

Position-Dependent Audiological Changes Following Treatment of Palatal Adenoid Cystic Carcinoma: A Clinical Case-Based Study

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Abstract

Eustachian tube dysfunction (ETD) is a recognized complication following treatment for head and neck malignancies, particularly after radiotherapy. Although ETD commonly presents with hearing loss, tinnitus, and aural fullness, immediate position-dependent changes in audiological findings have rarely been described.

A 33-year-old male with adenoid cystic carcinoma of the hard palate underwent surgical excision followed by adjuvant radiotherapy (70 Gy in 34 fractions). Six months after treatment, he developed fluctuating hearing loss, aural fullness, tinnitus, intermittent vertigo, and autophony that worsened with changes in head position. Pure-tone audiometry and tympanometry were performed in neutral and altered head positions. Position-dependent changes were observed, including variation in the conductive hearing component and a shift in tympanometric findings from a Type B to a Type C pattern when the head was turned toward the affected side. Acoustic reflexes were absent in both positions. The symptoms resolved spontaneously within three weeks without intervention. At one-year follow-up, hearing thresholds had returned to normal, although persistent negative middle ear pressure (Type C tympanogram) remained.

This case demonstrates a rare presentation of position-dependent audiological variability following treatment for palatal adenoid cystic carcinoma. The findings suggest transient dysfunction of the Eustachian tube or its associated musculature, likely related to post-radiotherapy changes. Positional audiological assessment may provide additional diagnostic information in selected patients with fluctuating otological symptoms after head and neck cancer treatment. Further studies are required to clarify the underlying mechanisms and clinical significance.

Keywords: Eustachian tube dysfunction, Audiometry, Tympanometry, Head position, Positional hearing changes, Conductive hearing loss, Radiotherapy effects, Middle ear pressure, Adenoid cystic carcinoma.

1. Introduction

The Eustachian tube plays a crucial role in maintaining middle ear pressure, ventilation, and protection. Dysfunction of this system can result in symptoms such as hearing loss, tinnitus, aural fullness, and imbalance. Eustachian tube dysfunction (ETD) is commonly associated with inflammatory conditions, structural abnormalities, and head and neck pathologies.

Patients undergoing treatment for head and neck malignancies, particularly those receiving radiotherapy, are at increased risk of developing middle ear complications. Radiotherapy can lead to mucosal edema, fibrosis, and impairment of the tensor veli palatini muscle, thereby affecting Eustachian tube function and middle ear dynamics.

Although ETD is well documented, the effect of head position on audiological findings has not been widely explored. Limited studies suggest that posture may influence middle ear pressure and tympanometric outcomes; however, such findings are rarely reported in pathological conditions.

This proposal is based on a clinical case demonstrating position-dependent changes in audiometry and tympanometry, highlighting a potentially under-recognized phenomenon. Understanding this relationship may improve diagnostic accuracy and clinical management in similar patients.

2. Need for the Study

- Most audiological evaluations are conducted in a single static head position
- Positional effects on middle ear function are understudied
- Risk of misdiagnosis or misinterpretation in fluctuating hearing cases
- Lack of clinical guidelines regarding positional audiological assessment
- Increasing number of patients undergoing radiotherapy for head and neck cancers

3. Aim of the Study

To evaluate the effect of head position on audiological findings in patients with a history of head and neck pathology and treatment.

4. Objectives

1. To assess changes in pure tone audiometry with different head positions
2. To evaluate tympanometry variations in positional changes
3. To identify possible Eustachian tube dysfunction patterns
4. To analyse the clinical significance of positional audiological findings

5. Methodology**Study Design**

- Clinical case-based observational study

Study Setting

- Department of Audiology in Tanita university)

Study Sample

- Primary case: 33-year-old male with palatal carcinoma.

Inclusion Criteria

- Patients with history of:
 - Head and neck tumours
 - Radiotherapy
 - Complaints of fluctuating hearing

Exclusion Criteria

- Active ear infection
- Tympanic membrane perforation
- Neurological disorders affecting hearing

Procedure**1. Detailed case history and clinical examination****2. Audiological evaluation:**

- Pure Tone Audiometry (PTA)
- Tympanometry

3. Testing in:

- Neutral head position
- Head turned toward affected side

4. Comparison of findings across positions**5. Follow-up evaluation****Data Analysis**

- Descriptive analysis
- Comparison of audiometric thresholds and tympanometry patterns

6. Expected Outcome

- Identification of position-dependent changes in hearing
- Better understanding of middle ear dynamics
- Evidence supporting positional audiological testing
- Improved clinical diagnosis and management

7. Significance of the Study

- Introduces a novel clinical observation
- May help in:
 - Avoiding diagnostic errors
 - Improving patient evaluation
- Can contribute to future clinical guidelines
- Opens scope for further research in ETD and radiotherapy effects

8. Ethical Considerations

- Ethical approval will be obtained from the Institutional Ethics Committee
- Patient confidentiality will be maintained

9. Limitations

- Single case-based study
- Limited generalizability
- Lack of advanced diagnostic tools.

