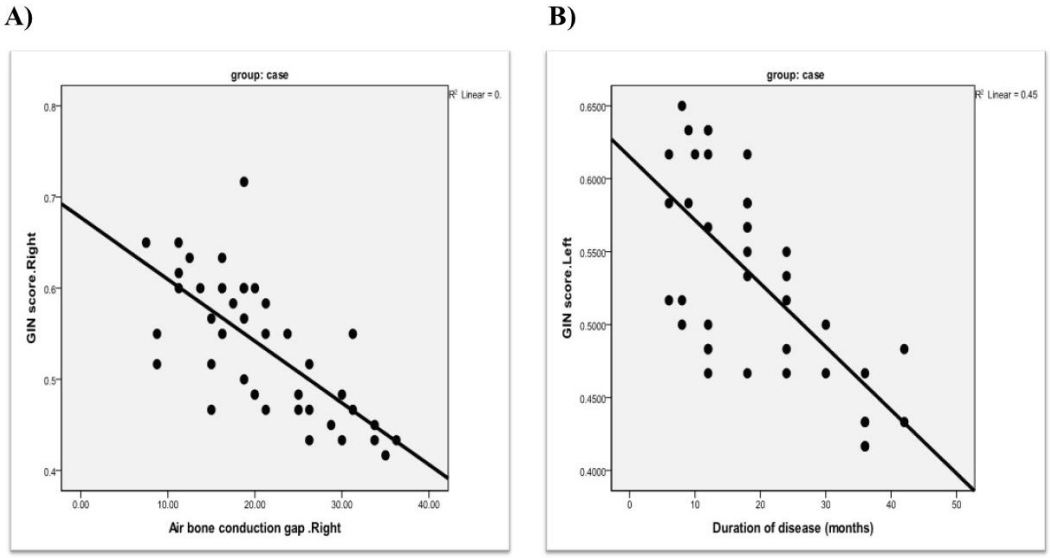

Figure 2: Chart illustrating the relation between duration of disease and GIN scores in A) right ear and B) Left ear; within cases.

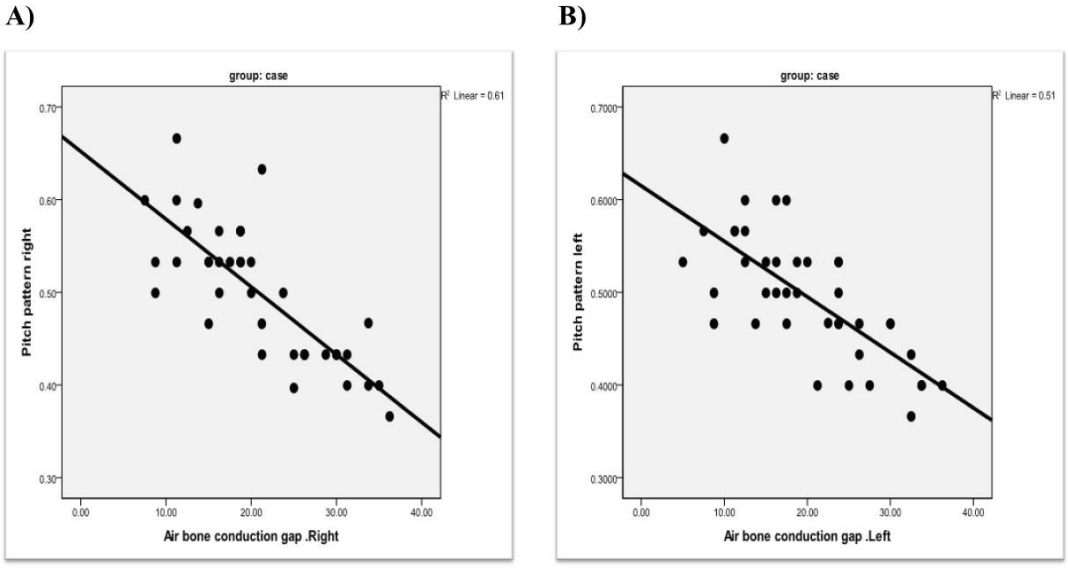

Figure 3: Chart illustrating the relation between air-bone gap and pitch pattern scores in A) right ear and B) Left ear; within cases.

