Innovations

"Dental Peace: The Impact of Noise Protection on Dentists' Performance"

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Abstract

Purpose*: Dental professionals face significant challenges due to the constant exposure to high levels of noise in clinical environments, which can impact both their performance and well-being. This study investigates the effectiveness of different noise protection methods—Active Noise Cancellation (ANC) and Passive Noise Cancellation (PNC)—on dentists' performance during dental procedures.* ***Materials & Methods:*** *A total of 45 dental students were divided into three groups: ANC, ANC with binaural beats, and PNC with binaural beats. The study aimed to assess noise perception, concentration, communication, and overall satisfaction with the devices.* ***Results:*** *the study revealed that PNC with binaural beats provided the highest satisfaction in noise reduction and communication, followed by ANC with binaural beats, which significantly enhanced concentration. While no significant differences were found in terms of disruption during procedures, PNC with binaural beats effectively addressed the participants' main concerns.* ***Conclusion:*** *These findings suggest that noise cancellation technologies, particularly PNC with binaural beats, may improve the dental working environment, offering potential benefits for both practitioners and patients. The study highlights the need for further exploration of noise control in dental settings to enhance performance and reduce stress.*

Keyword: *Active Noise Cancellation, Binaural Beats, Passive Noise Cancellation, Noise Protection, Music Therapy, Dentist Performance*

Introduction

Dentistry, a profession known for its precision and attention to detail, has long faced a persistent challenge: noise. The high-pitched whirring of drills, suction devices, and other dental equipment has become synonymous with patient anxiety and discomfort. Additionally, prolonged exposure to these loud sounds

poses significant risks to the hearing and overall well-being of dental professionals.[1]
Sound can have either a negative impact, perceived as noise or a positive one, for example while listening to pleasant music. [2]Noise is an unwanted sound that makes people uncomfortable and it is physically defined as a sound pressure of 50dB or more. [1]
Research conducted in dental clinics and laboratories has revealed that air turbine hand pieces and air guns generate excessive noise levels, often exceeding 85 decibels (dB), primarily at high frequencies. This high-frequency noise can lead to hearing loss among dental professionals, particularly in the left ear, due to its closer proximity to the noise source.Messano and Petti reported a 40% prevalence of hearing impairment among dentists. However, other studies have found minimal or no significant hearing loss in dentists when compared to control groups.[3]
With the continuous advancement of noise cancellation technology and its integration into dental practices, it becomes crucial to explore its applications, advantages, and future prospects. This article delves into the role of noise cancellation in dentistry using active and passive methods, examining its potential to transform the dental experience and foster a quieter, more compassionate environment for patients and professionals alike.[4]

Active noise cancellation (anc) techniques

This technique employs an electro-acoustic system to neutralize the original noise. It does so by introducing a noise-countering signal with the same antiphase and amplitude. Researchers used ANC in the microcontroller and were able to reduce 25 dB of the 60Hz periodic noise component.[1]

Passive noise cancellation

This technique minimizes unwanted sound waves without relying on electronic noise cancellation technology. Instead, it utilizes physical barriers or materials to block, absorb, or dampen sound waves effectively.[1]

Music promotes relaxation by masking the sound of the dental drill. Its calming effects are attributed to its influence on the brain's limbic system, which stimulates the release of endorphins and encephalins. [5]
Binaural beats consist of two different pure-tone waves with slightly different frequencies. When these beats are heard, they produce psychophysiological effects. One notable effect is relaxation, which occurs when the frequency of binaural beats matches the alpha brain waves. The brainwave entrainment induced by alpha wave stimulation may trigger the release of endorphins, leading to a clinical relaxation effect.[6]

Noise cancellation technology holds the potential to revolutionize the dental industry by offering effective hearing protection, boosting productivity, and improving the overall patient experience. As advancements in the dental field progress, prioritizing noise cancellation technology becomes essential to ensure a safe and healthy environment for both dental professionals and patients.[7]

This study aims to compare the effectiveness of noise cancellation in dentistry using Active Noise Cancellation (ANC) and Passive Noise Cancellation (PNC) devices during dental procedures, as experienced by dentists and dental assistants.

Materials and methods

The study was carried out at the Department of Prosthodontics, Adhiparashakthi Institute of Dental Sciences, Melmaruvathur. A total of 45 dental students, including interns and postgraduates from the institution, participated in the study. The participants were divided into three groups, with 15 students in each group.

GROUP 1: 15 dental students were provided with Active Noise Cancellation (ANC) devices, specifically Apple Air Pods Pro 2nd generation, during dental procedures.

GROUP 2: 15 dental students were provided with Active Noise Cancellation (ANC) devices, Apple Air Pods Pro 2nd generation, with binaural beats playing during dental procedures.

