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# A STUDY TO ASSESS HEARING LOSS IN DENTATE AND EDENTATE PATIENTS

Vishal Tatiya[1], Shilpa Dandekeri[1], Shwetha Sada[2], Chethan Hedge[1]

[1]Department of Prosthodontics and Crown & Bridge, AB Shetty Memorial Institute of Dental Science, Nitte (Deemed to be University), Mangaluru, India
[2]Nitte Institute of Speech and Hearing, Mangaluru, India

## ABSTRACT

**Introduction:** Hearing is a process, through which humans understand, process, and respond to different sound waves. Hearing loss is one of the most common chronic conditions of elderly adults that hampers their basic daily activity. Studies show influence of various risk factors in age-related hearing loss, and few studies observed an association between tooth loss and hearing acuity.

**Objectives:** The present study evaluated the relation between edentulous and dentate patients and their hearing loss.

**Material and methods:** This in-vivo study was conducted in Department of Prosthodontics and Crown & Bridge, Department of Speech and Hearing at our institute, among a total of 52 subjects, including dentulous patients ($n$ = 26) and completely edentulous patients ($n$ = 26). These patients were subjected to pure tone audiometry. Data in the study followed non-parametric distribution based on Kolmogorov-Smirnov test for normality, and to compare means in both the groups, Mann-Whitney *U* test was applied.

**Results:** Air conduction thresholds and bone conduction levels between both the groups were found to be statistically significant. PTA (pure tone average) scores of both the groups over the right and left ears were statistically significant, with $p$-value = 0.000. Based on the findings, we could conclude that loss of teeth does have an impact on hearing.

**Conclusions:** Hearing impairment due to tooth loss can result from compression of the Eustachian tube by overclosure of mandible and decrease in the transfer of vibration to the ear canal for every tooth unit lost. Tooth loss affects hearing regardless of the use of full dentures. This study highlights the importance of the presence of teeth, and every effort should be made to prolong their presence in the oral cavity in a healthy state. This could have a positive impact on hearing, nutritional status, and quality of life of individuals. Quantitative data may help in providing proper support with respect to clinical interventions, and thus reducing the risk of hearing loss.

**Key words:** edentulous jaw, person with hearing impairment, hearing impairment, dentulous jaw.

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## INTRODUCTION

Edentulism is an irreversible condition and a debilitating disease, which is defined by the Glossary of Prosthodontics-9 as "The state of being edentulous, without natural teeth" [1]. It is a multifactorial disease that may be due to caries, periodontal, pulpal pathology, or oral cancer. A subject or the patient can be either partially edentate or completely edentulous. The presence of opposing posterior teeth helps in maintaining vertical di-

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**Address for correspondence:** Shilpa Dandekeri, Department of Prosthodontics and Crown & Bridge, AB Shetty Memorial Institute of Dental Science, Nitte (Deemed to be University), Mangaluru, India, e-mail: drshilpadandekeri@nitte.edu.in

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mension by maintaining a stop. Having an efficient masticatory function is of utmost importance, as it affects the intake of nutrition and diet of an individual. Considering the impact on speech and nutrition, it has a poor impact on an individual's quality of life.

Hearing is a process, by which humans understand, process, and respond to different sound waves. Hearing loss is one of the most common chronic conditions of elderly adults, due to which their basic daily activity is hampered. It includes partial or total inability of the ear either unilateral or bilateral. As elder adults have hearing loss, their life quality is substantially reduced, and some of them develop depression, isolation, and social awkwardness. The gold standard for audiological examination is pure-tone audiometry, with its' role to test whether hearing acuity is normal or impaired. The readings are plotted in an audiogram and are interpreted for the type and degree of loss [2].

Studies have shown an association between tooth loss and age-related hearing loss. When there is loss of teeth, there is a narrowing of the Eustachian tube with change in the size and shape of the ear canal, which accentuates when vertical dimension is lost to a greater level; tooth acts as an apparatus for hearing as a bone conductor, as it transfers vibration to the bones of the skull because of their buttressing action. Few authors attributed deafness to tooth loss, as there is a decrease in vertical dimension leading to occlusion of the Eustachian tube. Unanimity on the findings about the temporomandibular joint by various authors indicates that impairments are caused by over-closure of the mandible, as in cases where vertical dimension of occlusion is decreased or due to malocclusion, which may cause symptoms of vertigo, tinnitus, and impaired hearing.