4. Discussion

OME is the most common infection of the middle ear in children and the main cause of clinical visits [16]. At the age of ten, roughly 80% of children would have experienced at least one OME attack, with the incidence increasing between the ages of two and five [17].

OME is associated with behavioral and developmental difficulties in certain children [18], such as hearing loss. Clinicians are concerned about the need for early illness identification and prevention due to the disease's high prevalence, complications, and detrimental impact on various elements of a child's life [19]. Auditory processing disorder (APD) is frequently associated with linguistic, psychological, behavioral, and scholastic difficulties, which are regarded as frequent consultation concerns [20].

All subjects in the case group had chronic OME and conductive hearing loss with excellent speech discrimination. People with that form of hearing loss might effectively comprehend speech, when stimuli are delivered at a higher level (most comfortable level) [21].

Children in the control group responded to PPS more effectively than those in the case group (63% versus 48%). Researchers examined temporal ordering and found that healthy hearers had higher scores [22]. Hartley and Moore, 2003, investigated the effects of OME on children and found no evidence of the temporal hearing problem in those with a history of recurrent OME [23].

The GIN demonstrated a statistically significant difference between the two groups. Bayat *et al.*, 2017, observed that children with hearing impairments had significantly greater GDT and a lower proportion of correct responses than normally developing children [3]. Those findings corroborate the current study.

We correlated disease duration, air-bone gap, and TAP to identify new risk variables. The longest OME duration and biggest air-bone gaps were correlated with the lowest PPS and GIN scores. Similarly, Machado *et al.*, 2020, discovered that the impact of CAPD is related to the condition's severity and duration [22].

Jeselsohn *et al.*, 2005, evaluated the effects of CHL by injecting fluid into guinea pigs' open middle ears ad assumed that any increase in middle ear effusion volume raised hearing thresholds [24].

The CHL linked with OME can change the air conduction pathway via diverse pathways, including the phase difference at the air-fluid interface across the tympanic membrane, fluid, the phase cancellation induced by sound pressure waves propagating through the fluid to the round window, and finally increased tension on the tympanic membrane and stiffness of the ossicular chain due to thick effusion. Those mechanical changes may explain wavelength and phase changes in middle-ear signals that may lead to sound energy loss

[23]. OME can decrease sound volume by 40 dB and delays it by 150-300 ms [2]. Moreover, increased middle ear fluid volume exacerbates this loss [25].

The central auditory system relies on the quality and consistency of peripheral sound data [6]. A peripheral auditory transfer function disease limits the ability to perceive acoustic signals, producing a failure to make fine temporal discriminations of acoustic signals, a fundamental component of many auditory senses, including speech comprehension and sound localization [26-27].

According to the continuum theory, which views otitis media as a series of continuous events beginning with secretory otitis media and progressing to chronic otitis media if not cured early, impairments in temporal auditory capabilities and a lengthened disease duration are hallmarks of chronic OME [28]. Hence, mild middle ear problems will have developed over time prior to the diagnosis of chronic OME [22]. It is hypothesized that long-term adverse effects on the quality of acoustic impulses led to the improper development of the central auditory nerve system, causing these anomalies [8].

Conclusion

Comparing children with chronic OME to those with normal hearing, temporal ordering and resolution was diminished. The long duration of disease and low hearing thresholds were correlated with a significantly greater degree of impairment. OME screening programs are advised for children, besides, after hearing reversals, it is suggested that children diagnosed with chronic OME have APD screening and retesting.

Declarations

Ethical approval and consent to participate: The study was authorized by the local research ethics board of Fayoum University (603), and all patient guardians provided written informed consent to participate in this study.

Consent for publication: All patients' guardians provided signed, informed consent for this work to be published.

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Conflicts of Interest: All authors declare no conflict of interest.

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