GROUP 3: 15 dental students were provided with Passive Noise Cancellation (PNC) devices, Sony WH-CH720N headphones, during dental procedures.

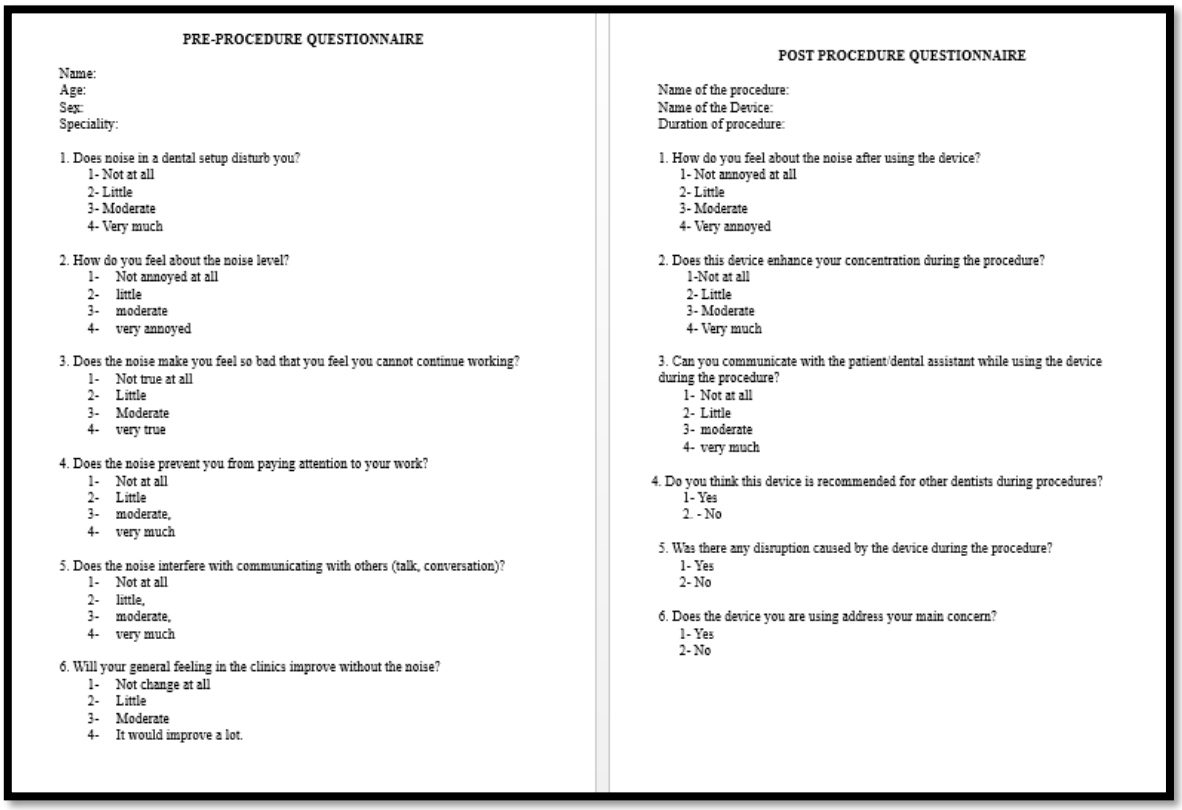
The dental procedures took place in an isolated dental office, which was well-ventilated and adhered to strict infection control protocols. The office was disinfected and sterilized before and after each procedure, but there were no soundproofing materials in the walls of the office. The office was equipped with a Confident Body Contoured Electrically Operated Dental Chair, High and Low Vacuum Motorized "DRYCO" Suction with Auto Drain and Auto flush system, and the Supreme Micro motor 35,000 RPM with a digital display for speed.

The dental procedures included in the study were:

- **Ultrasonic Scaling**: Performed with a Woodpecker UDS-J Ultrasonic Scaler operating at a frequency of 28 kHz, adjustable power input ranging from 10-50W, and a voltage range of 100-240V AC (50/60Hz).
- **Impaction**: Bone removal procedures were carried out using 701 or 702 burs in a Marathon Headpiece, with an RPM range of 0 to 40,000, weighing 52 grams, and a maximum temperature of 135°C.

- **Tooth Preparation during FPD Procedure**: Performed with an NSK Pana Air Hand piece FX SU B2, with a rotational speed range of 350,000 to 450,000 RPM and an air pressure range of 0.20-0.25 MPa.

Each procedure was standardized and conducted for no more than 15 minutes. Before the procedure began, participants were asked to complete a pre-questionnaire, and after the procedure, they were asked to fill out a post-questionnaire based on their experiences in their respective groups.