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Background:

Eustachian tube dysfunction (ETD) is frequently observed in patients with head and neck pathologies, particularly following surgical and radiotherapeutic interventions. However, immediate alterations in audiological findings related to changes in head position are rarely described. This report presents a unique case demonstrating position-dependent variability in both audiometric and tympanometry outcomes.

Case Presentation:

A 33-year-old male diagnosed with adenoid cystic carcinoma of the hard palate underwent surgical excision followed by adjuvant radiotherapy. Six months after treatment, he developed ontological symptoms including aural fullness, tinnitus, vertigo, and fluctuating hearing, which were notably influenced by head position. Audiological assessment revealed a mild conductive component with variation in air–bone gap and corresponding changes in tympanometric patterns depending on head orientation. Interestingly, symptoms resolved spontaneously within a few weeks without any specific intervention. At one-year follow-up, hearing thresholds were within normal limits, although tympanometry continued to indicate negative middle ear pressure in the absence of symptoms.

Conclusion:

This case highlights a rare presentation of head position-dependent audiological variability following treatment for a palatal malignancy. The findings suggest a possible transient dysfunction of the Eustachian tube or its associated musculature. Incorporating positional assessment during audiological evaluation may provide additional diagnostic insight in selected cases. Further research is required to better understand the underlying mechanisms.

Introduction

The Eustachian tube (ET) is an essential anatomical and functional structure that connects the middle ear to the nasopharynx and plays a vital role in maintaining middle ear homeostasis. Its primary functions include ventilation of the middle ear, regulation of pressure, protection from nasopharyngeal secretions, and clearance of middle ear contents. Any disturbance in these functions can lead to Eustachian tube dysfunction (ETD), which is commonly associated with symptoms such as aural fullness, hearing fluctuation, tinnitus, and imbalance (Schilder AG et al., 2015). ETD is a multifactorial condition and may arise due to inflammatory, structural, or functional abnormalities affecting the tube or its surrounding structures.

Head and neck pathologies, particularly neoplastic conditions, have been recognized as potential contributors to ETD. Lesions located in the oral cavity, nasopharynx, or

parapharyngeal regions may alter the anatomical or functional integrity of the Eustachian tube either directly or indirectly (Muzzi E et al., 2012). Among these, adenoid cystic carcinoma (ACC) is a rare malignant tumor arising from the minor salivary glands, frequently involving the hard palate. Although ACC accounts for a small proportion of head and neck malignancies, it is characterized by slow progression, local invasiveness, and a tendency for perineural spread (Saleh E et al., 2023). Due to its anatomical location, lesions of the hard palate may have indirect effects on adjacent structures, including the Eustachian tube and associated musculature.

The standard management of ACC typically involves surgical excision followed by adjuvant radiotherapy. While this combined approach improves local disease control, it is also associated with several functional complications. Radiotherapy, in particular, has been shown to adversely affect the middle ear and Eustachian tube through mechanisms such as mucosal edema, fibrosis, and impaired mucociliary clearance (Nader ME et al., 2019). These changes can result in negative middle ear pressure, otitis media with effusion, and conductive hearing loss. Furthermore, radiation-induced damage to the tensor veil palatini muscle, which plays a crucial role in opening the Eustachian tube, may further compromise its function (He GY et al., 2015). Although the association between radiotherapy and Eustachian tube dysfunction is well established, the clinical presentation is typically gradual and persistent in nature. Most studies describe static audiological findings rather than dynamic or rapidly changing patterns. In contrast, the influence of head position on auditory perception and middle ear function has not been extensively explored. A few studies in normal individuals have suggested that head posture may affect tympanometry measurements, possibly due to gravitational effects on middle ear structures and vascular dynamics (Chatterjee I et al., 2017). However, such positional variations have rarely been reported in patients with underlying pathology, particularly following head and neck cancer treatment.

