Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

Audiological Implications of Type 2 Diabetes Mellitus: A Narrative Review of Hearing Loss in Adults

Erafana[1], Meghana N[2], Niharika M[3], Dr. Mohammed Yaseen, PT[4]

[1,2,3] Associated Professor, Department of Audiology
heritage City Institute of Allied Health Science, Mysore.
[4] Physiotherapist, Physiotherapy Department
Heritage City College of Physiotherapy

Abstract

Type 2 Diabetes Mellitus (T2DM) is a prevalent metabolic disorder associated with multiple systemic complications, including auditory dysfunction. Emerging evidence suggests a significant association between T2DM and hearing loss, particularly sensorineural hearing loss in adults (Bainbridge et al., 2008; Kakarlapudi et al., 2003). This narrative review aims to explore the audiological implications of T2DM, focusing on underlying pathophysiological mechanisms, patterns of hearing impairment, and clinical considerations for audiological practice. Literature was reviewed from electronic databases including PubMed, Scopus, and Google Scholar. Findings indicate that chronic hyperglycemia may contribute to microvascular damage, neuropathy, and oxidative stress affecting cochlear structures (Lisowska et al., 2001; Fukushima et al., 2006). Audiological assessments commonly reveal bilateral, progressive, high-frequency hearing loss among diabetic individuals (Dalton et al., 1998). Additionally, poor glycemic control and longer disease duration are associated with greater auditory deficits (Akinpelu et al., 2014). Early identification through routine audiological screening is essential for timely intervention. Audiologists play a critical role in monitoring hearing function and providing rehabilitative support. The review highlights the need for interdisciplinary management and increased awareness of hearing health in diabetic care.

1. Introduction

Type 2 Diabetes Mellitus is a chronic metabolic disorder characterized by insulin resistance and persistent hyperglycemia (American Diabetes Association [ADA], 2023). It represents one of the most prevalent non-communicable diseases globally, with a rapidly increasing incidence due to sedentary lifestyles, urbanization, and dietary changes. The long-term metabolic imbalance associated with T2DM contributes to a wide range of systemic complications, including microvascular and macrovascular damage affecting organs such as the eyes, kidneys, heart, and nervous system. While complications like retinopathy, nephropathy, and peripheral neuropathy are well recognized, emerging evidence suggests that the auditory system may also be adversely affected, although it is often overlooked in routine clinical assessments.

Hearing loss is a significant public health concern that negatively impacts communication, social interaction, and overall quality of life. It is associated with psychological consequences such as social isolation, depression, and reduced occupational performance. Among adults, sensorineural hearing loss (SNHL) is the most common type and is typically linked to aging, noise exposure, and genetic predisposition. However, systemic conditions such as diabetes have been increasingly implicated as contributing factors (World Health Organization [WHO], 2021). Epidemiological studies have demonstrated a higher prevalence of hearing impairment among individuals with T2DM compared to non-diabetic populations, suggesting a potential causal or associative relationship (Bainbridge et al., 2008). This association has prompted growing interest in understanding the underlying mechanisms and clinical implications of diabetes-related auditory dysfunction.

The auditory system is particularly vulnerable to metabolic and vascular disturbances due to its high energy demands and dependence on an adequate blood supply. Chronic hyperglycemia in T2DM can lead to microangiopathy, characterized by thickening of capillary walls and reduced blood flow, which may compromise the function of the cochlea, especially the stria vascularis (Lisowska et al., 2001). In addition, diabetic neuropathy can affect the auditory nerve, impairing neural transmission of sound signals to the central auditory pathways. Oxidative stress and the accumulation of advanced glycation end products further contribute to cellular damage within the inner ear structures. Despite the growing body of evidence supporting these mechanisms, hearing loss is still not routinely considered a complication of diabetes in clinical practice, leading to underdiagnosis and delayed intervention.

2. Overview of Type 2 Diabetes Mellitus

Type 2 Diabetes Mellitus is a chronic metabolic disorder characterized by a combination of impaired insulin secretion and peripheral insulin resistance, resulting in persistent hyperglycemia (American Diabetes Association [ADA], 2023). It accounts for the majority of diabetes cases worldwide and is strongly associated with modifiable risk factors such as obesity, physical inactivity, and unhealthy dietary patterns, as well as non-modifiable factors including age and genetic predisposition. The progressive nature of the disease often leads to delayed diagnosis, allowing metabolic disturbances to persist for extended periods before clinical intervention is initiated.

