CASE SERIES

Journal of Otorhinolaryngology and Facial Plastic Surgery 2022;8(1):1-8.
https://doi.org/10.22037/orlfps.v8i1.39342

Evaluation of the Relation between Tuning Fork Tests, Glue ear Presence, and Conductive Hearing Loss in Patients with Otitis Media with Effusion

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Article Info

Article Note:
Received: June, 2022
Accepted: August, 2022
Publish Online: September, 2022

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Keywords:
Conductive Hearing Loss;
Glue ear;
Otitis Media with Effusion;
Tuning Fork Tests.

Abstract

Background: In the middle ear inflammation, otitis media with effusion (OME) leads to a sterile effusion. Although most OME resolves without any complications, long-lasting OME may cause conductive hearing loss (CHL).

Aim: In this article, we investigate the validity of the Rinne and Weber tests in different frequencies of tuning forks in predicting the conductive hearing loss secondary to OME as diagnosed by more modern audiometric tests.

Methods: A case series of 25 consecutive patients visited the Loqman Hakim Hospital clinic. Each patient was evaluated by tuning fork tests (256, 512, 1024, 2048 Hz), audiometry, tympanometry, and tympanocentesis.

Results: In evaluation of the hearing status in OME patients, there was no significant association between the Weber test, audiometry, and tympanometry. The 256 Hz Rinne test correlated with the level of hearing loss in patients with OME. Results revealed no relationship between the presence of glue ear, audiometric, tympanometric, and tuning fork tests.

Conclusion: 256 Hz Rinne test can predict the presence of CHL in cases suffering from OME. Adhesive otitis does not worsen the hearing condition of patients.

Conflicts of Interest: The Authors declare no conflicts of interest.
Please cite this article as: khajavi M, Mokhtarinejad F, Bazgir N, Kordjazi M. Evaluation of the Relation between Tuning Fork Tests, Glue ear Presence, and Conductive Hearing Loss in Patients with Otitis Media with Effusion. J Otorhinolaryngol Facial Plast Surg 2022;8(1):1-8. https://doi.org/10.22037/orlfps.v8i1.39342

Introduction

Otitis media with effusion (OME) is defined as inflammation of the middle ear that leads to uninfected effusion. OME occurs commonly during childhood, especially in 6- 8 year olds. Approximately 91% of children by age 2 have at least one episode (1). Majority of OME cases may be asymptomatic and resolves in 50% of children after three months (2,3). However, long-lasting cases of OME are presented with aural fullness, mild discomfort, poor school performance, and conductive hearing loss (CHL) (3). Mild and moderate conductive hearing loss is the most common symptom. Conductive hearing loss across 500 to 4000 Hz is usually between 15dB and 40 dB (4, 5). Also, lower (speech) frequencies are affected more than higher (speech) frequencies in conductive hearing loss (6). Over decades audiological tests have been promoted and subsequent advances. However, Tuning fork tests (TFTs) are still known as the fundamental diagnostic tool, most common, available, and easy-to-use

Journal of Otorhinolaryngology and Facial Plastic Surgery 2022;8(1):1-8.
https://doi.org/10.22037/orlfps.v8i1.39342

instruments. TFTs confirm audiological results and differentiate conductive and sensorineural hearing loss for initial treatment (7). Other studies revealed that sensitivity and specificity of TFTs are not appropriate for use in screening (5,8).The Rinne test, characterized by a vibrating tuning fork, compares the loudness of the sound produced by air conduction (AC) to bone conduction (BC). The Weber test is characterized by applying the base of the vibrating fork to the midline of the patient's forehead or the bridge of the nose then the patient is asked to lateralize the sound (5).

The air-bone gap (ABG) is calculated by subtracting the BC from AC in decibels. An increase in ABG was significantly associated with a higher rate of response. There is disagreement about how large an air-bone gap (ABG) is necessary for an abnormal Rinne result. This value and overall test accuracy differ by tuning fork frequency, material, test technique, or patient population (5, 9, 10).

There are different types of otitis media, including acute otitis media (AOM), adhesive otitis media, otitis media with effusion (OME), and chronic suppurative otitis media (10). The presence of the glue ear is assessed by tympanocentesis. In this article, we investigate the validity of the Rinne and Weber tests in different frequencies (256, 512, 1024, 2048 Hz) of tuning forks in predicting the conductive hearing loss secondary to OME as diagnosed by more modern audiometric tests. We also evaluated the hypothesis of whether glue ear affect the level of hearing loss.

Methods

Subjects

The total number of 25 consecutive patients with OME diagnosis, who visited Loghman Hakim Hospital clinic from April to November of 2020, were included in this study.

