Effects of 4% Articaine and 2% Lidocaine Local Anaesthetics on the Vital Signs' Parameters and Dental Anxiety Level during Dental Extraction: A Comparative Study

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ABSTRACT

This study aims to compare the effects of Lidocaine and Articaine on heart rate, blood pressure, respiratory rate, body temperature, and dental anxiety, as well as the impact of different anaesthesia techniques (infiltration vs. nerve block) in patients undergoing routine dental extraction. This randomized, single-blind study included 80 participants, with 40 receiving 4% Articaine and 40 receiving 2% Lidocaine. Patients were blinded to the anesthetic used. Vital signs (heart rate, blood pressure, respiratory rate, and temperature) were recorded before and after anaesthesia administration. Dental anxiety was measured using the Modified Dental Anxiety Scale (MDAS). Data were analyzed to assess the effects of the anaesthetics and techniques on these variables. Articaine was associated with a statistically significant increase in heart rate (mean change = +0.23 bpm, p = 0.012), whereas Lidocaine led to a decrease (mean change = –1.38 bpm). No significant differences were observed in systolic blood pressure (p = 0.138), respiratory rate (p = 0.627), or body temperature (p = 0.116). Anxiety scores (MDAS) showed a slight, non-significant increase in the Lidocaine group (mean change = +0.58) and a smaller increase in the Articaine group (mean change = +0.30, p = 0.438). No statistically significant differences were found between infiltration and nerve block techniques for any outcome. Vital signs (body temperature, blood pressure, respiratory rate) and oral anxiety were not significantly affected by either lidocaine or Articaine procedures. However, Articaine may be associated with a statistically significant increase in heart rate compared to Lidocaine, which could be clinically relevant for patients with cardiovascular concerns. Practitioners should consider this when selecting anaesthetics, especially in patients with pre-existing heart conditions.

Keywords: Articaine, Lidocaine, Local anaesthesia, Heart rate, Blood pressure, Dental anxiety

INTRODUCTION

Local anaesthesia plays an essential role in modern dentistry, ensuring minimal pain and discomfort for the patients undergoing various dental procedures[1,2]. Among the most commonly used local anaesthetics, Lidocaine has long been considered the gold standard due to its safety, efficacy, low toxicity, and minimal side effects[3]. Since its introduction in 1943, this amide-type local anaesthetic is metabolized in the liver, and its action is typically of moderate duration, making it suitable for most dental procedures[4]; therefore Lidocaine has been the preferred choice for dental procedures globally[5]. However, over time, Articaine has emerged as a promising alternative due to its enhanced properties, such as superior tissue penetration and faster metabolism that may offer advantages in certain clinical scenarios, such as complex tooth extractions or surgeries requiring longer duration of anaesthesia[6].

Despite Lidocaine's popularity, many patients experience discomfort during needle insertion, especially in certain areas of the mouth, such as the palatal region, which can result in patient anxiety and distress[7]. This has prompted research into newer anaesthetic agents, such as Articaine, which was developed in 1969[8]. Articaine differs from Lidocaine in its chemical structure, containing both an amide group and an ester group, which contributes to its superior tissue penetration and faster metabolism[9]. These properties may make Articaine a better choice in situations where quicker onset and longer-lasting aesthesia are required, such as in extraction or flap surgeries[10]. Recent advancements in the dental field have highlighted the potential benefits of Articaine over Lidocaine in certain settings[11].

Articaine's higher lipid solubility enhances its diffusion through both soft and hard tissues, allowing it to provide faster onset of anaesthesia

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and more prolonged duration of effect compared to Lidocaine[12]. This advantage is particularly important for dental surgeries that involve significant tissue manipulation, where prolonged numbness can reduce the need for additional injections during the procedure[13]. Furthermore, Articaine's ability to diffuse more effectively through bone has led to the reduction of the need for palatal injections, which are often a source of significant discomfort for patients[14]. Studies comparing these two anaesthetics have found that Articaine might lead to less discomfort during injection and provide better overall pain control for patients during procedures like extractions[15].

Both drugs achieve their action by binding to the sodium channels in nerve fibers, but Articaine's additional ester group results in a faster breakdown and more rapid elimination from the body compared to Lidocaine[16,17]. This rapid metabolism is associated with a shorter onset time and a longer duration of local anaesthesia, making Articaine a more efficient choice in specific dental surgeries that require extended anaesthesia[18]. However, while both drugs are effective at controlling pain, they can influence various hemodynamic parameters, including blood pressure, heart rate, and oxygen saturation (SpO2). These changes in vital signs are of particular concern, especially in patients with underlying cardiovascular conditions[19]. Both Lidocaine and Articaine are often combined with vasoconstrictors such as epinephrine, which serve to reduce bleeding during procedures but can also increase heart rate and blood pressure[20].

