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Eustachian tube function test: analysis of different conditions and comparison with the ETDQ-7 self-perception questionnaire

Teste de função tubária: análise de diferentes condições e comparação com o questionário de autopercepção ETDQ-7

Prueba de función tubária: análisis de diferentes condiciones y comparación con el cuestionario de autoevaluación ETDQ-7

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Abstract

Introduction: In the field of speech therapy, the assessment of Eustachian tube dysfunction (ETD) uses methods such as the Eustachian Tube Dysfunction Questionnaire (ETDQ-7) and objective research with the Tubal Function Test (TFT). There is still no clear research investigating the effectiveness of objective tests in comparison with self-perception. **Purpose:** To analyze the TFT in comparison with the ETDQ-7 and determine the variation in pressure in daPa presented by healthy subjects in each test maneuver. **Method:** Quantitative, observational, cross-sectional study. Sixty individuals participated,

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Authors´contributions:
FCT, ASC, BRM, LC, HGM, VCM: writing and correction of the manuscript; general revision of the manuscript; literature atualization.
HGM: coorientation and correction of the manuscript.
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17 men and 43 women, with normal meatoscopy, tympanometric curve A, with or without complaints related to the Eustachian tube, divided into two groups: G1-individuals with normal self-perception of Eustachian tube function (M=28), and G2-with self-perception of ETD (M=32). The following procedures were performed: visual inspection of the external auditory canal, tympanometry, ETDQ-7, and TFT. **Results:** Given the different conditions analyzed, the order of swallowing (negative) and after Valsalva (positive) was the test condition that presented the highest percentage of specificity and sensitivity, 46% and 33%, respectively. The other analyses showed high specificity and low sensitivity. The average pressure variation in daPa was 36 daPa for Valsalva and seven daPa for swallowing. **Conclusion:** When analyzing the TFT, it was observed that performing it in the Swallowing (negative) + Valsalva (positive) condition is most equivalent to the ETDQ-7, when comparing the two. The pressure variation in daPa was established for both conditions, being higher in the Valsalva maneuver.

Keywords: Eustachian Tube; Valsalva Maneuver; Deglutition; Hearing; Hearing Tests; Sensitivity and Specificity.

Resumo

Introdução: No campo fonoaudiológico, a avaliação da Disfunção de Tuba Auditiva (DTA) utiliza-se de métodos como o Questionário de Autopercepção para Avaliação da Disfunção Obstrutiva da Tuba Auditiva (ETDQ-7) e a pesquisa objetiva com o Teste de Função Tubária (TFT). Ainda não há pesquisas claras que investiguem a eficácia de testes objetivos na mensuração comparada com a autopercepção. **Objetivo:** Analisar o TFT comparando com o ETDQ-7 e determinar a variação de pressão em daPa apresentada pelos sujeitos saudáveis em cada manobra do teste. **Método:** Estudo quantitativo, observacional, transversal. Participaram 60 indivíduos, 17 homens e 43 mulheres, com meatoscopia normal, curva timpanométrica A, com ou sem queixas relativas a Tuba Auditiva, distribuídos em dois grupos: G1-indivíduos com autopercepção normal de funcionamento da tuba auditiva(M=28), e G2-com autopercepção de DTA(M=32). Foram realizados os procedimentos: Inspeção Visual do Meato Acústico Externo, Timpanometria, ETDQ-7 e TFT. **Resultados:** Frente às diferentes condições analisadas, a ordem deglutição(negativar) e após Valsalva(positivar) foi a condição de testagem que apresentou maior porcentagem de especificidade e sensibilidade, sendo respectivamente 46% e 33%. As demais análises demonstraram alta especificidade e baixa sensibilidade. A média de variação de pressão em daPa foi de 36 daPa para Valsalva e sete daPa para deglutição. **Conclusão:** Ao analisar o TFT, foi observado que realizar o mesmo na condição Deglutição(negativar)+Valsalva(positivar) é o que mais se equivale ao ETDQ-7, realizando a comparação. A variação de pressão em daPa foi estabelecida para ambas as condições, sendo maior na manobra de Valsalva.

Palavras-chave: Tuba Auditiva; Manobra de Valsalva; Deglutição; Audição; Testes Auditivos; Sensibilidade e Especificidade.