Various theories have been proposed by authors over the causative factors of the symptoms, few of the widely accepted theories are:

1. Retrusion of the condyles causing the compression of the external auditory canal.
2. Compression of the Eustachian tube by the auditory muscles.
3. Tympanic membrane retraction is caused due to negative pressure build-up.
4. Myofascial trigger mechanism.
5. The impairment of the lymphatic drainage system to drain inflamed the temporomandibular joint causes swelling of the tubal mucosa.
6. The involvement of the autonomic nervous system in the formation of a vacuum in Eustachian tube [3, 4].

For every loss of a dental unit, the chances of decline in hearing are as high as 1.04 times [5]. Studies have shown promising results in the improvement of hearing impairment symptoms after rehabilitation of the extracted teeth. On the contrary, various studies show no changes in hearing ability after a decrease in vertical dimension post-extraction. Due to the difference in opinion of various authors, this study was conducted with an aim to evaluate the association of tooth and hearing loss. The objective of the study was to assess hearing in dentulous and edentulous patients, and to evaluate the relation between loss of teeth and hearing ability.

## MATERIAL AND METHODS

This *in-vivo* study was conducted in Department of Prosthodontics and Crown & Bridge and Department of Speech and Hearing at our institute, and included a total of 52 samples, which were sub-divided into dentate patients – control group ($n$ = 26), and completely edentulous patients – experimental group ($n$ = 26). Ethical clearance was obtained from Institutional Ethical Clearance Board, with approval number of ABSM/EC 33/2019. The sample size estimation was done using G* Power sample size software, based on 5% level of significance and 80% power and effect size of 0.8. Patients of age 60-70 years, who never wore a complete denture and were receiving dentures for the 1st time, and willing to give consent for participation were included in the study. Patients who had any middle ear pathology, ototoxicity, or were using any hearing aids, and had hearing loss due to occupational hazards were excluded from the study. Also, patients below 60 and above 70 years of age were excluded from the study. Since occlusal conditions of patients were not investigated, only dentate and edentate patients were qualified for the research. Patients were informed about the purpose and procedure of the study. Patients were subjected to pure-tone audiometric testing (air and bone conduction) in the Department of Speech and Hearing. For non-parametric distribution, Kolmogorov-Smirnov test for normality was applied, and to compare the means in both the groups, Mann-Whitney *U* test was used.

### PROCEDURE FOR PURE-TONE AUDIOMETRY TEST

#### *EQUIPMENT*

A two-channel diagnostic audiometer (Piano-Inventis) with a bone vibrator B-70 radio-ear and a circum-aural headphones (Sennheiser) was used.

#### *TEST ENVIRONMENT*

Patient was seated in a sound-treated environment/room, where the patient face was visible through a window, with necessary communication established with the patient.

#### *IMMITTANCE TEST*

As a part of exclusion criteria to diagnose/eliminate patients with middle ear pathology, immittance test was performed, with inter-acoustics AT 235 instrument used.


**FIGURE 1.** From left to right: circum-aural earphone placed over the patient's ear; bone vibrator placed in the mastoid region

### *AIR CONDUCTION AUDIOMETRY*

Circum-aural earphone was placed over the patient's ear without causing any discomfort, and the patient was instructed not to adjust the earphone (Figure 1). A modified Hughson-Westlake method was applied, and specified how to obtain a threshold. The audiometry test started with 1 KHz. The patient's response was plotted on the audiogram and further responses were noted for frequencies in 2 KHz, 4 KHz, 8 KHz, 500 Hz, and 250 Hz [6].

### *BONE CONDUCTION AUDIOMETRY*

Bone vibrator was placed over the mastoid region on better-hearing ear based on the scores of air conduction threshold averaged from 500 Hz to 4 KHz. The vibrator should be placed as close as possible to the mastoid region, behind the pinna without contacting it or the hair present. Bone conduction threshold was noted at 1 KHz, 2 KHz, 4 KHz, 500 Hz, and 250 Hz [6]. Pure-tone average (PTA) score was an average of air conduction threshold at 500 Hz, 1 KHz, 2 KHz, and 4 KHz.

### *AUDIOGRAM*

An audiogram was a graph plotted against the hearing threshold values at a particular frequency, which is also known as 'tonal audiogram' [2]. The audiogram was plotted with the following legend: Right air conduction (R-AC): red circle 'O'; Left air conduction (L-AC): blue cross 'X'; Right bone conduction (R-BC): red '<'; Left bone conduction (L-BC): blue '>'.