PRE-PROCEDURE QUESTIONNAIRE

Name:
Age:
Sex:
Speciality:

1. Does noise in a dental setup disturb you?
   1- Not at all
   2- Little
   3- Moderate
   4- Very much

2. How do you feel about the noise level?
   1- Not annoyed at all
   2- little
   3- moderate
   4- very annoyed

3. Does the noise make you feel so bad that you feel you cannot continue working?
   1- Not true at all
   2- Little
   3- Moderate
   4- very true

4. Does the noise prevent you from paying attention to your work?
   1- Not at all
   2- Little
   3- moderate,
   4- very much

5. Does the noise interfere with communicating with others (talk, conversation)?
   1- Not at all
   2- little,
   3- moderate,
   4- very much

6. Will your general feeling in the clinics improve without the noise?
   1- Not change at all
   2- Little
   3- Moderate
   4- It would improve a lot.

POST PROCEDURE QUESTIONNAIRE

Name of the procedure:
Name of the Device:
Duration of procedure:

1. How do you feel about the noise after using the device?
   1- Not annoyed at all
   2- Little
   3- Moderate
   4- Very annoyed

2. Does this device enhance your concentration during the procedure?
   1-Not at all
   2- Little
   3- Moderate
   4- Very much

3. Can you communicate with the patient/dental assistant while using the device during the procedure?
   1- Not at all
   2- Little
   3- moderate
   4- very much

4. Do you think this device is recommended for other dentists during procedures?
   1- Yes
   2. - No

5. Was there any disruption caused by the device during the procedure?
   1- Yes
   2- No

6. Does the device you are using address your main concern?
   1- Yes
   2- No

The questionnaire was used to examine the effects of the noise produced during dental procedures on dentist's perceptions and assess the relationship between that noise and dentist performance. All the collected data were tabulated in Microsoft Excel spreadsheet and analysed statistically.

Results

Table 1 - Represents the intergroup comparison between the post intervention outcomes of the study population

QUESTIONS	GROUPS	MEAN	S.D	95% CONFIDENCE INTERVAL		SIG
				UPPER	LOWER	
How do you feel about the noise after using the device?	Passive Noise Cancellation With Binaural Beats	3.07	.884	2.58	3.56	0.000*
	Active Noise Cancellation	1.67	.617	1.32	2.01	
	Active Noise Cancellation With Binaural Beats	2.00	.756	1.58	2.42	
Does this device enhance your concentration during the procedure?	Passive Noise Cancellation With Binaural Beats	1.47	.743	1.06	1.88	0.000*
	Active Noise Cancellation	2.33	.724	1.93	2.73	
	Active Noise Cancellation With Binaural Beats	2.47	.834	2.00	2.93	
Can you communicate with the patient/dental assistant while using the device during the procedure?	Passive Noise Cancellation With Binaural Beats	3.20	.941	2.68	3.72	0.000*
	Active Noise Cancellation	2.00	.845	1.53	2.47	
	Active Noise Cancellation With Binaural Beats	2.13	.516	1.85	2.42	
you think this device is ommended for other ntists during procedures?	Passive Noise Cancellation With Binaural Beats	2.00	.000	2.00	2.00	0.000*
	Active Noise Cancellation	1.47	.516	1.18	1.75	
	Active Noise Cancellation With Binaural Beats	1.53	.516	1.25	1.82	
	Passive Noise Cancellation With	1.73	.458	1.48	1.99	

s there any disruption aused by the device during e procedure?	Binaural Beats					**0.887**
	Active Noise Cancellation	1.80	.414	1.57	2.03	
	Active Noise Cancellation With Binaural Beats	1.80	.414	1.57	2.03	
Does the device you're using address your main concern?	Passive Noise Cancellation With Binaural Beats	2.00	.000	2.00	2.00	**0.000***
	Active Noise Cancellation	1.27	.458	1.01	1.52	
	Active Noise Cancellation With Binaural Beats	1.20	.414	.97	1.43	

Table 1 Interpretation: Intergroup Comparison of Post-Intervention Outcomes

1. Noise Perception:
   - Passive noise cancellation with binaural beats (mean = 3.07) showed significantly higher satisfaction regarding noise reduction compared to active noise cancellation (mean = 1.67) and active noise cancellation with binaural beats (mean = 2.00).
   - P-value = 0.000, indicating a statistically significant difference among groups.
2. Concentration Enhancement:
   - Active noise cancellation with binaural beats (mean = 2.47) and active noise cancellation (mean = 2.33) were more effective in enhancing concentration compared to passive noise cancellation with binaural beats (mean = 1.47).
   - P-value = 0.000, confirming the significant difference.
3. Communication Ability:
   - Passive noise cancellation with binaural beats (mean = 3.20) allowed better communication than the other two groups (active noise cancellation: mean = 2.00, active noise cancellation with binaural beats: mean = 2.13).
   - P-value = 0.000, highlighting the statistical significance.
4. Recommendation to Other Dentists:
   - Passive noise cancellation with binaural beats (mean = 2.00) had unanimous agreement, outperforming other groups.
   - P-value = 0.000, signifying a strong difference.
5. Disruptions During Procedures:

- There was no significant difference between the groups regarding disruptions caused during procedures (means ranged from 1.73 to 1.80, P-value = 0.887).