Resumen

Introducción: En el campo de la fonoaudiología, la evaluación de la disfunción de la trompa de Eustaquio(DTE) utiliza métodos como el Cuestionario de Autopercepción para la Evaluación de la Disfunción Obstructiva de la Trompa de Eustaquio(ETDQ-7) y la investigación objetiva con la Prueba de Función Tubárica (PFT). Aún no hay investigaciones claras que investiguen la eficacia de las pruebas objetivas en la medición comparada con la autopercepción. **Objetivo:** Analizar la TFT en comparación con el ETDQ-7 y determinar la variación de presión en daPa presentada por los sujetos sanos en cada maniobra. **Método:** Estudio cuantitativo, observacional y transversal. Participaron 60 individuos, 17 hombres y 43 mujeres, con meatoscopia normal, curva timpanométrica A, con o sin quejas relacionadas con la trompa de Eustaquio, distribuidos en dos grupos: G1-individuos con autopercepción normal del funcionamiento de la trompa de Eustaquio(M=28), y G2-con autopercepción de DTA(M=32). Se realizaron: inspección visual del conducto auditivo externo, timpanometría, ETDQ-7 y TFT. **Resultados:** el orden de deglución(negativo) y después de Valsalva(positivo) fue la condición de prueba que presentó el mayor porcentaje de especificidad y sensibilidad, con un 46% y un 33%, respectivamente. Los demás

análisis demostraron una alta especificidad y una baja sensibilidad. La media de variación de presión en daPa fue de 36 daPa para Valsalva y siete daPa para la deglución. **Conclusión:** Al analizar el TFT, se observó que realizarlo en la condición de deglución(negativo)+Valsalva(positivo) es lo que más se asemeja al ETDQ-7, al realizar la comparación. La variación de presión en daPa se estableció para ambas condiciones, siendo mayor en la Valsalva.

Palabras clave: Trompa Auditiva; Maniobra de Valsalva; Deglución; Audición; Pruebas auditivas; Sensibilidad y Especificidad.

Introduction

The Eustachian Tube (ET) is a structure that connects the middle ear cavity to the nasopharynx[1]. It plays a key role in equalizing external air pressure with the Middle Ear (ME) and in draining secretions. The importance of the ET in the ventilation, protection, and drainage of the middle ear is evident. Therefore, evaluation of the auditory tube function is essential to analyze the proper functioning of the ET[2]. The ET is closed at rest and dilates when yawning, chewing/swallowing, and/or during the Valsalva maneuver[3]. These maneuvers activate the levator veli palatini, tensor veli palatini, salpingopharyngeal, and tensor tympani muscles, which are involved in the opening and closing mechanisms of the Eustachian tube, allowing air to pass from the nasal part of the pharynx to the tympanic cavity[4] . Eustachian Tube Dysfunction (ETD) is the impairment of any of the functions of the ET. It can be classified into three types[5]: obstructive ETD, resulting from functional obstruction, dynamic dysfunction, or anatomical obstruction, such as the presence of a chronic infection; patent ETD, caused by the constant opening of the ET due to situations such as atrophy of the ET adipose tissue, loss of tone, and dysfunction of the peritubal musculature; and ETD resulting from changes in atmospheric pressure due to exposure to different pressure levels, such as during diving and changes in altitude. In the field of speech therapy, assessment and intervention are mainly performed in cases of obstructive ETD[6] . The Ear Tube Dysfunction Questionnaire (ETDQ-7) was translated and validated in Brazilian Portuguese as a way to assess individuals' self-perception of obstructive ETD[7]. In addition, there are different objective methods for researching ET permeability and mobility, such as the Eustachian Tube Function Test (ETF). The literature[8] points out that the ETF test is one of the main objective methods used to examine ET function. This consists of performing a reference tympanometric curve to measure the basal pressure of the middle ear, followed by the following maneuvers and measurements: swallowing with water and after the Valsalva maneuver. These maneuvers cause a change in pressure within the middle ear. The literature also cites the Sniff Test[9] (measurement of pressure after vigorous inspiration through the nostrils, with the mouth closed) and Toynbee Maneuver[10] (measurement of pressure after obstruction of the nostrils and swallowing with water or saliva). In this study, ETF test will be performed on individuals with intact tympanic membranes. Thus, it is expected that there will be mobility and permeability of the ET in individuals without complaints of ETD. These tests are methodologically heterogeneous, with differences ranging from application protocols to the standardization of tests and their results. Thus, there is still no clear research investigating the effectiveness of objective tests, using easily accessible equipment, in comparison with self-perception[11]. Therefore, this research is fundamental, as it aims to analyze the specificity and sensitivity of different conditions of the ETF test application and its effectiveness compared to the ETDQ-7. For this study, the ETDQ-7 questionnaire was chosen as the gold standard by means of self-perception from individuals, and thus analyze the ETF test behavior in different conditions. The ETDQ-7 questionnaire was recently analyzed in a systematic review[12], where the outcome provides an important measure of the individual's self-report. However, it should be noted that it must still be complemented by an objective measure. The ETDQ-7 was also cited in other studies, demonstrating its reliability, sensitivity, and specificity[7,13, 14, 15, 16, 17, 18]. Considering the widespread use of auditory tube assessment tests in clinical practice, this study is justified by the need to identify which maneuvers are most appropriate for analyzing their permeability, according to the resources available in the equipment used. The