Sustained hyperglycemia is the primary driver of long-term complications in T2DM. These complications are broadly categorized into microvascular and macrovascular disorders. Microvascular complications include diabetic retinopathy, nephropathy, and neuropathy, which arise due to damage to small blood vessels and capillary networks. Macrovascular complications, such as cardiovascular disease and stroke, result from atherosclerotic changes in larger blood vessels. Among these, diabetic neuropathy is particularly relevant to sensory systems, as it affects peripheral nerve function and may extend to cranial nerves, including those involved in auditory processing.

Microvascular damage is a hallmark feature of T2DM and is characterized by thickening of capillary basement membranes, endothelial dysfunction, and reduced vascular perfusion. These changes lead to tissue hypoxia and impaired nutrient delivery, ultimately compromising organ function. In parallel, chronic hyperglycemia induces metabolic disturbances such as the formation of advanced glycation end products (AGEs), increased oxidative stress, and activation of inflammatory pathways. These processes contribute to cellular damage and apoptosis in various tissues.

Neural degeneration is another significant consequence of prolonged diabetes, resulting from both direct metabolic injury and vascular insufficiency. Damage to nerve fibers can impair signal transmission, leading to sensory deficits and functional impairments (Fukushima et al., 2006). These pathological mechanisms are particularly relevant to the auditory system, as the inner ear relies on a rich vascular supply and precise neural signaling for normal hearing function. The cochlea, especially the stria vascularis, has high metabolic demands and is highly susceptible to ischemic and metabolic insults. Therefore, the systemic effects of T2DM create a physiological environment that may predispose individuals to auditory

3. Pathophysiology of Hearing Loss in Diabetes

The association between Type 2 Diabetes Mellitus and hearing loss is multifactorial, involving a combination of vascular, neural, and metabolic mechanisms that collectively impair auditory function. The inner ear is highly sensitive to systemic metabolic disturbances due to its high energy demands and dependence on an intact microvascular supply. Chronic hyperglycemia in diabetes initiates a cascade of pathological changes that progressively affect cochlear structures and auditory pathways, ultimately leading to sensorineural hearing loss.

One of the primary mechanisms implicated is **microangiopathy**, which refers to damage to the small blood vessels supplying the cochlea. In individuals with diabetes, prolonged hyperglycemia leads to thickening of capillary basement membranes, endothelial dysfunction, and reduced vascular perfusion. These changes compromise blood flow to critical cochlear structures such as the stria vascularis, which is responsible for maintaining the ionic composition of endolymph essential for auditory transduction. Reduced oxygen and nutrient delivery results in tissue hypoxia and degeneration of cochlear hair cells, contributing to hearing impairment (Lisowska et al., 2001).

Another significant mechanism is **neuropathy**, which affects the auditory nerve and neural pathways involved in sound transmission. Diabetic neuropathy, commonly observed in peripheral nerves, can also extend to the eighth cranial nerve (vestibulocochlear nerve). Degeneration of nerve fibers and demyelination impair the transmission of electrical signals from the cochlea to the central auditory system. This neural involvement may manifest as reduced speech discrimination ability and delayed neural conduction, even in cases where pure tone thresholds are only mildly affected (Fukushima et al., 2006).

In addition to vascular and neural factors, **oxidative stress** plays a crucial role in the pathogenesis of hearing loss in diabetes. Chronic hyperglycemia leads to the excessive production of reactive oxygen species (ROS), which overwhelm the body’s antioxidant defense mechanisms. This results in cellular damage, lipid peroxidation, and apoptosis of cochlear hair cells. The accumulation of advanced glycation end products (AGEs) further exacerbates oxidative damage and inflammation within the inner ear, accelerating degenerative changes (Akinpelu et al., 2014).

These mechanisms do not act independently but rather interact synergistically, amplifying the extent of auditory damage. The combined effects of microvascular insufficiency, neural degeneration, and oxidative stress lead to progressive and typically irreversible **sensorineural hearing loss**, often beginning at higher frequencies and advancing over time. Understanding these underlying pathophysiological processes is essential for audiologists, as it highlights the importance of early detection, monitoring, and targeted intervention in individuals with diabetes.

