International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Efficacy of Active Noise Cancellation Aid on Patient Anxiety Levels during Restorative Procedures: A Split-Mouth Clinical Study

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Abstract

INTRODUCTION: Dental anxiety is a significant barrier to dental care, noise from high-speed handpieces is one of the common trigger. Non-pharmacological interventions such as active noise cancellation (ANC) earplugs may help reduce anxiety levels in patients undergoing restorative procedures.

AIM: To evaluate the effectiveness of ANC earplugs in reducing patient anxiety levels during restorative dental procedures leading to improved patient experience and better acceptance of dental treatment using a split-mouth clinical design.

METHODOLOGY: Fifteen patients aged 20–50 years with bilateral carious lesions of posterior teeth participated in this randomized split-mouth clinical study.Total thirty (n=30)carious tooth were randomly and equally divided into two groups with each patient acting as his own control. Restorative procedures were performed on one side using ANC earplugs (Test) and on the contralateral side using dummy earplugs (control). Anxiety was assessed using a Visual Analog Scale (VAS) and heart rate recordings at baseline and post-procedure. Data was analyzed using the statistical package **SPSS 26.0** (SPSS Inc., Chicago, IL) and level of significance was set at **P<0.05**. **Descriptive statistics** was performed to assess the mean and standard deviation of the respective groups. **Inferential statistics** to find out the difference **Between the group was done by Independent T test**

Results: ANC earplugs significantly reduced VAS anxiety scores and heart rate compared to dummy earplugs ($p < 0.05$). Patients also reported greater comfort with ANC.

Conclusion: ANC earplugs are effective in reducing dental anxiety during restorative procedures caused by noise, which will help patients be slightly less afraid of dental treatment and visit the dental clinic in a timely manner.

They may serve as a simple, non-invasive adjunct to improve patient comfort and cooperation in clinical dentistry.

Keywords: Active noise cancellation, Dental anxiety, Visual Analog Scale, Heart rate, Split-mouth study

Introduction

Dental anxiety remains a widespread concern, affecting patient cooperation, treatment acceptance, and overall oral health leading to a vicious cycle of dental anxiety .

- Dental anxiety can arise from multiple factors , both psychological and sensory related . Some common causes include fear of pain, Noise related anxiety, Fear of dental instruments, Chemical Odors, Fear of Unknown,Previous Negative Experience

The sound of the dental drill, particularly from high-speed handpieces and ultrasaonic scalers , is around 70-90 Decibles (typical comfortable sound level for humars -50 to 60 decibles) Contribute significantly to patient discomfort and anxiety making treatment more challenging for both dentist and patient. This auditory stimulus can elevate stress, trigger fear, and discourage patients from seeking timely dental care. Traditional strategies to manage anxiety include behavioral therapy, sedation, and distraction techniques such as music. However, non-invasive technological approaches such as Active Noise Cancellation (ANC)-(Device that uses microphone and digital circuits to reduce unwanted background sound). earplugs represent a novel adjunct.

ANC works by detecting ambient noise and generating sound waves of opposite phase to cancel it out, effectively reducing unwanted sound perception.

Although ANC devices are widely used in aviation, industry, and personal music systems, their application in dentistry is limited. This study investigates whether ANC earplugs can reduce patient anxiety during restorative procedures compared to dummy earplugs, using a split-mouth clinical study design.

Materials

Active noise cancellation ear buds of mivi opera and a dummy ear plugs are used for study

Methodology

Study Design:

This study is designed as randomised split mouth clinical trial.The split mouth design was chosen to minimize inter-individual variability ,as each participant served as their own control.Randomization was

employed to allocate the test and control interventions to either side of the mouth ,thereby reducing selection bias.