objective is to answer the following question: Is it possible to apply the ETF test in the format currently offered for clinical use - with baseline curve, swallowing, and Valsalva maneuver - or would it be sufficient to use only one of these maneuvers to obtain reliable information about the functioning of the auditory tube? Thus, this study aimed to: analyze the ETF test in comparison to the ETDQ-7 questionnaire, an instrument that has already been validated and has established accuracy in detecting tubal dysfunction; evaluate the methods of interpreting the ETF test described in the literature; and to determine the variation in pressure in daPa presented by healthy individuals (without auditory tube dysfunction) in each of the test maneuvers. The relevance of this study lies in contributing to the clinical validation and increased reliability of the ETF test as a diagnostic tool in audiological practice.

Method

This was a cross-sectional, observational, descriptive study using a quantitative method, conducted from June to December 2024. The sample was convenience-based, and the consultations were carried out at a Clinical Audiology Clinic attached to a Hospital of a Public Higher Education Institution.

Ethical aspects

Approved by the Research Ethics Committee (REC) under number 050387. Individuals who agreed to participate in this research signed the Free and Informed Consent Form prepared in accordance with Resolution 466/12 of the National Health Council.

Eligibility criteria

Individuals of both sexes aged 18 years or older participated in the study; normality in the inspection of the external auditory meatus; bilateral type A tympanometric curves, indicating normal mobility of the tympanic-ossicular system; with or without complaints related to ET, without previously diagnosed organic changes and regardless of peripheral hearing acuity.

Characterization of the sample

Participants were recruited at the speech therapy course teaching clinic and consisted of subjects who came to the audiology clinic for audiometry and students from the course. Thus, the sample consisted of 60 individuals, 17 males and 43 females, with a mean age of 30.6 years (minimum=20 and maximum=55), who were divided into two groups:

- Control group (G1): individuals with normal self-perception of ET functioning (measured using the ETDQ-7), comprising 10 males and 20 females with a mean age of 28.4 years (minimum=19 and maximum=55);
- Study group (G2): individuals with self-perceived Eustachian tube dysfunction, comprising 7 males and 23 females with a mean age of 32.8 years (minimum=20 and maximum=55).

The homogeneity of the sample was analyzed with regard to the age variable, and no significant differences were found between the groups (p-value=0.291).

Procedures

Sample composition procedures

All participants participants in study were to to following procedures:

- Visual Inspection of the External Acoustic Meatus: performed with a Mikatos otoscope to verify the normality of the ear canal and tympanic membrane.
- Tympanometry: performed with an Interacoustics AT 235 Immittance Meter to verify the normal mobility of the tympanic-ossicular system. For research purposes, values were considered according to the classification of Jerger (1970) and Jerger, Jerger, and Mauldin (1972)[19].