The exclusion criteria consist of sensorineural hearing loss, any tympanic membrane injuries, and a history of developmental delays. Children who were not corporative were also excluded. The ethical committee of Shahid Beheshti University of Medical Sciences approved this investigation (date of approval: 21/1/2021). All included individuals cooperated during the whole process of examinations and audiometric evaluations.

Examinations

History of any obstructive symptoms and recurrent infections such as upper respiratory infections (URI) and acute otitis media (AOM) was inquired. An otoscope and microscope visualized tympanic membranes. Before tuning fork examination, the whole process was explained thoroughly for each case. The tuning fork test was performed by a single otolaryngologist. First, the Weber test was conducted. The 2048, 1024, 512, and 256 aluminum tuning forks were used, respectively. The elbow of the otolaryngologist struck every tuning fork, and the base of the fork was placed on the patient's nasal bridge. Then, the patient was asked for any sound lateralization. Subsequently, the Rinne test was performed with forks 2018, 1024, 512, 256. In the Rinne test, air conduction was compared with bone conduction. After striking of tuning fork, the fork was held at the external ear axis for approximately two seconds. Then the base of the fork was rapidly placed gently on the mastoid bone to assess BC. The base of the tuning fork was held on the mastoid bone for nearly 2 seconds. The exact process was repeated for the opposite ear. All included patients underwent tympanocentesis in Loqman Hakim Hospital clinic. The tympanic membrane was punctured with a small gauge needle to aspirate the fluid in middle ear.

Each patient was assessed by audiometric and tympanometric evaluations. Pure-tone audiometry was performed by audiometrists who were blinded to the tuning fork tests. Furthermore, the otolaryngologist was not informed of the audiometric evaluation results.

Statistical analysis

The statistical analysis was conducted using SPSS version 22. The Fisher's exact test was

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conducted to evaluate the relation of TFTs with audiometric and tympanometric tests. In addition, Fisher's exact was performed to assess the relation between presence of glue ear, and severity of hearing loss, tympanometric tests, and FTs. A P-value less than 0.05 was considered to be statistically significant.

Results

Subjects and frequencies

Twenty-five consecutive cases met the inclusion criteria and were added to our study. The mean age of patients was 18±4 (standard deviation) years. 16 (61.5%) males and 9 (34.6%) females were included in this investigation.

Physical examination revealed that the majority (21 patients or 84 percent) of patients had bilateral OME. In addition, a tympanic membrane Microscopic examination revealed that 19 patients (73.1%) suffered from bilateral OME. The physical examination details and tympanic membrane microscopy are listed in Tables 1 and 2.

Table 1. The frequencies and percentages of physical examination findings

Physical examination	Frequency	Percentage
Unilateral Right tympanic membrane bulging	3	12
Unilateral Left tympanic membrane bulging	1	4
Bilateral tympanic membrane bulging	5	20
Unilateral Right tympanic membrane retraction	0	0
Unilateral Left tympanic membrane retraction	0	0
Bilateral tympanic membrane retraction	16	64

Table 2. The frequencies and percentages of tympanic membrane microscopy

Tympanic membrane microscopy	Frequency	Percentage
Unilateral Right tympanic membrane bulging	2	8
Unilateral Left tympanic membrane bulging	1	4
Bilateral tympanic membrane bulging	11	44
Unilateral Right tympanic membrane retraction	1	4
Unilateral Left tympanic membrane retraction	1	4
Bilateral tympanic membrane retraction	9	36

Tympanogram revealed that in evaluated 50 ears, 35 ears (70%) were type B showing advanced OM with effusion. Moreover, nine ears (18%) were type c (indicating early phases of OM). Figure 1 shows the results of tympanometry. Audiometry was also conducted for patients to assess the consequent CHL. The speech discriminating score (SDS) was normal in all cases.

Speech reception (SRT) was normal or slightly affected in 60 % of assessed ears. Eighteen years (36%) presented mild impairment. In 66 percent of studied (33 ears), the air-bone gap was abnormal. Fifty-four percent (27 ears) of the ears had no hearing loss, 42% (21) and 4 % (2) suffered from mild and moderate hearing, respectively. The mean of the air-bone gap was 17±10.8 (ranging from 0 to 50). All patients underwent tympanocentesis. Twenty-two (88%) patients had glue ear (adhesive otitis media). The details of glue presence are summarized in Table 3.