The potential for an increase in systolic and diastolic blood pressure, as well as changes in heart rate, has been well-documented in existing literature. However, there is limited research comparing the effects of these two agents on other vital sign parameters and dental anxiety[21,22]. Existing studies comparing the hemodynamic effects of Lidocaine and Articaine have provided valuable insights, but there remain inconsistencies in their findings. For example, some studies have indicated that Articaine may cause smaller increases in systolic blood pressure compared to Lidocaine, particularly when lower concentrations of vasoconstrictors are used[23].

Other research has found no significant difference in the hemodynamic effects of these two anaesthetics[24]. Additionally, the effect of Articaine and Lidocaine on oxygen saturation and other vital signs, such as respiratory rate, is not as extensively studied, leaving a gap in the current literature. Many studies have focused primarily on the efficacy of these anaesthetics in terms of pain relief and duration, without fully exploring their cardiovascular effects and potential risks these might pose in vulnerable populations[25,26]. Understanding these effects will enable dental practitioners to make more informed decisions when selecting an anaesthetic, ensuring patient safety and optimizing clinical outcomes.

Therefore, this research aimed to explore the effects of two local anesthetics on physiological parameters, including blood pressure, heart rate, respiratory rate, body temperature, and dental anxiety levels assessed using the Modified Dental Anxiety Scale (MDAS). It investigates whether there are significant differences between the two anesthetic drugs and examines variations based on gender, age, and anesthetic techniques (infiltration versus nerve block) across different groups.

MATERIALS AND METHODS

Study design and setting: This study was a comparative interventional clinical randomized and single-blind study comparing the effects of both Articaine and Lidocaine local anaesthetic agents after their administration for dental extraction. The group that received 2% Lidocaine represents the control group. The primary outcomes measured were changes in vital signs (such as blood pressure and heart rate) and degrees of dental anxiety during dental operations. Patients admitted to Taibah University dental clinics are the targeted population for this study. Ethical approval was obtained from Taibah University, College of Dentistry Research Ethics Committee (TUCDREC/101023/MAljohan).

Sample size: To compare the effects of 4% Articaine and 2% Lidocaine on vital signs and dental anxiety, the following parameters were used: Power is 80% ($\beta = 0.20$) at a 5% significance level, with an estimated standard deviation of 10 units. The total sample size was 80 patients, with 40 patients in each group. This sample size was sufficient to detect clinically relevant differences in vital signs and anxiety scores with the desired statistical power.

Inclusion and Exclusion criteria: The inclusion criteria included: 1) Patients attending dental clinics at dental college, Taibah university, 2) Adult female or male patients ≥16 years old, 3) Healthy patients with no severe medical problems and according to American Society of Anaesthesiologists (ASA) must be ASA I or ASA II, 4) Patients who can consent for themselves with or without an interpreter, 5) Non-surgical dental procedures.

The exclusion criteria included: 1) Young patient <16 years old, 2) Patient with severe medical or psychological problems, 3) Patients whom are unable to consent for themselves, 4) Surgical dental procedures.

Sampling process: Eighty patients with ages ranging from 18 to 73 years, both females and males that have been admitted to Taibah University dental clinics for dental extractions. Patients have been randomly disturbed to 2 groups, 40 patients for each group, Group 1 has been given (Lidocaine %2 with 1:100000 epinephrine) as the local anaesthetic drug before the dental extraction, while Group 2 has been given (Articaine hydrochloride %4 with 1:100000 epinephrine).

Data collection process: Following the clinical examination of the patients and taking their medical history, patients were asked to sign the consent form to participate in the study, and then their vital signs measurements were collected at the baseline 5 minutes prior to administering the local anesthetic agent, pre-operative measurements include: heart rate (HR), blood pressure (BP), respiratory rate (RR), and temperature (Temp.). All examiners have been calibrated, as well as all devices were standardized between examiners to give accurate and standardized measurements. The heart rate and blood pressure are measured by using an electronic sphygmomanometer monitor (Omron M2 Intellisense (HEM-7143-E)), respiratory rate is measured by observation of the patients' chests for 1 minute and finally, temperature is measured using a thermometer (Welch Allyn SureTemp Plus 690 thermometer). Once the procedure was completed, patients were left at rest for 5 minutes, and then their previously mentioned vital signs were remeasured again.