Research procedures

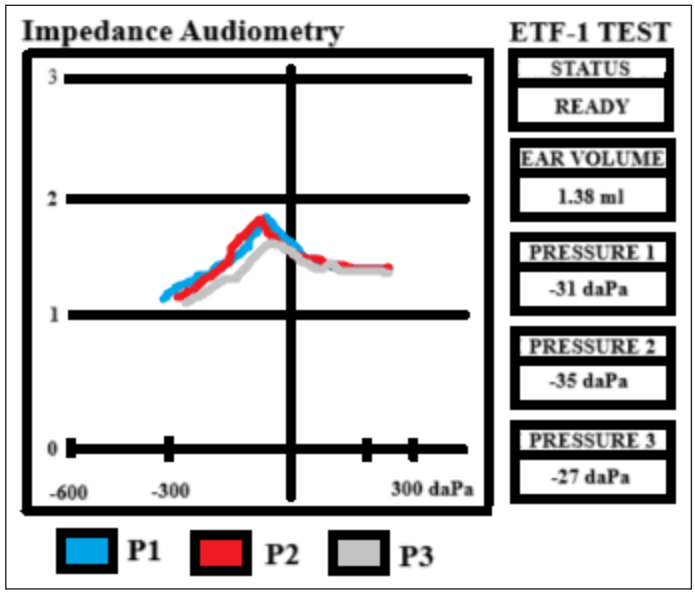
- Self-Perception Questionnaire for the Assessment of Eustachian Tube Obstructive Dysfunction (ETDQ-7): consists of seven questions, rated from one to seven, with one representing absence and seven representing maximum severity of the symptom. The questions address feelings of pressure in the ears; pain; feeling of blocked ears 8 ; symptoms in the ears when having a cold/sinusitis; popping; tinnitus; and muffled hearing. The cutoff point used to consider self-perception

change is ≥14 points, which showed 100% sensitivity and 100% specificity in diagnosis in a previous study7 . It is important to note that question 6 (ringing in the ears) was disregarded in the calculation for patients with Tinnitus Disorder, since, in this case, the perception and severity of the symptom could influence the test score, not representing the actual complaint of Tinnitus Disorder[20].

- Eustachian Tube Function Test (ETF): performed using an immittance meter. The ETF was performed only once, with the probe placed only in the right ear or on the side of the symptom[4]. It is important to note that the sequence of maneuvers for checking tube permeability may vary, involving both swallowing and the Valsalva maneuver, depending on the equipment used. In the "eustachian tube function test" (ETF) mode of the Interacoustics AT-235 device, the tympanometric curve is recorded, which serves primarily as a reference curve (pressure I). Next, ask the patient to swallow water (approximately 30 ml) (pressure II), followed by the Valsalva maneuver (pressure III). In this way, it is possible to analyze the pressure variations in each recorded curve. During the test, the following instructions were given to the patient, who was seated in a comfortable chair: "swallow the water with effort" and, for the Valsalva maneuver, "close your nostrils and inflate your cheeks with force," with the examiner verifying the correct execution of the maneuver.

After each of these maneuvers, a new tympanometric curve is measured.

Figure 1 shows a graphical representation of the ETF performed on the equipment.



Legend: P1: reference pressure; P2: water swallowing; P3: Valsalva maneuver

Figure 1. Graphical representation of normal etf performed on the equipment

For analysis of the results, they were performed under three conditions described below:

I. Condition I: Presence of pressure variation in the comparison between pressures I-II (pressure peak II must obtain a negative value in relation to pressure I) and pressures II-III (pressure peak III must obtain a positive value in relation to II)[4], for the ETF result to be considered normal in individuals with an intact tympanic membrane in this condition. Results not compatible with this description were considered abnormal. No specific value for pressure variation was considered, but rather whether or not it occurred within the proposed condition.
II. Presence of any pressure variation in the comparison between pressures I-II and pressures III-II[21], for the ETF test result to be considered normal in individuals with intact tympanic membrane, in this condition. Results not compatible with this description were considered altered. Similarly, the swallowing and Valsalva maneuvers were analyzed separately. No specific value for pressure variation was considered, but rather whether or not it occurred within the proposed condition.
III. The swallowing and Valsalva[6] tasks were analyzed separately to identify whether only one maneuver would be sufficient for TA permeability.

Data analysis

The sample calculation was performed using G*Power software, with a confidence level of 0.95 and a sampling error of 0.8. The final result was 30 individuals in each group. The data were tabulated in Excel. In the statistical analysis, an analysis of the normality of the variables was performed using the Shapiro-Wilk test, identifying a non-normal sample. Next, the nonparametric MannWhitney U test was selected to perform the comparative analysis. A p-value less than or equal to 0.05 (5%) was considered the significance level. In addition, the variation in pressure in dapa was analyzed for each condition (swallowing and Valsalva) in subjects with normal ETDQ-7. Sensitivity and specificity were analyzed.

Results

For the presentation of results, each subject was analyzed in all conditions. The 60 research subjects underwent the same procedures.