Sample Size:

A total of 15 individuals with bilateral carious lesions were recruited for the study,providing 30 teeth for evaluation (n=30).The sample size was determined based on feasibility ,avalability of subjects ,and previous literature demonstrating adequate power with similar number of samples in split mouth design

Inclusion Criteria:

Individuals Aged between 20–50 years

Presence of Bilateral carious lesions requiring restorative treatment

Patients willing to participate and provide informed consent

Exclusion Criteria:

Patients with history of psychiatric illness

Patients using anxiolytic medications

Patients with hearing impairment

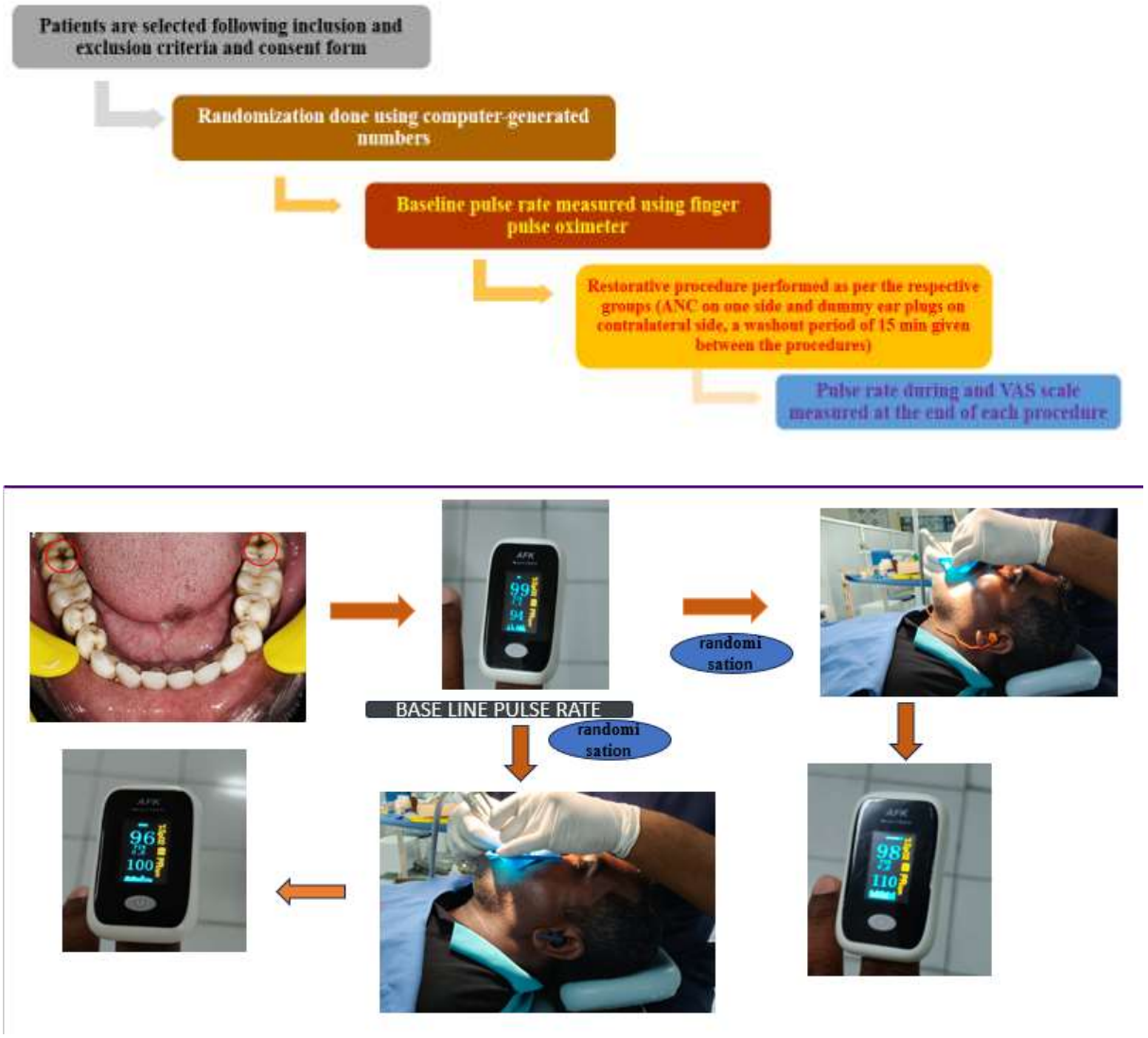
Medically compromised patients (ASA III or above)

Procedure:

Fifteen individuals who are included in the study requiring restorative treatment for carious lesions one on each side total 30 carious tooth are ramdomized into two groups

Group 1- Test group (restorative procedure done with patients wearing ANC ear plugs)