## RESULTS

Air conduction thresholds at 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz, and 8 KHz, and bone conduction thresholds at 250 Hz, 500 Hz, 1 KHz, 2 KHz, and 4 KHz were obtained. Threshold of frequency at 250 Hz, 500 Hz, 1 KHz, 2 KHz, and 4 KHz for R-AC, L-AC, R-BC, and L-BC between the control and experimental groups was found statistically significant (Table 1). Threshold of frequency at 8 KHz for R-AC and L-AC between the control and experimental groups was found statistically significant (Table 1). When the PTA scores of the right and left sides between the two groups were compared, the data was found statistically significant ($p$ = 0.000) (Table 2). The experimental and control PTA scores for the right side were 36.25 ± 10.58 and 21.34 ± 6.31, respectively, with p-value of 0.000. For the left side, the PTA scores for the experimental and control groups were 35.34 ± 9.75 and 21.83 ± 7.92, respectively, with $p$-value of 0.000. Based on the findings of this clinical study, we can conclude that loss of teeth does have an impact on hearing.

## DISCUSSION

Ear, an organ of hearing, also helps a human in maintaining balance of the body, and is divided into 3 segments. The first segment, the outer ear, comprises the pinna and external auditory canal, which transmits the sound from external environment to tympanic membrane. The second segment is the middle ear consisting of three bones, namely the malleus, incus, and stapes, which help in transmitting sound waves from tympanic membrane to inner ear [7]. The tympanic plate separates external auditory meatus from the head of condyle, and is a part of temporal bone [8]. Squamotympanic fissure corresponds to the boundary between the tympanic plate and medial aspect of articular fossa [7]. The inner ear comprises of cochlea that causes a conversion of vibration to nerve impulses, and vestibular labyrinth that helps humans to maintain balance [9]. The Eustachian tube is a thin tube that creates a passage between the middle ear cavity and the nasopharynx, and there are six muscles, which participate in active functioning of the tube, including the lateral pterygoids, medial pterygoids, salpingo- pharyngeus, levator veli palatini, tensor tympani, and tensor veli palatini. This tube is usually

**TABLE 1.** Comparison of mean hearing values between edentulous experimental group and control group with post-stop

| Frequency | Position | Group[#] | *n* | Mean[#] | Std. deviation | *p*-value[*] |
|---|---|---|---|---|---|---|
| 250 Hz | Right air conduction threshold | Experimental | 26 | 24.23 | 11.549 | 0.001 |
| | | Control | 26 | 15.19 | 5.741 | |
| | Left air conduction threshold | Experimental | 26 | 24.62 | 9.265 | 0.003 |
| | | Control | 26 | 16.73 | 8.938 | |
| | Right bone conduction threshold | Experimental | 26 | 14.81 | 7.808 | 0.000 |
| | | Control | 26 | 6.73 | 6.472 | |
| | Left bone conduction threshold | Experimental | 26 | 17.69 | 9.923 | 0.000 |
| | | Control | 26 | 6.54 | 7.179 | |
| 500 Hz | Right air conduction threshold | Experimental | 26 | 29.42 | 12.754 | 0.000 |
| | | Control | 26 | 18.08 | 5.306 | |
| | Left air conduction threshold | Experimental | 26 | 28.27 | 11.827 | 0.001 |
| | | Control | 26 | 17.69 | 8.394 | |
| | Right bone conduction threshold | Experimental | 26 | 22.50 | 11.683 | 0.001 |
| | | Control | 26 | 11.73 | 7.608 | |
| | Left bone conduction threshold | Experimental | 26 | 25.38 | 12.564 | 0.001 |
| | | Control | 26 | 11.54 | 7.716 | |
| 1 KHz | Right air conduction threshold | Experimental | 26 | 29.23 | 10.554 | 0.001 |
| | | Control | 26 | 18.46 | 5.791 | |
| | Left air conduction threshold | Experimental | 26 | 29.62 | 11.826 | 0.001 |
| | | Control | 26 | 16.92 | 6.794 | |
| | Right bone conduction threshold | Experimental | 26 | 24.62 | 11.910 | 0.001 |
| | | Control | 26 | 12.50 | 7.906 | |
| | Left bone conduction threshold | Experimental | 26 | 26.54 | 10.933 | 0.001 |
| | | Control | 26 | 12.31 | 6.961 | |
| 2 KHz | Right air conduction threshold | Experimental | 26 | 35.96 | 12.002 | 0.001 |
| | | Control | 26 | 19.04 | 8.946 | |
| | Left air conduction threshold | Experimental | 26 | 34.42 | 11.604 | 0.001 |
| | | Control | 26 | 20.00 | 8.944 | |
| | Right bone conduction threshold | Experiment | 26 | 29.04 | 13.492 | 0.001 |
| | | Control | 26 | 15.38 | 9.687 | |
| | Left bone conduction threshold | Experimental | 26 | 30.19 | 10.907 | 0.001 |
| | | Control | 26 | 15.77 | 9.240 | |
| 4 KHz | Right air conduction threshold | Experimental | 26 | 50.38 | 14.347 | 0.001 |
| | | Control | 26 | 29.81 | 11.356 | |
| | Left air conduction threshold | Experimental | 26 | 49.04 | 12.886 | 0.001 |
| | | Control | 26 | 32.69 | 14.438 | |
| | Right bone conduction threshold | Experimental | 26 | 32.31 | 14.780 | 0.009 |
| | | Control | 26 | 21.73 | 13.187 | |
| | Left bone conduction threshold | Experimental | 26 | 37.69 | 14.299 | 0.001 |
| | | Control | 26 | 21.73 | 11.657 | |
| 8 KHz | Right air conduction threshold | Experimental | 26 | 58.65 | 12.374 | 0.001 |
| | | Control | 26 | 33.08 | 13.644 | |
| | Left air conduction threshold | Experimental | 26 | 58.65 | 13.081 | 0.001 |
| | | Control | 26 | 34.81 | 14.105 | |