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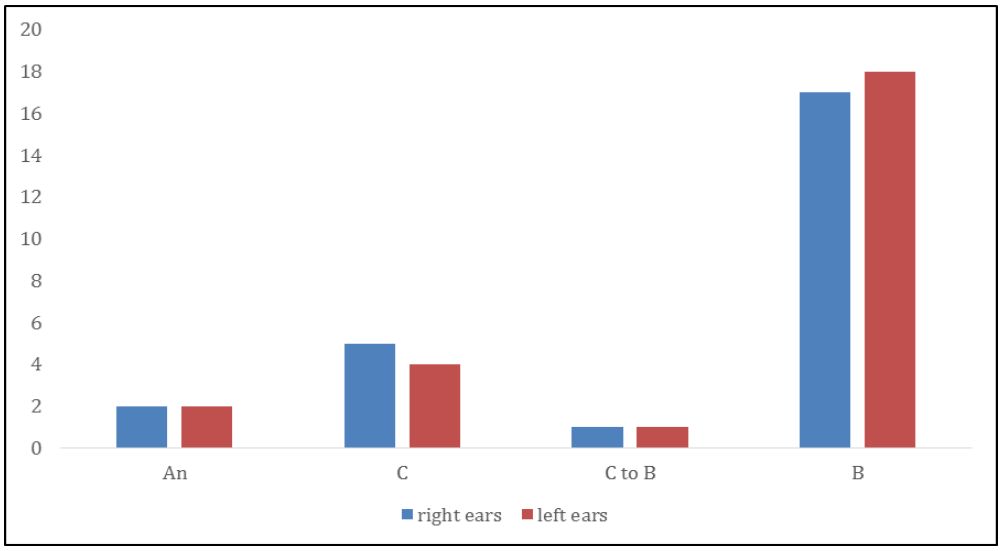

Figure 1. Exhibits and compares results of tympanometry in right and left ears.

The Chi-square test was conducted to assess the relation between glue ear presence of glue ear, TFTs, audiometric, and tympanometric tests. No statistically significant correlation was observed. The results of conducted tests are summarized in table 4.

Table 3. Frequency and percentage of glue ear

Glue ear	Frequency	Percentage
Negative	3	12
Right	2	8
Left	2	8
Bilateral	18	72

As it is illustrated in table 4 no statistically significant relation between audiometry, tympanometry, TFTs, and presence of glue ear was found. The detailed results of Weber and Rinne's tests are presented in Tables 5 and 6.

As illustrated in table 4, the 1024 Hz Rinne test was positive for most cases. Approximately half of the patients could not detect the 2048 Rinne test.

Weber test

The correlation between Weber tests, audiometry, and tympanometry was evaluated using Fisher's exact test. No statistically significant relation was found. This fact indicates that Weber tests could not detect hearing loss in patients with OME.

Rinne test

Rinne tests were performed using 256, 512, 1024, and 2048 Hz tuning forks. 256 Hz Rinne correlated with the level of hearing loss (P- value: 0.043, Cramer's V: 0.381). No statistically significant relation between the remained Rinne tests and audiometry or tympanometry was found.

Table 4. The correlation between TFTs, tympanometry, audiometry, and presence of glue ear

Correlation	P-value
Glue ears*hearing loss	0.321
Glue ears* air bone gap	0.323
Glue ears*SRT	0.464
Glue ears*SDS	0.880
Glue ears*tympanometry	0.443
Glue ears*weber 256	0.185
Glue ears*weber 512	0.491
Glue ears*weber 1024	0.407
Glue ears*weber 2048	0.615
Glue ears*rinne 256	0.346
Glue ears* rinne 512	0.99
Glue ears* rinne 1024	0.943
Glue ears* rinne 2048	0.088

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Table 5. The results of performed Weber tests

Weber test	Right lateralization	Left lateralization	No lateralization
256 Hz	9 (36%)	9 (36%)	7 (28%)
512 Hz	6 (24%)	10 (40%)	9 (36%)
1024 Hz	9 (36%)	8 (32%)	8 (32%)
2048 Hz	4 (16%)	7 (28%)	14 (56%)

Table 6. The result of Rinne tests

Unilateral Right-side Rinne	Negative	Positive	Not heard
256 Hz	12 (48%)	13(52%)	0
512 Hz	10(40%)	14(56%)	1(4%)
1024 Hz	7(28%)	17(68%)	1(4%)
2048 Hz	1(4%)	11(44%)	13(52%)
	Left Rinne		
256 Hz	14(56%)	10(40%)	1(4%)
512 Hz	10(40%)	14(56%)	1(4%)
1024 Hz	8(32%)	16(64%)	1(4%)
2048 Hz	2(8%)	12(48%)	11(44%)

Discussion

This study aimed to determine whether the tuning fork test can reliably detect the CHL resulting from OME. OME is one of the typical ear involvements, especially in childhood (11). Nonetheless, about 1.5 percent of people aged 35 to 44 are affected by otitis media (12). OME is defined as an active infection of the middle ear with the presence of fluid (11). Middle ear effusion develops as a budged yellow, or red tympanic membrane and decreased membrane mobility (13). The AOM is often caused by Eustachian tube dysfunction, caused mainly by viral upper respiratory infection (URI). The prolonged alteration in middle ear pressure results in effusion (13). Chronic otitis media(COM) is caused by recurrent AOM or persistent negative pressure of the middle ear. The sensorineural hearing loss is one of the sequelae of COM (14).