Group 2 – Control group (restorative procedure done with patients wearing dummy ear plugs) . Patients were randomized for the first side (ANC or dummy) and Baseline anxiety recorded using Visual Analog Scale (0–10) and Heart rate (beats/min) using pulse oximeter.Then Restorative procedure performed with the assigned earplug type.On completion of restorative procedure on each side Post-procedure anxiety was recorded using Visual Analog Scale (0–10) and Heart rate (beats/min) using pulse oximeter.A 10-minute washout period was provided in between to eliminate the effects of first treatment. Then . Patients were randomized for the second side (ANC or dummy) and Baseline anxiety recorded using Visual Analog Scale (0–10) and Heart rate (beats/min) using pulse oximeter.Then Restorative procedure performed with the assigned earplug type.On completion of restorative procedure on each side Post-procedure anxiety was recorded using Visual Analog Scale (0–10) and Heart rate (beats/min) using pulse oximeter.



Statistical Analysis:

Paired t-tests and Wilcoxon signed-rank tests were used to compare groups. Significance set at $p < 0.05$.

Results

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	**15**	**25**	**45**	**36.00**	**6.268**

Table 1 provides a summary of the ages of the study participants. The dataset includes 15 individuals, with ages ranging from a minimum of 25 years to a maximum of 45 years. The mean age of the participants is 36.00 years, indicating that the average participant falls within the mid-range of the provided age span.

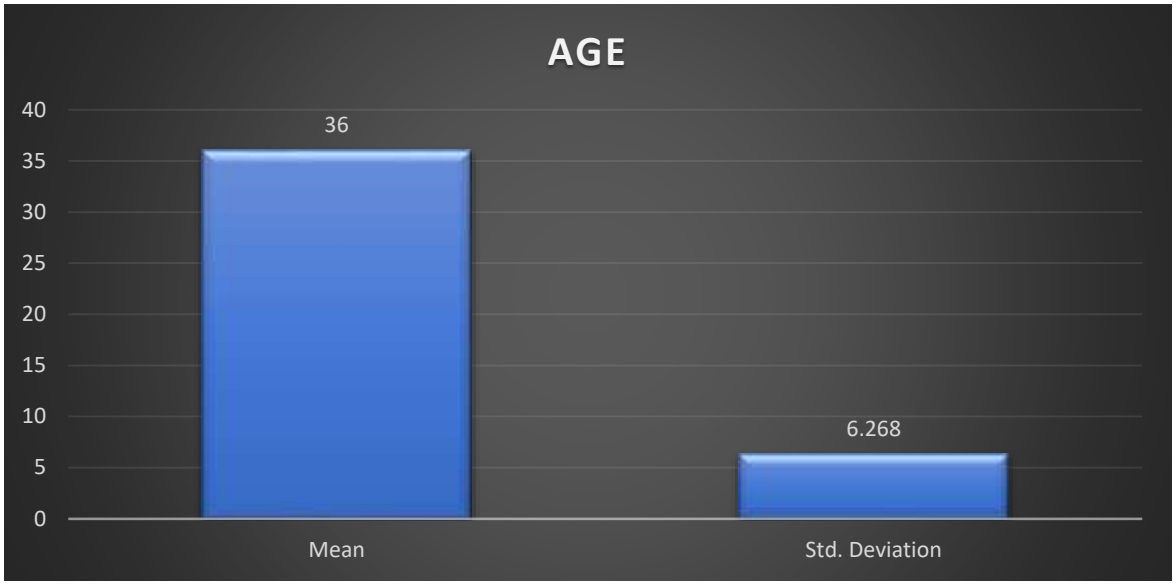


Table 2- Gender

		Frequency	Percent
Gender	**F**	**8**	**53.3**
	M	**7**	**46.7**
	Total	**15**	**100.0**

Table 2 summarizes the gender distribution of the study participants. Out of a total of 15 individuals, 8 participants (53.3%) identified as female (F), while 7 participants (46.7%) identified as male (M).