Table 1 shows the results of specificity and sensitivity in each of the conditions analyzed.

Table 1. Comparison of ETF results in different analyses with the ETDQ-7

ETF Test: Negative and Positive S+V	**ETDQ-7**		
	Altered	**Normal**	**Total**
Altered	10	16	26
Normal	20	14	34
Total	30	30	60
Sensitivity (s)		33%	
Specificity (e)		46%	
ETF Test: Positive only with Valsalva maneuver	**ETDQ-7**		
	Altered	**Normal**	**Total**
Altered	8	11	19
Normal	22	19	41
Total	30	30	60
Sensitivity (s)		26%	
Specificity (e)		63%	
ETF Test: Negative only with swallowing	**ETDQ-7**		
	Altered	**Normal**	**Total**
Altered	6	8	14
Normal	24	22	46
Total	30	30	60
Sensitivity (s)		20%	
Specificity (e)		73%	

ETF Test: Any pressure variation with both tasks	ETDQ-7		
	Altered	Normal	Total
Altered	1	4	5
Normal	29	26	55
Total	30	30	60
Sensitivity (s)		3%	
Specificity (e)		86%	
ETF Test: Any pressure variation with swallowing	**ETDQ-7**		
	Altered	**Normal**	**Total**
Altered	1	1	2
Normal	29	29	58
Total	30	30	60
Sensitivity (s)		3%	
Specificity (e)		96%	
ETF Test: Any pressure variation with Valsalva	**ETDQ-7**		
	Altered	**Normal**	**Total**
Altered	0	3	5
Normal	30	27	55
Total	30	30	60
Sensitivity (s)		0%	
Specificity (e)		90%	

Legend: ETF= Eustachian Tube Function Test; ETDQ-7= Self-Perception Questionnaire for the Evaluation of Obstructive Dysfunction of the Eustachian Tube; S+V= swallowing plus Valsalva; %= percentage; s= sensitivity; e= specificity

When comparing the different ETF results with the ETDQ-7, it was observed that in the "negative and positive (swallowing + Valsalva)" condition, there were low percentages of specificity and sensitivity, but it was the only condition that presented a balance between the percentages. In all other analyses, there was greater specificity and very low sensitivity. Thus, the condition that showed the highest fidelity to the ETDQ-7 result for both groups (G1 and G2) was condition I, which refers to the presence of pressure variation in the comparison between pressures I-II (pressure peak II must obtain a negative value in relation to pressure I) and pressures II-III (the peak pressure III must obtain a positive value in relation to II)[4], as presented above.

Chart 1. Analysis of pressure variation in daPa for each condition (swallowing and valsalva) in subjects with normal ETDQ-7 (n= 30)

Task	Min	Avg	Máx	SD
Swallowing (negative)	1	7	26	9,78
Valsalva maneuver (positive)	1	36	122	37,75

Legend: min=minimum; avg=average; max=maximum; SD=standard deviation

Chart 1 shows that the Valsalva maneuver provides greater mobilization of the auditory tube in subjects with normal ETDQ-7 (N= 30 individuals).

Discussion

In Table 1, when observing the condition of pressure variation with swallowing (negative) and Valsalva (positive), also equivalent to condition I analyzed in this study, percentages of 33% for sensitivity and 46% for specificity were obtained, the latter being the best balance of specificity and sensitivity among the analyses performed. A study[4] performed the ETF using the same proposed methodology, with the aim of comparing the function of the ET in adults with and without a history of

otitis media and/or upper airway infections. In this study, it was evident that these characteristics influenced the test responses, with altered findings and less pressure variability between maneuvers when compared to their peers. Furthermore, it demonstrated that the control group presented 100% normality in the evaluation and the study group 78.6%, emphasizing the importance of using this measure in assessing ET function. In the present study, such findings were not evident in such a significant way in typical subjects.