Twenty-five individuals were included in this case series and evaluated with Rinne and Weber's test using 256, 512, 1024, and 2048 Hz tuning forks.

The sensitivity and specificity of the Weber test have been measured by plenty of studies. The overall sensitivity and specificity were estimated at 65 % and 75 %, respectively(8). In a survey performed on 164 patients, 256 Hz Weber TFT produced the most accurate results(15). In a systematic review done by Kelly et al., it was revealed that although the 512 Hz Weber tuning fork test (TFT) had the most sensitivity in discovering CHL in patients, the Weber test has poor sensitivity in discovering unilateral CHL (7). Following prior studies, we found no relationship between audiometric, tympanometric evaluations, hearing loss (HL), and Weber TFT.

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Emphasizing that Weber TFT is not a reliable tool for identifying CHL in patients with OME. In conclusion, we found no relationship between audiometric, tympanometric evaluations, hearing loss (HL), and Weber TFT following previous studies.

Different studies have compared the sensitivity of Rinne using different tuning fork tests. A systematic review by Kelly et al. revealed that the sensitivity of the 256, 512 Hz Rinne tuning fork test ranged from 43-91% and 16-87%, respectively. It yielded that the 256 Hz Rinne TFT is more sensitive for diagnosing HL. The specificity of Rinne tests performed by two tuning forks for detecting CHL was approximately the same (ranging from 50 to 100%)(18). A hundred patients were evaluated by four different frequencies of Rinne TFTs. Following the study, 256 Hz Rinne TFT had the most sensitivity, while patients were more responsive to 512 Hz Rinne TFT. This rise in responsiveness was not observed using 1024 and 2048 Hz Rinne TFTs (13). Despite the high sensitivity of 256 Hz Rinne TFT, the high number of false positives limited its utility (7). Despite the high sensitivity of 256 Hz Rinne TFT, the high number of false positives limited its utility (7). By analyzing 1000 adults with all four Rinne TFT, 512 Hz TFT was the best screening tool (16).

Moreover, Crowley et al. stated that Rinne TFT is more of a qualitative test rather than a quantitative one (17). The transitional point of air-bone gap (ABG) that Rinne TFTs became positive ranged from 13 to 40 dB(7). By assessing 153 ears, Crowley et al. exhibited that the Rinne TFT is more likely to become optimistic when ABG is 30 or more(17). Gelfand et al. assessed 100 ears with TFTs and audiometry. He concluded that the Rinne TFTs have no clinical value when the gap is less than 25 dB (18). Sheehy et al. estimated this transitional point to be 15, 20 dB for 512 and 1024 Hz Rinne TFTs (19). In agreement with Sheehy et al., the calculated mean ABG of our study was nearly 17 dB, and the positive 256 Hz Rinne TFT could reliably detect CHL.

The term glue ear was first introduced in 1949 (20). The glue ear is a subacute or chronic secretory otitis media. It is manifested by the fluid presence in the tympanic cavity containing columnar and inflammatory cells. The typical clinical manifestation is hearing loss (21).

The presence of the glue ear was evaluated by visualization of the tympanic membrane. We evaluated whether there is a relation between glue ear presence and severity of hearing loss. Although the ear glue is commonly presented by hearing loss, we found no relation between glue ear and hearing loss severity.

Eight hundred forty patients with unilateral COM were assessed by pure tone audiometry. The majority of patients showed sensorineural (SNHL) hearing loss after five years of COM (22). Other studies also have proved the relation between sensorineural hearing loss and duration of COM (23–25). The risk of developing CHL or SNHL is higher in adults affected by COM during their childhood (26–28). In conclusion, hearing is mainly affected by the duration of disease and age rather than glue ear presence.

Moreover, this study showed no correlation between glue ear and tympanometric, audiometric, TFTs.

Limitations

This study was conducted as a single-center survey. A multi-center study with more patients is required to have more precise results.

Conclusion

The recent article demonstrated that the 256 Hz Rinne TFT had a significant correlation to HL in patients with OME. In contrast, Weber's TFTs were not associated with CHL. The TFTs cannot reliably identify CHL in patients. Therefore, these tests could be used as screening rather than diagnostic tools. Furthermore, the glue ear is not related to the

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severity of hearing loss. The glue ear presence did not significantly correlate with tympanometric and tuning fork tests.

Acknowledgments
Not declared.

Conflicts of Interest
The authors declare no conflicts of interest.

Financial Support
The authors declare there is no funding support for this study.

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