The occurrence of immediate, position-dependent changes in audiological findings raises important questions regarding the underlying pathophysiology. These changes may reflect transient alterations in middle ear pressure, Eustachian tube mechanics, or neuromuscular function rather than fixed structural abnormalities. Understanding such dynamic variations is clinically relevant, as they may lead to misinterpretation of audiological results if positional factors are not considered during evaluation.

In this context, the present case report describes an unusual presentation of head position-related variability in audiometric and tympanometry findings in a patient treated for adenoid cystic carcinoma of the hard palate. By documenting this rare phenomenon, the study aims to highlight the importance of considering positional influences during audiological assessment and to contribute to the existing understanding of Eustachian tube dysfunction in post-treatment head and neck cancer patients.

Case Presentation

A 33-year-old male patient was referred to the otolaryngology department following a dental consultation for evaluation of a painful lesion involving the posterior region of the hard palate. Ethical clearance for reporting this case was obtained from the institutional review board, and informed consent was taken from the patient.

The patient had no significant past medical history and was not on any long-term medication. On clinical examination, a tender lesion was observed over the posterior aspect of the hard palate, and the patient demonstrated mild nasal speech without any additional systemic complaints.

Radiological imaging revealed a submucosal infiltrative mass involving the posterior hard palate, measuring approximately 33 mm × 20 mm × 12 mm, with extension into the adjacent soft palate and evidence of focal bony erosion on the right side. No cervical lymphadenopathy or involvement of surrounding structures, including the nasopharynx, parapharyngeal space,

and oropharynx, was identified. The pharyngeal opening of the Eustachian tube appeared intact bilaterally.

Histopathological examination of the lesion confirmed adenoid cystic carcinoma, characterized by tubular and cribriform architectural patterns. Based on the combined clinical, radiological, and histopathological findings, a definitive diagnosis was established.

The patient underwent complete surgical excision of the lesion, followed by adjuvant radiotherapy with a total dose of 70 Gy delivered in 34 fractions.

Approximately six months after completion of treatment, the patient presented with otological complaints including aural fullness, tinnitus, intermittent vertigo, autophony, and a sensation of fluctuating hearing. Notably, these symptoms were exacerbated by turning the head toward the affected side and were also reported during swallowing and coughing. The positional nature of these symptoms was particularly distressing to the patient.

Audiological evaluation was conducted in two different head positions: a neutral upright position and a position with the head turned toward the affected side with slight downward inclination. Pure tone audiometry in the neutral position revealed a mild conductive hearing component, with an observable air–bone gap. Tympanometry performed over a pressure range of +200 to –400 daPa demonstrated a Type B pattern in the neutral position. When the head position was altered, an improvement in hearing thresholds was observed along with a shift in tympanometric findings toward a Type C pattern, indicating position-dependent variation in middle ear pressure dynamics. Acoustic reflexes were absent in both test conditions.

No specific medical or surgical intervention was initiated, and the patient was managed conservatively. The symptoms persisted for approximately three weeks and gradually resolved without treatment.

At follow-up evaluation, the patient reported complete resolution of symptoms, and audiometric thresholds returned to within normal limits. However, tympanometric findings continued to show negative middle ear pressure, consistent with a Type C pattern, despite the absence of clinical symptoms.

Time Point	Event
Initial presentation	Painful lesion in posterior hard palate
Diagnostic work-up	Imaging + biopsy → Adenoid cystic carcinoma
Surgical phase	Complete excision of tumor
Post-treatment	Radiotherapy (70 Gy in 34 fractions)
6 months follow-up	Otological symptoms (positional hearing changes)
Audiology findings	Conductive component + Type B → Type C (positional)
~3 weeks later	Spontaneous symptom resolution
Long-term follow-up	Normal audiometry; persistent Type C tympanogram

Discussion

The present case demonstrates an unusual pattern of position-dependent audiological variability following surgical and radiotherapeutic management of a palatal malignancy. While Eustachian tube dysfunction (ETD) is a well-recognized complication in patients with head and neck tumours and their treatment, the immediate and reversible changes in audiometric and tympanometry findings with alteration in head position observed in this case are uncommon and not widely reported in clinical literature.