In the analysis of individual evaluations, i.e., positive with Valsalva and negative with swallowing, similar sensitivity and specificity were evident, with higher percentages for the diagnosis of subjects who do not have ETD. A study that sought to guide diagnostic pathways reinforced the low sensitivity of the tubal function test[21]. These findings can be justified mainly due to the influence of several factors in performing the test, such as regular olfaction, which can cause a false ETD, or even incorrect performance of the maneuver. The results of these analyses demonstrate that, in the ETF test, there is a greater balance of specificity and sensitivity when analyzing the test with both tasks performed consecutively, promoting the opening and closing of the ET, and not just mobilizing one mechanism. In the assessments of pressure variation, regardless of negativity or positivity, low sensitivity and high specificity rates were also evident. These findings can be justified mainly due to the anatomy and physiology of the maneuver, since it is expected that when performing the Valsalva maneuver, the airflow directed to the middle ear will increase pressure positivity, and swallowing will be negated[4]; therefore, a different functioning does not seem to be sufficient for a diagnosis of alteration. Thus, maneuvers performed separately, regardless of pressure variation analysis (positive/negative or any variation), only have good specificity. Therefore, it is not recommended to perform only swallowing or only Valsalva in the investigation of tubal function. In general, condition I (swallowing + Valsalva maneuver) with negative and positive analysis was the condition that presented the highest percentage of sensitivity. It is believed that regardless of the equipment used, the results would be similar. The condition of any pressure variation with swallowing presented the highest percentage of specificity, demonstrating that swallowing with water causes good ET permeability in normal individuals. One justification for this finding is based on a study[22] that mentions that the levator palatini muscle may be the most important muscle for ET function, which is also involved in swallowing. This study contributes to the aforementioned studies. Furthermore, the literature[2] points out that for a test to be considered of high diagnostic value, it must present a balance of specificity and sensitivity. Within the conditions tested, condition I, which follows the format provided in the equipment, has the best balance, but still presents low percentages. However, this research sought to fill a gap in the specialized literature, since the need for advances in ETF analysis is often emphasized, given that there is still no ETF test technique with high diagnostic value in terms of specificity and sensitivity[12]. However, given the low sensitivity and specificity values obtained, the study only contributed to the topic and did not fill the gap. There is a need for further studies that seek to analyze the sensitivity and specificity for each subtype of tubal dysfunction, seeking to highlight the diagnostic value and recommendation of the test according to the alteration (obstructive or patulous). For the analysis of pressure changes, it was observed in Table I that the subjects presented great pressure variability, that is, according to the maneuver. This finding was also evidenced in another study, justified by the fact that, according to the evaluation, changes in the functioning of the middle ear are expected. Therefore, it seems that any pressure variation can demonstrate ET permeability, provided that these changes are physiological according to the maneuver, i.e., negative for swallowing and positive for Valsalva[4]. The fact that the references do not total 70% of the last five years can be understood as a limitation of this study. However, this circumstance further strengthens the importance of this research, as it agrees with the study cited below[12]. The authors note that ETD presents a complex diagnostic challenge due to its multifaceted nature and overlapping symptoms, and that there is still no gold standard diagnostic tool to determine the presence of ETD. Therefore, it is recommended that, in clinical practice, when faced with patients with complaints compatible with ETD (e.g., ear fullness), the professional should apply the ETDQ-7 in conjunction with the ETF test, following the swallowing (negative) and Valsalva (positive) protocol, with a minimum variation of 1 daPa between measurements. The adoption of a

minimum variation of 1 daPa between the measurements obtained during swallowing (negative) and the Valsalva maneuver (positive) was considered a clinical criterion indicative of functional mobility of the auditory tube. This minimum value reflects the tube's ability to respond adequately to physiological pressure changes, which depends on the efficient opening and closing of the auditory tube and the integrity of the muscles involved in its dynamics, especially the levator veli palatini. Although the variation of 1 daPa may seem slight, it is a real and measurable change, sufficient to distinguish physiological responses from potentially altered patterns. The literature[21,23] on the ETF test reinforces that any pressure variation consistent with the maneuver performed already indicates functional patency of the auditory tube, while the absence of this response suggests impaired ventilation or mobility. This association is recommended because the ETDQ-7 allows the identification of subjective symptoms compatible with dysfunction, while the ETF test provides an objective measure of tubal patency, especially when both maneuvers are performed in sequence, mobilizing the opening and closing mechanisms of the auditory tube. Thus, the combined use of the instruments increases the accuracy diagnóstica e offers greater segurança clínica for o speech therapists in determining the course of action.

Conclusion

When analyzing the Eustachian Tube Function Test, it was observed that performing it under swallowing (negative) + Valsalva (positive) conditions is most equivalent to the ETDQ-7, when comparing the two. The pressure variation in daPa was established for both conditions, being higher in the Valsalva maneuver.

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