Data analysis: Data management involved secure storage of completed data, with immediate coding for anonymity. A double-entry verification process was executed to prevent data loss. The dataset was organized into variables for demographic information, medical history, anesthetic details, pre-operative measurements, and post-operative measurements. Missing data was addressed ethically, either through imputation or exclusion. Access is restricted to authorized personnel, with confidentiality agreements and security measures in place to protect data integrity. At the end of the study, the dataset is archived securely for future use. Then, SPSS is used for statistical analysis. The data analysis is based on descriptive statistics that are used to identify

demographic characteristics of study participants. Inferential statistics (i.e., testing for significance, using appropriate paired t-tests, Pearson correlation coefficients, and independent sample t-tests) were also used.

RESULTS

Demographic data

The study included a total sample size of 80 participants with an equal distribution of genders. The participants were divided based on the type of local anesthetic and technique used. For Articaine, 19 individuals underwent the infiltration technique, while 21 received a nerve block. In the Lidocaine group, 29 participants were treated using the infiltration technique, and 11 received a nerve block. Regarding age distribution, the majority of participants (63%) were between 17 and 37 years old, 32% were between 38 and 58 years, and a small proportion (3%) were aged between 58 and 77 years. Figure 1 shows the difference in nationalities and percentage of participants.

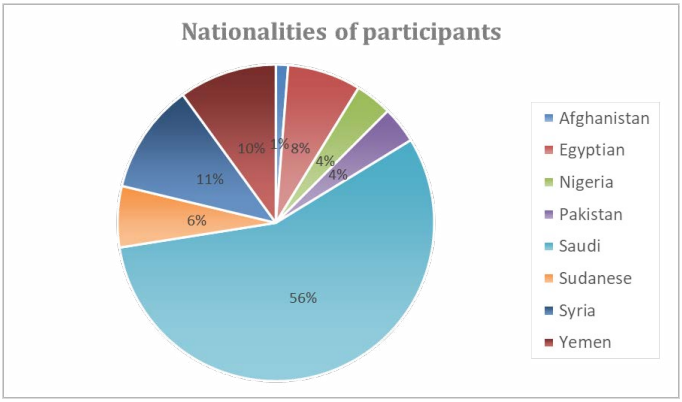

Figure 1. It shows the percentage of nationalities of the participants in both genders.

Comparative analysis of vital signs and dental anxiety scores across different anesthesia techniques

Table 1 showed the following results: Articaine showed a significant increase in heart rate ($p>0.05$), whereas Lidocaine led to a significant decrease in heart rate ($p<0.05$). Both Lidocaine and Articaine did not show significant effects on blood pressure, respiratory rate, or temperature as indicated by the p-values greater than 0.05. MDAS increased after administration of Articaine (0.30 (SD = 1.07)) and Lidocaine (0.58 (SD = 1.96)) with a p-value of 0.438, indicating no significant change in anxiety or discomfort.

Table 1. Comparison of changes in vital signs and dental anxiety scores between Articaine and Lidocaine

Study Variables	Anesthetic agent used	N	Mean	SD	t	P-value
Heart Rate	Articaine	40	0.23	2.49	2.562	0.012
	Lidocaine	40	-1.38	3.07		
Blood pressure	Articaine	40	-0.73	4.01	1.497	0.138
	Lidocaine	40	-1.85	2.55		
Respiratory rate	Articaine	40	-0.25	1.82	0.488	0.627
	Lidocaine	40	-0.40	0.67		
Body Temporature	Articaine	40	-0.07	0.26	-1.591	0.116
	Lidocaine	40	-0.01	0.04		
MDAS	Articaine	40	0.30	1.07	-0.779	0.438
	Lidocaine	40	0.58	1.96		

Table 2 showed the following results: Both infiltration and nerve block anaesthesia did not show any significant effects on heart rate, blood pressure, respiratory rate, or body temperature as the p-values were greater than 0.05. The mean change in the MDAS for the infiltration group was 0.65 (SD = 1.67). The mean change for the nerve block group was 0.13 (SD = 1.39), which also suggests a slight increase but is not statistically significant as the p-value was 0.148.