*[#]Mann-Whitney U test. *Statistically significant $p < 0.05$.*

**TABLE 2.** Comparison of PTA values across edentulous experimental group and control post-stop group

| PTA | Group[#] | n | Mean[#] | Std. deviation | p-value[*] |
|---|---|---|---|---|---|
| Right | Experimental | 26 | 36.25 | 10.58 | 0.000 |
| | Control | 26 | 21.34 | 6.31 | |
| Left | Experimental | 26 | 35.34 | 9.75 | 0.000 |
| | Control | 26 | 21.83 | 7.92 | |

[#]Mann-Whitney U test. *Statistically significant $p < 0.05$.

closed, and opens by muscular contractions caused by the above-mentioned muscles, and also during deglution, yawning, and phonation.

Tensor veli palatini and levator veli palatini usually function by opening up the Eustachian tube, and the salpingo-pharyngeus muscle that plays a role in swallowing indirectly has a minor role to play in opening up of the Eustachian tube. The lateral and the medial pterygoid play a role in mastication, jaw movement, and function of the middle ear. Tensor veli palatini and levator veli palatini mimic the lateral pterygoids even when there is no deglutition occurring by opening or changing the shape of Eustachian tube [10].

The shorter belly of medial pterygoid creates narrowing of the cartilaginous part of Eustachian tube as tensor veli palatini is hindered when there is overclosure of the mandible. This is seen in cases of deep bite or edentulousness. The function of tensor veli palatini improves when the medial pterygoid is relieved, which helps in the opening of auditory tube [11].

A study by Costen in 1934 on a series of patients reported that malocclusion and lack of teeth in posterior segments create a decreased vertical dimension, leading to disturbance in mandibular joint function. Based on this, he conducted a hearing test on patients and concluded that patients had hearing impairment due to occlusion of the Eustachian tube and due to overclosure of the mandible [4].

There are three widely accepted theories of bone conduction hearing, including compressional bone conduction, inertial bone conduction, and osseo-tympanic bone conduction [12]. Excitation of the cochlea involves the impulse being transferred from the point of initiation in the skull to the inner ear, which is a purely osseous route of transmission to the temporal bone. In 2002, a fluid pathway was demonstrated, where the fluid vibration dynamics were transferred to fluid channels, and from there to the inner ear [13].

Based on these research, the aim of the present study was to evaluate if loss of teeth had a role to play in the hearing ability of the subjects, and to what extent is the difference noted.

When the patients were subjected to a frequency of 250 Hz of the experimental and control groups, R-AC of the experimental group had a mean of 24.23 ± 11.549, and the control group had a mean value of 15.19 ± 5.741. L-AC of the experimental group had a mean of 24.62 ± 9.265, and the control group had a mean value of 16.73 ± 8.938. The values were statistically significant with, a *p*-value of 0.001 for R-AC, and 0.003 for L-AC.

Similarly, when the patients were presented with a frequency of 500 Hz, 1 KHz, 2 KHz, 4 KHz, and 8 KHz of the experimental and control groups, R-AC and L-AC of the experimental and control groups were statistically significant (Table 1). The obtained values for the air conduction after statistical interpretation agrees with the observation noted in the literature showing that loss of teeth affects the air conduction, of which one possible reason could be the compression of Eustachian tube leading to pressure changes. It was also noted that patients, who had no teeth on one side presented with a greater impact on the hearing impairment to the side with teeth.