4. Audiological Findings in Adults with Type 2 Diabetes Mellitus

A growing body of evidence indicates that individuals with Type 2 Diabetes Mellitus are at an increased risk of developing auditory dysfunction, particularly sensorineural hearing loss (SNHL). This form of hearing loss is typically bilateral, symmetrical, and progressive in nature. Unlike age-related hearing loss alone, diabetes-associated auditory impairment may occur earlier and progress more rapidly, especially in individuals with poor glycemic control or longer disease duration.

One of the most consistent audiological findings in adults with T2DM is greater impairment at higher frequencies, typically in the range of 4 kHz to 8 kHz. This pattern suggests early involvement of the basal turn of the cochlea, which is particularly vulnerable to metabolic and vascular insults. Over time, hearing loss may extend to mid and lower frequencies, affecting speech perception and communication ability.

Pure tone audiometry (PTA) remains the gold standard for assessing hearing thresholds and has consistently demonstrated elevated thresholds in diabetic individuals compared to age-matched non-diabetic controls (Dalton et al., 1998). The degree of hearing loss has been shown to correlate with factors such as duration of diabetes, glycemic control (e.g., HbA1c levels), and the presence of other diabetic complications.

In addition to threshold-based deficits, speech audiometry findings indicate that some individuals with T2DM may exhibit reduced speech discrimination ability, even when pure tone thresholds are only mildly affected. This suggests possible involvement of central auditory pathways or neural processing deficits (Kakarlapudi et al., 2003). Such findings highlight that auditory dysfunction in diabetes is not limited to peripheral structures but may also involve higher-level auditory processing.

Overall, the audiological profile of individuals with T2DM is characterized by a gradual decline in hearing sensitivity, initially affecting high frequencies and progressively impacting communication abilities. These findings underscore the importance of routine hearing evaluation in this population.

5. Audiological Assessment Considerations

Given the increased risk of hearing impairment, routine audiological evaluation is recommended for individuals with Type 2 Diabetes Mellitus, particularly those with long-standing disease or poor glycemic control. Early identification of auditory deficits allows for timely intervention and may help prevent further deterioration in communication function and quality of life.

A comprehensive audiological test battery should be employed to assess both peripheral and central auditory function. Pure Tone Audiometry (PTA) is essential for determining hearing thresholds across frequencies and identifying the degree and configuration of hearing loss. It provides a baseline for monitoring progression over time.

Speech audiometry complements PTA by evaluating speech recognition thresholds and word recognition scores, offering insight into the functional impact of hearing loss on communication. This is particularly important in diabetic individuals, where neural involvement may affect speech processing abilities.

Otoacoustic Emissions (OAE) are valuable for assessing outer hair cell function within the cochlea. Reduced or absent OAEs in individuals with diabetes may indicate early cochlear damage, even before measurable changes appear in pure tone thresholds (Lisowska et al., 2001). Thus, OAEs can serve as a sensitive tool for early detection of subclinical auditory dysfunction.

Auditory Brainstem Response (ABR) testing provides information about neural conduction along the auditory pathway from the cochlea to the brainstem. Prolonged latencies or abnormal wave patterns observed in ABR testing may reflect neural involvement due to diabetic neuropathy (Fukushima et al., 2006). This is particularly useful in identifying retrocochlear or central auditory abnormalities.

In clinical practice, a combination of these assessments ensures a comprehensive evaluation of auditory function in individuals with T2DM. Regular monitoring is especially important for patients with longer disease duration, poor metabolic control, or coexisting complications. Incorporating audiological screening into routine diabetic care can facilitate early diagnosis, appropriate management, and improved patient outcomes.

6. Implications for Audiological Management

Audiologists play a pivotal role in the identification, management, and long-term monitoring of hearing impairment associated with Type 2 Diabetes Mellitus. Given the progressive and often under-recognized nature of diabetes-related auditory dysfunction, early and proactive audiological intervention is essential to minimize its impact on communication and quality of life.

One of the primary management strategies is hearing aid fitting for individuals with sensorineural hearing loss. Since hearing loss in T2DM is typically bilateral and progressive, appropriate selection and fitting of amplification devices are crucial. Modern digital hearing aids can be programmed to address high-frequency hearing loss, which is commonly observed in diabetic individuals. Regular follow-up and fine-tuning are necessary to accommodate changes in hearing sensitivity over time.

Patient education is another critical component of audiological management. Individuals with diabetes should be informed about the potential impact of chronic hyperglycemia on hearing health. Educating patients regarding the importance of glycemic control, routine hearing evaluations, and early reporting of auditory symptoms can enhance self-management and prevent further deterioration. Awareness also helps reduce the likelihood of delayed diagnosis, which is common in this population.