Table 2. Comparison of changes in vital signs and dental anxiety scores between infiltration and nerve block techniques

Study Variables	Anesthesia Technique	N	Mean	SD	t	P-value
HR	Infiltration	48	-0.63	2.80	-0.188	0.851
	Nerve Block	32	-0.50	3.06		
BP	Infiltration	48	-1.56	2.54	-0.888	0.377
	Nerve Block	32	-0.88	4.38		
RR	Infiltration	48	-0.33	1.26	-0.066	0.947
	Nerve Block	32	-0.31	1.53		
Temp	Infiltration	48	-0.01	0.17	1.496	0.139
	Nerve Block	32	-0.08	0.21		
MDAS	Infiltration	48	0.65	1.67	1.460	0.148

Tables 3 and 4 showed the following results: Nerve block with Articaine resulted in a significant decrease in blood pressure ($p>0.05$). Infiltration with Lidocaine resulted in a significant decrease in blood pressure ($p>0.05$). Neither infiltration nor nerve block with Articaine and Lidocaine showed significant effects on heart rate, respiratory rate, body temperature, or MDAS ($p<0.05$). Infiltration with Lidocaine and nerve block with Articaine might cause higher MDAS; however, p-value showed no significant difference (p-value = 0.092). The mean change in the MDAS for the Articaine infiltration group was 0.26 (SD = 1.05). The mean change for the nerve block group, though, was 0.33 (SD = 1.11). With a p-value of 0.092, which is close to statistical significance. Nerve block possibly causing a higher MDAS score.

Table 3. Comparison of changes in vital signs and dental anxiety scores for Lidocaine and Articaine based on anesthesia technique

	Study Variables	Anesthesia Technique	N	Mean	SD	T	P-value
Articaine	Heart rate	Infiltration	19	0.95	1.58	-0.936	0.355
		Nerve Block	21	-0.43	2.98		
	Blood pressure	Infiltration	19	-0.21	2.42	-2.581	0.014
		Nerve Block	21	-1.19	5.07		
	Respiratory rate	Infiltration	19	-0.21	1.87	-0.208	0.836
		Nerve Block	21	-0.29	1.82		
	Body Temporature	Infiltration	19	-0.03	0.26	0.405	0.688
		Nerve Block	21	-0.11	0.25		
	MDAS	Infiltration	19	0.26	1.05	1.727	0.092

Table 3 showed the mean change in heart rate for the Articaine infiltration group was 0.95 (SD = 1.58); the mean change for the nerve block group however was -0.43 (SD = 2.98), showing a slight decrease. The t-value of -0.936 and a p-value of 0.355 indicate no significant change in heart rate. The mean change in blood pressure for the Articaine infiltration group was -0.21 (SD = 2.42), while the mean change for the nerve block group was -1.19 (SD = 5.07). Nerve block using Articaine showed a significant decrease in blood pressure with a t-value of -2.581 and a p-value of 0.014. The mean change in respiratory rate for the Articaine infiltration group was -0.21 (SD = 1.87). The mean change for the nerve block group was -0.29 (SD = 1.82). Both anesthesia techniques had no significant effect on respiratory rate, as indicated with a t-value of -0.208 and a p-value of 0.836. The mean

change in temperature for the Articaine infiltration group was -0.03 (SD = 0.26); the mean change for the nerve block group, however, was -0.11 (SD = 0.25). Both techniques did not have a significant effect on body temperature with a t-value of 0.405 and a p-value of 0.688.

Table 4. Comparison of changes in vital signs and dental anxiety scores for Lidocaine based on anesthesia technique

		Anesthesia Technique	N	Mean	SD	t	P-value
Lidocaine	**Heart rate**	Infiltration	29	-1.66	2.97	-0.936	0.355
		Nerve Block	11	-0.64	3.35		
	Blood pressure	Infiltration	29	-2.45	2.25	-2.581	0.014
		Nerve Block	11	-0.27	2.72		
	Respiratory rate	Infiltration	29	-0.41	0.63	-0.208	0.836
		Nerve Block	11	-0.36	0.81		
	Body Temperature	Infiltration	29	0.00	0.03	0.405	0.688
		Nerve Block	11	-0.01	0.05		
	MDAS	Infiltration	29	0.90	1.95	1.727	0.092