VAS SCORES

S NO	VAS- (ACTIVE NOISE CANCELLATION DEVICES)	VAS- (DUMMY EAR PLUGS)
1	4	5
2	6	6
3	6	7
4	7	7
5	5	7
6	4	8
7	6	7
8	5	6
9	7	8
10	5	7
11	6	7
12	4	7
13	5	8
14	6	7
15	6	7

N	**15**	**15**
MEAN	**5.3**	**7.07**

Table 3–Comparison -VAS SCORE

	Mean	N	Std. Deviation	Std. Error Mean	Median	Min-Max	Mean Difference	P Value T Test
DUMMY EAR BUD	**7.07**	**15**	**.799**	**.206**	**7.07**	**6-8**	**1.93**	**0.0001***
ANC EARBUD	**5.13**	**15**	**.834**	**.215**	**5.13**	**4-6**		

Table 2 compares the Visual Analog Scale (VAS) scores for two types of earbuds: Dummy Ear Buds and ANC (Active Noise Cancelling) Ear Buds. The mean VAS score for participants using Dummy Ear Buds is 7.07, with a standard deviation of 0.799 and a standard error of the mean of 0.206. In contrast, participants using ANC Ear Buds reported a lower mean VAS score of 5.13, with a standard deviation of 0.834 and a standard error of the mean of 0.215. The mean difference between the two groups is 1.93, and the p-value is 0.0001, indicating a statistically significant difference in VAS scores.

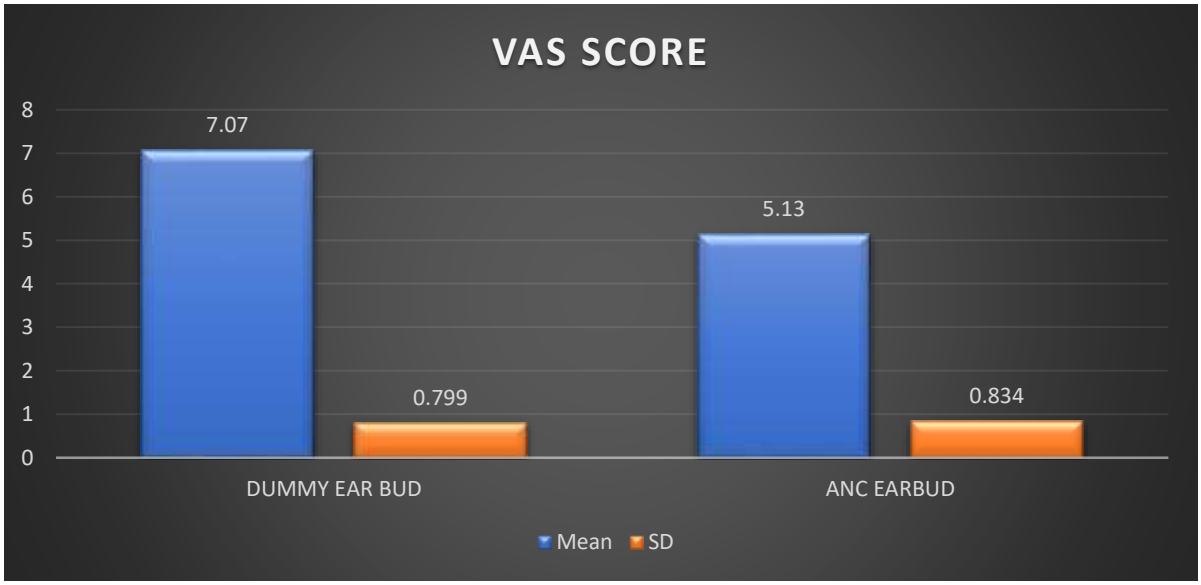


Table 3–Comparison -Pulse Rate (Baseline)

	Mean	N	Std. Deviation	Std. Error Mean	Median	Min-Max	Mean Difference	P Value T Test
DUMMY EAR BUD	**84.13**	**15**	**11.243**	**2.903**	**85**	**65-98**	**2.33**	**0.06**
ANC EAR BUD	**86.466**	**15**	**11.41344**	**2.9469**	**90**	**65-99**		

The comparison of pulse rates between the DUMMY EAR BUD and ANC EAR BUD reveals interesting findings. The mean pulse rate for the DUMMY EAR BUD was 84.13 beats per minute, while the ANC EAR BUD showed a slightly higher mean of 86.466 beats per minute. Both groups consisted of 15 participants, with standard deviations of 11.243 and 11.41344, respectively, indicating similar variability in pulse rates. The median pulse rates were 85 for the DUMMY EAR BUD and 90 for the ANC EAR BUD, suggesting that a larger proportion of participants using ANC EAR BUD experienced higher pulse rates. The mean difference of 2.33 indicates that users of the ANC EAR BUD had a greater average pulse rate compared to those using the DUMMY EAR BUD. However, the P value of 0.06 suggests that this difference is not statistically significant at the 0.05 level,