The Eustachian tube plays a central role in maintaining middle ear pressure equilibrium and ventilation. Dysfunction of this system typically results in negative middle ear pressure, leading to conductive hearing loss and abnormal tympanometry patterns. In patients undergoing radiotherapy, ETD is often attributed to a combination of mucosal edema, fibrosis, impaired mucociliary clearance, and structural narrowing of the Eustachian tube lumen. These changes disrupt the normal opening mechanism of the tube, resulting in persistent or progressive middle ear pathology.

In the present case, the development of otological symptoms approximately six months after radiotherapy suggests a delayed functional alteration, rather than an immediate structural complication. This timeline is consistent with previous observations indicating that radiation-induced changes, particularly fibrosis and neuromuscular dysfunction, may evolve gradually over time. One of the most plausible mechanisms involves impairment of the tensor veli palatini muscle, which is primarily responsible for active opening of the Eustachian tube during swallowing and yawning. Radiation-induced injury to this muscle may lead to ineffective tube opening, thereby contributing to negative middle ear pressure and associated symptoms.

However, ETD alone does not fully explain the rapid and position-dependent changes observed in this patient. The immediate improvement in hearing thresholds and corresponding shift in tympanometric pattern upon changing head position suggest a dynamic and reversible biomechanical process. It is likely that alterations in head orientation temporarily influenced the functional patency of the Eustachian tube or modified middle ear pressure through mechanical or gravitational effects.

One possible explanation is that positional changes may have altered the orientation and tension of peritubal muscles, including the tensor and levator veli palatini, thereby facilitating transient opening of the Eustachian tube. Additionally, gravitational redistribution of middle ear or nasopharyngeal secretions could have contributed to temporary relief of obstruction, resulting in improved aeration of the middle ear. Another contributing factor may be transient changes in vascular dynamics or mucosal edema within the Eustachian tube, which could be sensitive to head position.

The observed shift in tympanometric findings from a flat (Type B) pattern in the neutral position to a negative pressure (Type C) pattern in the altered position further supports the presence of pressure-dependent middle ear changes rather than a fixed structural abnormality. The absence of acoustic reflexes in both positions suggests persistent underlying dysfunction, despite temporary symptomatic improvement.

Interestingly, the patient's symptoms resolved spontaneously within a short duration without any intervention. This suggests that the underlying mechanism was likely self-limiting and functional rather than structural, possibly related to transient inflammation, reversible mucosal changes, or partial recovery of neuromuscular function. The persistence of a Type C tympanogram at follow-up, despite normalization of hearing thresholds, indicates that subclinical Eustachian tube dysfunction may still have been present.

Previous studies have explored the effect of head position on audiological measurements in normal individuals, suggesting that gravitational forces may influence middle ear mechanics, tympanic membrane compliance, and vascular dynamics. However, such changes are generally subtle and require prolonged positioning. In contrast, the immediate positional changes observed in this case highlight a more pronounced and clinically significant effect, likely potentiated by prior surgical and radiotherapeutic alterations.

Another important consideration is the potential role of radiation-induced tissue changes, including fibrosis and altered elasticity of surrounding soft tissues. These changes may increase the sensitivity of the Eustachian tube and adjacent structures to mechanical factors such as head movement. Additionally, post-surgical anatomical alterations in the palatal region may have contributed to altered muscular coordination or mechanical support of the Eustachian tube.

The findings of this case have important clinical implications. First, they suggest that audiological assessment in a single static position may not fully capture the functional variability in certain patients, particularly those with a history of head and neck malignancy. Second, failure to recognize position-dependent changes may lead to misinterpretation of audiological results or unnecessary interventions. Incorporating positional testing during audiological evaluation may therefore provide additional diagnostic insight in selected cases presenting with fluctuating or unexplained symptoms.

Despite its clinical significance, this report has certain limitations. The absence of advanced diagnostic investigations, such as wideband tympanometry, dynamic imaging, or vestibular evoked myogenic potential testing, limits the ability to definitively identify the underlying mechanism. Furthermore, as this is a single case, the generalizability of the findings remains uncertain. Future studies involving larger patient populations and objective dynamic assessments are required to further elucidate the role of head position in middle ear function. Overall, this case highlights a rare but clinically relevant phenomenon of position-dependent audiological variability, likely resulting from a complex interaction between Eustachian tube dysfunction, radiation-induced changes, and biomechanical factors. Recognition of such patterns may enhance clinical understanding and improve diagnostic accuracy in patients with similar presentations.