Table 4 showed the mean change in heart rate for the Lidocaine infiltration group was -1.66 (SD = 2.97). The mean change for the nerve block group though was -0.64 bpm (SD = 3.35). Both infiltration and nerve block with Lidocaine resulted in non-significant changes in heart rate, with a t-value of -0.936 and a p-value of 0.355. While the mean change in blood pressure for the Lidocaine infiltration group was -2.45 (SD = 2.25), the mean change for the nerve block group was -0.27 (SD = 2.72). Infiltration with Lidocaine resulted in a significantly greater reduction in blood pressure compared to nerve block ($p = 0.014$), suggesting the technique may influence hemodynamic response. The mean change in respiratory rate for the Lidocaine infiltration group was -0.41(SD = 0.63), the mean change for the nerve block group though was -0.36 (SD = 0.81). Both infiltration and nerve block with Lidocaine had no significant effect on respiratory rate as indicated with a t-value of -0.208 and a p-value of 0.836. The mean change in temperature for the Lidocaine infiltration group was 0.00 (SD = 0.03) and -0.01 (SD = 0.05) for nerve block group. Both techniques did not significantly affect body temperature with a t-value of 0.405 and a p-value of 0.688. The mean change in MDAS for the Lidocaine infiltration group was 0.90 (SD = 1.95) and for the nerve block group was -0.27 (SD = 1.79). The infiltration technique with Lidocaine showed a tendency toward marked increased MDAS, but it did not reach statistical significance as presented with a t-value of 1.727 and a p-value of 0.09.

The Pearson correlation coefficients between various variables, such as age, heart rate, respiratory rate, and MDAS scores, both pre- and post-operatively. Several correlations are statistically significant, such as the strong relationship between pre-operative and post-operative heart rate ($r = 0.966$, $p < 0.01$) and pre-operative and post-operative respiratory rate ($r = 0.824$, $p < 0.01$). Additionally, pre-operative MDAS and post-operative MDAS show a significant negative correlation ($r = -0.880$, $p < 0.01$), indicating a reduction in anxiety levels postoperatively.

DISCUSSION

Our study aimed to evaluate and compare the effects of two anesthetics, Articaine and Lidocaine, administered through infiltration and nerve block techniques, on physiologic vital signs parameters and anxiety levels. The results revealed that Articaine caused a statistically significant increase in heart rate ($p = 0.012$), while Lidocaine led to a significant reduction. This highlights a notable difference in cardiovascular response between the two agents. However, neither anesthetic had a significant impact on blood pressure, respiratory rate, body temperature, or the MDAS, as all p-values for these parameters were greater than 0.05. The study age groups allowed for a comprehensive comparison of the effects of Articaine and Lidocaine on vital signs and dental anxiety across different age groups and anesthetic techniques.

Regarding the anesthesia techniques, neither infiltration nor nerve block had a significant effect on heart rate, respiratory rate, body temperature, or MDAS. Interestingly, nerve block with Articaine and infiltration with Lidocaine both caused significant decreases in blood pressure ($p = 0.014$ for both), but the effects were not significantly different between the techniques. Additionally, while infiltration with Lidocaine and nerve block with Articaine showed slight increases in MDAS scores, the differences were not statistically significant ($p = 0.092$). Overall, our findings suggest that while Articaine and Lidocaine affect heart rate differently, their impact on other physiological and anxiety measures is minimal.

One of the main objectives of this study was to assess the impact of Articaine and Lidocaine on vital signs, including blood pressure, heart rate, respiratory rate, and temperature. Our results indicate that both Articaine and Lidocaine had minimal impact on vital signs, with all values remaining within normal limits. This finding aligns with studies that have demonstrated the safety of both drugs in terms of cardiovascular stability. For instance, Bajwa and Jindal's study (2012)[27] showed that Articaine had minimal effects on hemodynamic parameters, and similar results were reported by Sanatkar (2013)[28], who noted no significant differences between Articaine and Lidocaine in terms of blood pressure and heart rate[29]. Additionally, in our study, the changes in blood pressure and heart rate were not statistically significant, supporting the assertion that both anesthetics are well-tolerated and do not pose significant risks to cardiovascular function. This is in line with the findings of Rathi et al. (2019), who also observed no major variations in these parameters following Lidocaine or Articaine infiltration in pediatric patients[30].

When comparing two anesthetics, Articaine showed longer duration of action compared to Lidocaine. It is consistent with previous studies of Dreven et al. (1987)[31] and Potocnik et al. (2006)[32], who suggested that Articaine's chemical structure, particularly the thiophene ring, contributes to its prolonged anesthetic effect. Our study also found that Articaine's effect lasted longer, which is in line with findings of Krishna et al. (2023), who reported that Articaine provided longer-lasting anesthesia compared to Lidocaine when both were administered at a concentration of 1:100,000 epinephrine[33]. The superior duration of Articaine's anesthetic effect can be attributed to its higher lipid solubility and faster tissue penetration, which allows for more effective nerve blockade, particularly during dental procedures requiring extended periods of numbness, such as dental extractions[34,35].