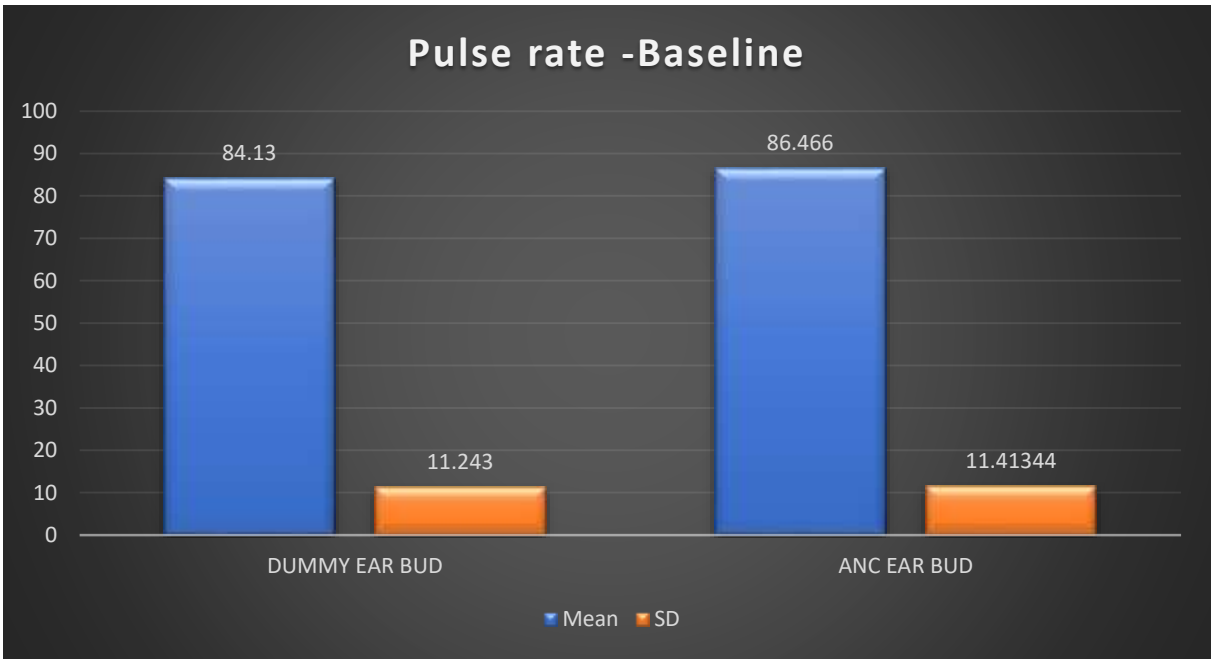


Table 4–Comparison -Pulse Rate (During)

	Mean	N	Std. Deviation	Std. Error Mean	Median	Min-Max	Mean Difference	P Value T Test
DUMMY EAR BUD	**106.20**	**15**	**9.601**	**2.479**	**106**	**92-122**	**15.40**	**0.0001***
ANC EAR BUD	**90.80**	**15**	**10.234**	**2.643**	**94**	**72-104**		

Table 4 presents a comparison of pulse rates (During procedure) between two different earbud types: Dummy Ear Buds and ANC (Active Noise Cancelling) Ear Buds. The mean pulse rate for participants using Dummy Ear Buds is 106.20 beats per minute, with a standard deviation of 9.601 and a standard error of the mean of 2.479. In contrast, the mean pulse rate for those using ANC Ear Buds is significantly lower at 90.80 beats per minute, accompanied by a standard deviation of 10.234 and a standard error of 2.643.

The mean difference between the two groups is 15.40 beats per minute, with a p-value of 0.0001, indicating a statistically significant difference in pulse rates.