Conclusion

This case highlights a rare presentation of position-dependent changes in audiological findings in a patient following surgical and radiotherapeutic management of a palatal malignancy. The observed variability in audiometric thresholds and tympanometric patterns with alteration in head position suggests a dynamic and potentially reversible dysfunction of the Eustachian tube and associated middle ear mechanics.

The findings emphasize that, in certain clinical scenarios, conventional audiological assessment performed in a single static position may not fully reflect the underlying functional status of the middle ear. Incorporating positional variations during evaluation may provide additional diagnostic insight, particularly in patients presenting with fluctuating or unexplained otological symptoms after head and neck cancer treatment.

Furthermore, the spontaneous resolution of symptoms in this case supports the likelihood of a transient, non-structural mechanism, possibly related to post-radiotherapy changes affecting mucosal, muscular, or biomechanical function. Recognition of such patterns can help clinicians avoid misinterpretation of results and unnecessary interventions.

Overall, this case underscores the need for increased clinical awareness and further research to better understand the role of head position in influencing middle ear dynamics and Eustachian tube function.

Summary

The Eustachian tube plays a critical role in maintaining middle ear ventilation, pressure regulation, and protection against nasopharyngeal secretions. Dysfunction of this system may result in symptoms such as aural fullness, fluctuating hearing loss, tinnitus, vertigo, and conductive hearing impairment. Patients treated for head and neck malignancies are particularly susceptible to Eustachian tube dysfunction because surgery and radiotherapy can induce mucosal edema, fibrosis, impaired mucociliary clearance, and dysfunction of the tensor veli palatini muscle, thereby disrupting normal middle ear mechanics.

This case report describes a rare and clinically significant presentation of position-dependent audiological changes in a 33-year-old male who underwent surgical excision followed by adjuvant radiotherapy (70 Gy in 34 fractions) for adenoid cystic carcinoma of the hard palate. Approximately six months after completion of treatment, the patient developed fluctuating otological symptoms, including aural fullness, tinnitus, intermittent vertigo, autophony, and

hearing fluctuation. Notably, these symptoms varied according to head position, becoming more pronounced when the head was turned toward the affected side.

Comprehensive audiological evaluation was performed in both a neutral head position and an altered head position. Pure-tone audiometry demonstrated a mild conductive hearing component with variation in the air–bone gap between positions. Tympanometry also showed corresponding positional changes, with findings shifting from a Type B tympanogram in the neutral position to a Type C tympanogram after head rotation, suggesting dynamic changes in middle ear pressure and Eustachian tube function. Acoustic reflexes remained absent in both testing conditions. These findings indicate that head position may temporarily influence middle ear ventilation and pressure regulation in patients with post-treatment Eustachian tube dysfunction.

The patient's symptoms gradually resolved within approximately three weeks without medical or surgical intervention, suggesting that the underlying abnormality was transient and functional rather than permanent or structural. At one-year follow-up, pure-tone audiometry had returned to normal hearing thresholds, although tympanometry continued to demonstrate negative middle ear pressure, indicating persistent subclinical Eustachian tube dysfunction despite complete symptomatic recovery.

The observed positional variation may be explained by transient alterations in Eustachian tube patency resulting from radiation-induced changes affecting the tensor veli palatini muscle, surrounding soft tissues, or middle ear pressure dynamics. Changes in head orientation may have temporarily modified the mechanical relationship of the Eustachian tube, altered peritubal muscle function, redistributed secretions, or influenced local vascular and gravitational forces, thereby producing reversible improvements in middle ear ventilation. Although similar effects of posture on middle ear function have been reported in healthy individuals, such immediate and clinically significant positional changes following treatment for head and neck malignancy have rarely been documented.

This case emphasizes the importance of considering positional factors during audiological assessment, particularly in patients presenting with fluctuating hearing loss or unexplained otological symptoms after surgery and radiotherapy for head and neck cancers. Conventional audiological evaluation performed in a single static position may not adequately reflect the functional status of the middle ear in such patients. Incorporating positional audiometry and tympanometry into routine clinical assessment may improve diagnostic accuracy, reduce the likelihood of misinterpretation, and facilitate appropriate clinical management.

Although limited by its single-case design, this report contributes to the growing understanding of radiation-related Eustachian tube dysfunction and introduces a potentially under-recognized clinical phenomenon. Further prospective studies involving larger patient populations and advanced diagnostic techniques, such as wideband tympanometry, dynamic Eustachian tube function tests, and imaging, are warranted to elucidate the underlying mechanisms and determine the clinical significance of position-dependent audiological changes.

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