In terms of pain control, Articaine provided superior pain relief during the procedure compared to Lidocaine as supported by results of Kakroudi et al (2015), who observed that Articaine's increased lipid solubility facilitated a more profound nerve block, resulting in better pain relief[36]. Moreover, a study by Shah et al. (2018) demonstrated that Articaine was more effective than Lidocaine in reducing pain during dental extractions[37]. Also, Somuri et al. (2013) found that children receiving Articaine as an infiltration agent experienced less pain during surgical procedures compared to those who received Lidocaine[38].

On the contrary, a study by Chaudhry et al. (2011) observed an increase

in heart rate and systolic blood pressure five minutes after Lidocaine injection in hypertensive patients, which was not seen in our study[39]. This discrepancy may be attributed to patient variability, as our study did not specifically focus on patients with pre-existing hypertension. Furthermore, the volume of anesthetic and dosage of epinephrine could also contribute to differences in hemodynamic responses[40]. Akinmoladun et al. (2013) highlighted that dose of epinephrine can influence the cardiovascular response, with higher doses potentially causing more pronounced increases in heart rate and blood pressure[41]. However, in context of dental procedures, the relatively low volume of anesthetic administered generally leads to minimal hemodynamic changes, which was reflected in our findings[24,42].

Regarding the technique of administration, we found no significant difference in efficacy between nerve block (IANB) and infiltration techniques, though Articaine's superior tissue penetration may explain its better pain control during infiltration procedures. This agrees with studies by Shah et al. (2018)[37] and Bataineh et al. (2016)[15], which demonstrated the efficacy of both Articaine and Lidocaine when administered via either technique, through Articaine's ability to diffuse through tissues may make it a more favorable option for infiltration, especially in the maxillary arch.

Our findings regarding the anxiety scores (MDAS) revealed a slight increase in anxiety for patients in the Lidocaine infiltration group (mean change of 0.90) compared to a minor decrease in anxiety for the nerve block group (mean change of -0.27). However, this difference did not reach statistical significance ($p = 0.092$). These results are consistent with previous studies that examined the impact of local anesthetic techniques on patient anxiety. A study by Aggarwal et al. (2018) found that patients receiving Lidocaine via infiltration had a higher reported anxiety level compared to those who underwent nerve block anesthesia[43]. The infiltration technique, while effective for anesthesia, can be perceived as more invasive or uncomfortable, which may contribute to heightened anxiety. Similarly, a study by Cho et al. (2017) observed that the nerve block technique was associated with lower anxiety levels, possibly due to its ability to provide a more profound and longer-lasting anesthetic effect, reducing the need for additional injections during the procedure[44]. Moreover, a study by Yıldırım et al. (2020) also noted that nerve block anesthesia resulted in a significant reduction in anxiety compared to infiltration, which they attributed to the reduced frequency of injections and the overall more predictable nature of nerve block procedures[45].

This study had several limitations that should be considered when interpreting the results. One key limitation was the small sample size. Additionally, factors such as the emotional status of patients, time of day, and other environmental variables that could influence blood pressure and anxiety levels were not controlled for, potentially introducing confounding effects. Furthermore, the study did not monitor or assess postoperative adverse effects, which limits our ability to draw conclusions about the safety or tolerability of the anesthetics. Future studies should incorporate systematic monitoring of adverse events, including allergic reactions, prolonged numbness, or cardiovascular complications, to fully evaluate clinical safety."

These findings highlight the need for further research, especially with larger sample sizes, to assess the long-term cardiovascular effects and anxiety management in patients.

CONCLUSION

In conclusion, both agents did not significantly alter blood pressure, respiratory rate, body temperature, or MDAS. Articaine caused a statistically significant increase in heart rate ($p = 0.012$), in contrast to Lidocaine, which significantly reduced heart rate. Infiltration techniques with Lidocaine and nerve block with Articaine showed a slight increase in MDAS, though not statistically significant. Articaine is a good alternative to Lidocaine and can be effectively used in dental procedures. Future studies should also consider the influence of patient characteristics, surgical complexity, and adverse event monitoring to better understand the full clinical implications of anesthetic choice.

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Competing Interest: None

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