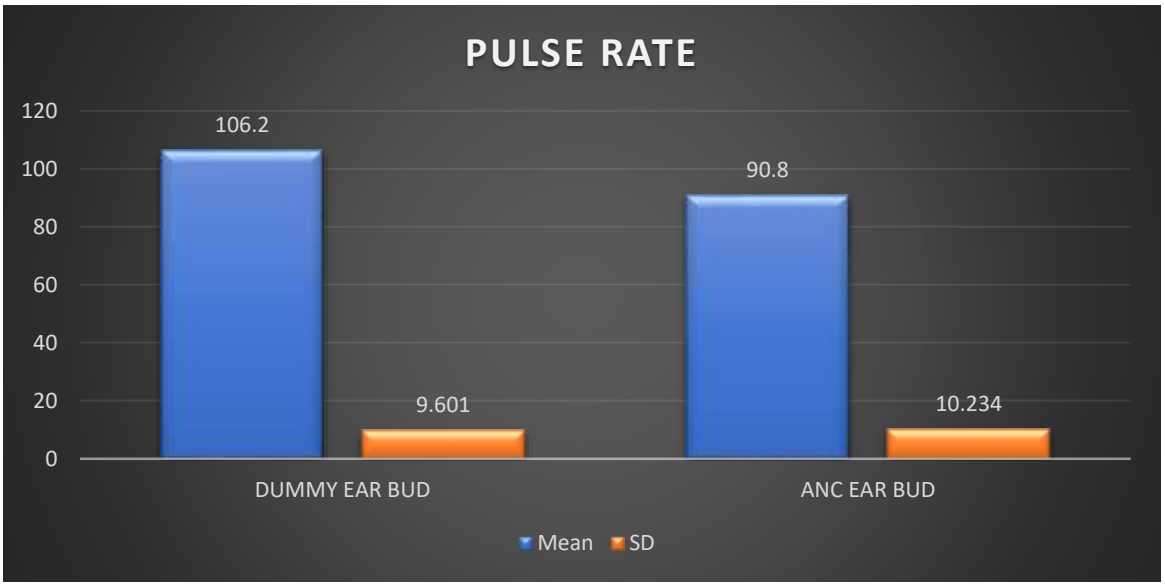
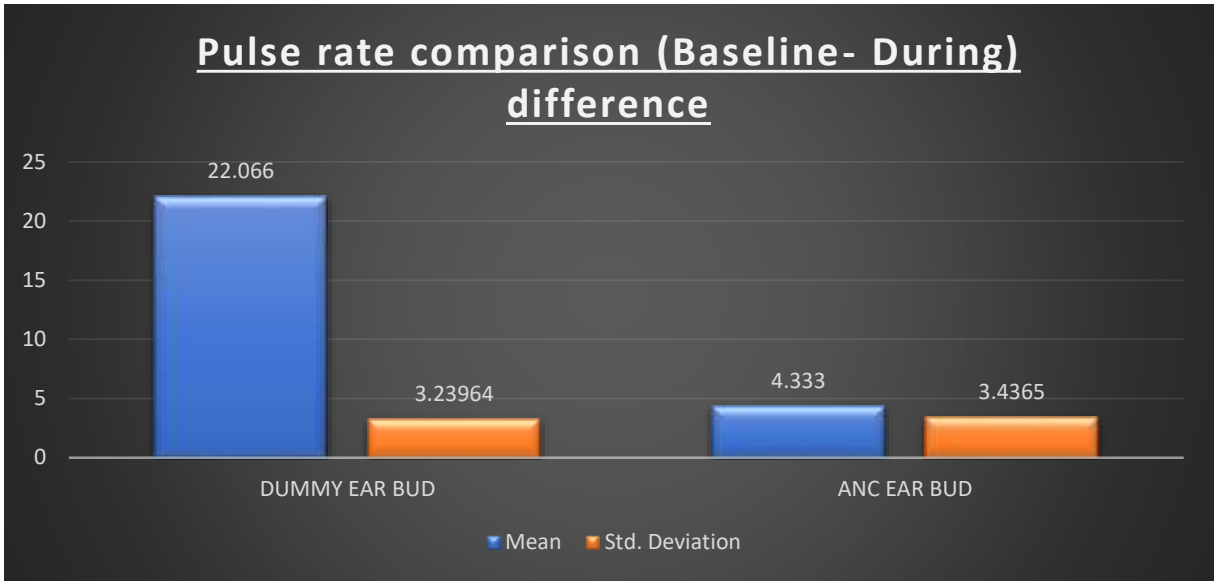