6. Addressing Main Concerns:
    - Passive noise cancellation with binaural beats (mean = 2.00) effectively addressed concerns better than active noise cancellation (mean = 1.27) and active noise cancellation with binaural beats (mean = 1.20).
    - P-value = 0.000, showing significant variation.

Passive noise cancellation with binaural beats is superior in communication, noise reduction, and addressing main concerns. Active noise cancellation with binaural beats is better for enhancing concentration but less favourable in other parameters. No significant differences were observed for disruptions during procedures.

Discussion

Noise pollution has become a significant concern across society. The National Institute for Occupational Safety and Health (NIOSH) has identified noise as one of the top ten causes of work-related diseases and injuries. Noise can lead to masking of important sounds, interference with speech and communication, pain and injury, as well as temporary or permanent hearing loss.[8]

In 2012, Giuseppe et al. reported that general dental practitioners are at a higher risk of hearing impairment compared to general medical practitioners. This risk was not universal among all dentists but was specifically associated with those who frequently used noisy equipment, such as aged turbines and ultrasonic scalers, in their daily practice. [9]Similarly, in 1980, H. Zubic et al. suggested a potential cause-and-effect relationship between hearing loss and the use of high-speed dental hand pieces.[10]

While numerous studies have demonstrated the effectiveness of noise cancellation techniques in reducing patient anxiety, there is limited research evaluating their impact on dentists. This study aims to assess the effects of noise cancellation methods on dentists during various dental procedures.

Active noise control (ANC) involves amplifying or reducing sounds as intended by the system developer. Its ultimate goal is to diminish unwanted noise while preserving or amplifying specific targeted sounds. First introduced in the 1930s, ANC application to headsets began in the 1950s. ANC operates by utilizing reference microphones that identify unwanted noise waveforms and selectively block or amplify sounds.[11]

Passive noise control (PNC), on the other hand, relies on mechanical physical barriers, such as sound absorbers or foam, to block sound waves. PNC is particularly effective at blocking high-frequency noise above 10 kHz, while ANC is more suited for reducing lower-frequency noise below 10 kHz.[1]

Ponni et al., in their article, cited music theorists like Bonny and Gfelle, who stated that music can divert attention from stressful stimuli and help refocus on more pleasurable states. [12] Hence, binaural beats, known for their relaxation-inducing effects, were incorporated.

In this study, 45 dental students participated and completed pre- and post-procedure questionnaires. The aim was to evaluate strategies for mitigating unwanted noise during dental procedures and to compare the effectiveness of active and passive noise cancellation devices. The questionnaire focused on aspects such as noise perception, concentration enhancement, communication ability, device recommendations, procedural disruptions, and addressing primary concerns.

The results indicated that passive noise cancellation devices were superior in noise perception and communication ability, whereas active noise cancellation and ANC combined with binaural beats were better for enhancing concentration. Participants recommended the use of PNC devices paired with binaural beats.

To prevent noise-induced hearing loss caused by dental noise, blocking high-frequency noise in the 4–6 kHz range and above 10 kHz is crucial, while maintaining or amplifying sounds around 1 kHz to facilitate verbal communication in dental clinics. This makes PNC a potentially better choice for dentists.[1]

P. Jiang et al., in their study, emphasized the importance of effective verbal communication between the dentist and patient during dental procedures. They noted that active noise-cancelling headphones suppress all sounds indiscriminately, including speech, thereby hindering communication. The study highlighted the effectiveness of low-cost passive devices in reducing unwanted drill noise in dental clinics.[13]

A 2022 study by Hoshina et al. highlighted that ANC could reduce background noise levels reaching the listener's ears, complementing the passive blocking of sound by earphones and leading to lower preferred listening levels. Similarly, [14] Kunal Wason, in 2015, emphasized that ANC is particularly effective at removing low-frequency ambient noise.[2]

Conclusion

Passive noise cancellation (PNC) combined with binaural beats emerged as the preferred noise cancellation method among participants. While active noise cancellation (ANC) was found to enhance concentration, PNC proved more effective in improving communication within the workplace, all the while effectively managing unwanted noise. Research has shown that music therapy can significantly reduce dental anxiety in patients. Therefore, incorporating PNC with binaural beats in dental setups could be a valuable and economical approach for safeguarding dentists and enhancing their work environment.

Limitation of the study

- The results are based on subjective perception
- The dentists involved in the study were each exposed to only one type of intervention.
- Future studies should include a detailed comparison of multiple variables conducted within a more controlled experimental environment for precise analysis.

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