When the patients were subjected to a frequency of 250 Hz of the experimental and control groups, R-BC of the experimental group had a mean of 14.81 ± 7.808, and the control group had a mean value of 6.73 ± 6.472. L-BC of the experimental group had a mean of 17.69 ± 9.923, and the control group had a mean value of 6.54 ± 7.179. The values were statistically significant, with a p-value of 0.000 for R-BC and 0.00 for L-BC.

Similarly, when the patients were presented to a frequency of 500 Hz, 1 KHz, 2 KHz, and 4 KHz of the experimental and control groups, R-BC and L-BC of the experimental group and control groups were statistically significant (Table 1).

With the above-mentioned data, a statistical significance was noted that reveals the importance of teeth as one of the units that could play an important role in the transmission of sound to the inner ear. One classic example is that after closing the ear with the index fingers, we could appreciate the sound when teeth contact on biting. This signifies that the transmission of sound also takes place within the body through the bones, and teeth in the cranium [14].

PTA scores were calculated by averaging scores of the air conduction at 500 Hz, 1 KHz, 2 KHz, and 4 KHz. When these PTA scores were compared between the experimental and control groups for the right and left sides, statistically significant data was found.

The experimental and control PTA scores for the right side were 36.25 ± 10.58 and 21.34 ± 6.31, respectively, with a *p*-value of 0.000 and for the left side. PTA scores for the experimental and control groups were 35.34 ± 9.75 and 21.83 ± 7.92, respectively, with a *p*-value of 0.000 (Table 2).

Lawrence *et al.* [5] conducted a cross-sectional study among USA veterans to connect the link between hearing ability and tooth loss. He reported that with every loss of a dental unit or tooth, there was a high odd of hearing decline of up to 1.04 times.

A study by Peeters *et al.* [15] in 2004 stated that the disparity of hearing impairment between patients wearing complete dentures and patients lacking vertical dimension (decreased) reinforces the statement that it is the absence of the latter, which correlate with hearing loss.

Shreedhar *et al.* [16] in their study in 2020 stated that patient's ability to hear increase on the restoration of the lost vertical dimension; these patients were given prosthetic rehabilitation by fabrication of an implant-supported overdenture. Placement of implant mimics the placement of tooth in bone, thus helping in bone conduction through the jaws and skull. Both of them showed a positive impact on hearing.

A study by Paturu *et al.* [17] in 2011 evaluated the eating pattern and nutritional status in patient, who got their denture fabricated for the 1st and 2nd time, concluded the need of rehabilitation in edentulous patient to positively reinforce their eating pattern to achieve better nutritional status. Patient who complained of impaired hearing had their micronutrients, such as vitamin A, vitamin B, vitamin C, vitamin D, and vitamin E, magnesium, iron, and zinc at a lesser levels, as stated by Jung *et al.* [18].

Over the data available, it was noted that edentulous patients presented with evident increased threshold for the air conduction at 4 KHz and 8 KHz, and patients with teeth in the control group presented with increased threshold for the air conduction at 4 KHz. Patients who presented with no teeth had their bone conduction affected equally. In patients who had posterior stop unilaterally, the air conduction and bone conduction were better on the maintained side.

In 2010, an intra-oral device was invented named 'the soundbite hearing system' that aids people with unilateral deafness in hearing. This system comprises a microphone placed over the deaf ear, and the use of an intra-oral device helps in the transmission of sound through the bone and teeth to the hearing ear. This also helps in bone conduction of the sound; the following invention also supports the role of teeth in hearing [14].

Loss of teeth (posteriorly) leads to overclosure of mandible, which could create a compression through the cartilaginous portion of the external auditory meatus, and teeth act as a medium to transfer the sound and vibrations to the inner ear through the bone and fluids in the foramina, as suggested by the fluid pathway. This could be the possible reason behind hearing loss through loss of teeth [11, 14].

## LIMITATIONS

The results of the study would vary in recording the data with respect to period of edentulism and its' association to hearing, as there was a gradual change that occurred post-extraction. A smaller sample size could have led to variation in normal distribution of data, which could have affected the statistical outcome of the study.

## CONCLUSIONS

Hearing impairment due to tooth loss can be due to compression of the Eustachian tube by overclosure of mandible and decrease in the transfer of vibration to the ear canal for every tooth unit lost. Tooth loss affects hearing regardless of the use of complete dentures. This study highlights the importance of the presence of teeth, and every effort should be made to prolong their presence in the oral cavity in a healthy state, which could have a positive impact on patients' hearing, nutritional status, and quality of life. Quantitative data may help in providing proper support with respect to clinical interventions, and thus reducing the risk of hearing loss.

## CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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