Table 5- Pulse rate comparison (Baseline- During) difference

	Mean	N	Std. Deviation	Std. Error Mean	Median	Min-Max	Mean Difference	P Value T Test
DUMMY EAR BUD	**22.066**	**15**	**3.23964**	**.83647**	**22**	**14-27**	**19.36**	**0.0001***
ANC EAR BUD	**4.333**	**15**	**3.43650**	**.88730**	**-2**	**-11-2**		

The comparison of pulse rates between baseline and during the use of different earbud types reveals notable differences. The DUMMY EAR BUD demonstrated a significant increase in pulse rate, with a mean difference of 19.36 and a p-value of 0.0001, indicating a statistically significant effect on heart rate during usage. The sample consisted of 15 participants, with a standard deviation of 3.24 and a median pulse rate of 22. In contrast, the ANC EAR BUD showed a smaller mean change of 4.33, with a median of -2, suggesting minimal impact on pulse rate. While both earbud types were tested on the same sample size, the pronounced effect of the DUMMY EAR BUD highlights the importance of considering different designs in relation to physiological responses.



Discussion

This study demonstrated that the use of active noise cancellation (ANC) devices reduced patients' anxiety and discomfort during restorative dental procedures. Dental noise, particularly from rotary instruments and suction systems, is a well-known trigger for anxiety and avoidance behavior. By introducing ANC technology, patients reported reduced perception of both noise intensity and procedure-related discomfort, supporting the notion that noise plays a significant role in shaping the overall treatment experience.

Interestingly, in addition to lowering noise-related discomfort, ANC use was associated with a reduction in perceived procedural anxiety and stress. Although ANC primarily targets auditory stimuli, the alleviation of disturbing sounds may indirectly modulate pain and stress perception. This finding aligns with the concept that noise and anxiety are interrelated, where diminished auditory stress lowers sympathetic activation and improves patient tolerance.

It is important to note that ANC did not completely eliminate procedural noise. This limitation arises from the dual transmission pathways of sound: air conduction and bone conduction. While ANC effectively cancels air-borne sounds generated by handpieces or suction, vibrations transmitted through dental hard tissues and bone persist, which explains why some residual discomfort was still reported. For a subset of patients, the masking of external sounds even heightened awareness of intraoral bone-conducted vibrations, which occasionally increased anxiety.

The observed moderate correlation between reduced noise perception and decreased anxiety further supports the hypothesis that sensory inputs influence emotional responses. Lower auditory disturbance may therefore lessen anticipatory fear and perceived invasiveness of treatment.

From a clinical perspective, ANC devices can serve as a simple and patient-friendly adjunct to enhance comfort during restorative procedures. However, patient preference should be respected, as a minority may find ANC devices uncomfortable or counterproductive. Incorporating ANC with additional distraction methods, such as music or guided relaxation, may further enhance the anxiety-reducing effect.

Limitations of the present study include the inability of ANC to mask bone-conducted vibrations fully, as well as potential variability in individual noise sensitivity. Moreover, operator blinding to device settings was not feasible, which may have introduced bias in patient interaction. Future studies should explore

combinations of ANC and other sensory interventions, as well as investigate whether ANC use can improve treatment compliance and long-term dental attendance.

In summary, ANC devices reduced both noise perception and procedure-related anxiety during restorative treatments. While not completely eliminating disturbing sounds, they represent a promising, non-invasive approach to improve patient comfort in dental practice.

It also has applicability in Improved Patient Comfort: ANC earplugs can help reduce dental anxiety by minimizing unpleasant dental noises, such as handpieces and suction devices, making the experience more comfortable.**Better Patient Cooperation**: Less anxious patients are more likely to remain still and cooperate during procedures, improving treatment efficiency.**Enhanced Patient Satisfaction**: A quieter and less stressful environment may lead to better patient experiences, encouraging regular dental visits. **Applicability in Pediatric and Special Needs Patients**: Noise reduction could be particularly beneficial for children or individuals with sensory sensitivities, such as those with autism or dental phobia

Conclusion

Active noise cancellation earplugs are effective in reducing patient anxiety during restorative procedures. They represent a simple, non-invasive, and cost-effective adjunct to conventional dental practice, enhancing patient comfort and cooperation.

AKNOWLEDGEMENT

I express my sincere gratitude to my respected guide, Dr.S.JAYAPRADA REDDY Professor Department of Conservative Dentistry and Endodontics for the invaluable guidance, constant encouragement, constructive suggestions, and unwavering support throughout the course of this study.

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