Regular monitoring of hearing function is essential due to the progressive nature of auditory changes associated with T2DM. Periodic audiological assessments allow clinicians to track changes in hearing thresholds, speech perception, and cochlear function. This is particularly important for patients with long-standing diabetes, poor metabolic control, or coexisting complications such as neuropathy. Early detection of subtle changes enables timely modification of intervention strategies.

Effective management also requires interdisciplinary collaboration. Audiologists should work closely with endocrinologists, physicians, and other healthcare professionals involved in diabetes care. Such collaboration ensures a holistic approach, where metabolic control and auditory health are managed simultaneously. Integrating hearing care into routine diabetes management protocols can significantly improve patient outcomes.

In addition to amplification, audiologists may also consider auditory rehabilitation strategies, including communication training and counseling, especially for individuals experiencing difficulties in speech perception. These interventions help improve functional communication and overall participation in daily activities.

Early identification and intervention are key to preventing the negative psychosocial consequences of hearing loss, such as social isolation, reduced work efficiency, and decreased quality of life. As highlighted by the World Health Organization (WHO, 2021), timely audiological care and rehabilitation significantly enhance communication outcomes and overall well-being. Therefore, incorporating routine audiological screening and management into diabetes care is essential for comprehensive patient-centered healthcare.

7. Conclusion

Type 2 Diabetes Mellitus is associated with significant auditory complications, particularly sensorineural hearing loss. The underlying mechanisms include microvascular damage, neuropathy, and oxidative stress. Given the progressive nature of hearing impairment, early screening and intervention are essential. Audiologists play a key role in assessment, management, and patient education, emphasizing the importance of integrating hearing care into diabetes management.

References

1. Akinpelu, O. V., Mujica-Mota, M., & Daniel, S. J. (2014). Is type 2 diabetes mellitus associated with alterations in hearing? A systematic review and meta-analysis. *The Laryngoscope*, *124*(3), 767–776. https://doi.org/10.1002/lary.24354
2. ElSayed, N. A., Aleppo, G., Aroda, V. R., Bannuru, R. R., Brown, F. M., Bruemmer, D., Collins, B. S., Hilliard, M. E., Isaacs, D., Johnson, E. L., Kahan, S., Khunti, K., Leon, J., Lyons, S. K., Perry, M. L., Prahalad, P., Pratley, R. E., Seley, J. J., Stanton, R. C., Gabbay, R. A., … on behalf of the American Diabetes Association (2023). 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes-2023. *Diabetes care*, *46*(Suppl 1), S19–S40. https://doi.org/10.2337/dc23-S002

3. Bainbridge, K. E., Hoffman, H. J., & Cowie, C. C. (2008). Diabetes and hearing impairment in the United States: audiometric evidence from the National Health and Nutrition Examination Survey, 1999 to 2004. *Annals of internal medicine*, *149*(1), 1–10. https://doi.org/10.7326/0003-4819-149-1-200807010-00231
4. Dalton, D. S., Cruickshanks, K. J., Klein, R., Klein, B. E., & Wiley, T. L. (1998). Association of NIDDM and hearing loss. *Diabetes care*, *21*(9), 1540–1544. https://doi.org/10.2337/diacare.21.9.1540
5. Fukushima, H., Cureoglu, S., Schachern, P. A., Paparella, M. M., Harada, T., & Oktay, M. F. (2006). Effects of type 2 diabetes mellitus on cochlear structure in humans. *Archives of otolaryngology--head & neck surgery*, *132*(9), 934–938. https://doi.org/10.1001/archotol.132.9.934
6. Kakarlapudi, V., Sawyer, R., & Staecker, H. (2003). The effect of diabetes on sensorineural hearing loss. *Otology & neurotology : official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology*, *24*(3), 382–386. https://doi.org/10.1097/00129492-200305000-00006
7. Lisowska, G., Namysłowski, G., Morawski, K., & Strojek, K. (2001). Early identification of hearing impairment in patients with type 1 diabetes mellitus. *Otology & neurotology : official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology*, *22*(3), 316–320. https://doi.org/10.1097/00129492-200105000-00008
8. Chadha, S., Kamenov, K., & Cieza, A. (2021). The world report on hearing, 2021. *Bulletin of the World Health Organization*, *99*(4), 242–242A. https://doi.org/10.2471/BLT.21.285643