

## Effects of Caffeine on local anesthesia failure

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### ABSTRACT

**Background:** There exists a prevalent belief among patients that the use of coffee diminishes the efficacy of local anaesthetic. Caffeine is extensively utilized on a global level through the consumption of coffee, tea, and chocolate. Throughout the duration of the day. Moreover, it is conventionally perceived as a demonstration of communal benevolence, specifically within the context of Saudi Arabia. The mechanism of action of local anaesthetics involves the disruption of sodium channel influx across the neuronal membrane. **Methodology:** A cross-sectional epidemiological observational study was done in the city. The data was gathered during a two-month period spanning from July 1st, 2022 to September 1st, 2022. The sample population consisted of individuals who sought dental services within the Hail region. The present investigation had a sample size of 131 individuals, with 47.69% representing the female population and 52.31% representing the male population. However, upon conducting an assessment of patients' knowledge and opinions, it was shown that 32% of participants concurred with the notion that coffee possesses the ability to mitigate the occurrence of local anaesthetic failure. A mere 10% of individuals possessed knowledge regarding the scientific evidence that establishes a correlation between the drinking of coffee and the failure of local anaesthetics. **Conclusion:** Research investigations have demonstrated that caffeine can expedite the recuperation process following anesthesia, exhibiting effectiveness even when administered at elevated levels of anesthesia. Based on the sole existing evidence, it can be inferred that caffeine exhibits a capacity to counteract the effects of general anesthesia. Based on the available scientific evidence, it has been observed that caffeine has the potential to influence cognitive function by enhancing alertness. Additionally, sleep loss has been found to induce worry and anxiety. These findings partially elucidate the challenges faced by individuals who consume coffee when delivering local anesthetics. In order to mitigate the incidence of local anaesthetic failure, it is advisable for dentists to incorporate stress reduction measures into their routine practice.

**KEYWORDS:** Caffeine, Anesthesia, coffee.

### ARTICLE DETAILS

**Published On:**  
**16 November 2023**

**Available on:**  
<https://ijmscr.org/>

### 1. INTRODUCTION

At a global scale, caffeine is commonly ingested in various forms such as coffee, tea, and chocolate throughout the course of the day. The act in question is conventionally recognized as a symbol of benevolence within societal contexts, particularly in Saudi Arabia (Badkook, 2013). According to a study conducted by Premnath et al. (2020), a significant number of patients hold the belief that their consumption of coffee can influence the efficacy of local anesthesia. The dental pain signal that originates in the pulp tissue is

conveyed via myelinated fibers known as A-fibers, which are responsible for the transmission of sharp pain. Additionally, 87% of these fibers are unmyelinated, referred to as C-fibers, which are responsible for conveying throbbing pain. Through these fibers the pain is transmitted into the spinal cord and form synapses in the thalamus which is responsible for organizing the pain signal and send it to the sensory cortex that defines the signal as pain then it travels to the motor cortex that sends information into to the thalamus which then send the signal to the spinal cord that which attribute to the

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motor response of the body during sensibility test (Sacerdote & Levrimi, 2012). Coffee is a beverage derived from the extraction of coffee beans, which are obtained from a naturally occurring alkaloid plant. These beans contain a substance that acts as a toxin and has the ability to enhance alertness. This effect is achieved through the inhibition of adenosine receptors, which are responsible for promoting sleep by binding to the neurotransmitter adenosine. The primary role of water in our coffee cup is to extract the various ingredients and chemicals present in coffee beans. These include citric acid, which has the ability to lower the pH of saliva, chlorogenic acid, which plays a role in regulating glucose levels, acetaldehyde, which, when metabolized in the liver, can elevate heart rate, and caffeine, which enhances alertness (Ashihara, 2006). In the past, caffeine has been utilized for the management of congestive heart failure accompanied by edema due to its diuretic properties. Additionally, it has been employed as a supplementary agent alongside analgesic medications (Tavares & Sakata, 2012). Local anesthesia functions by disrupting the inflow of sodium channels across the neuronal membrane. The mechanism of action of general anesthesia involves the selective modulation of synaptic activity within the central nervous system. The impact of local anesthesia on the axonal membrane of peripheral nerves is such that it mostly operates during the depolarization phase of nerve impulse production.

### Objectives

The objective of this study is to investigate the potential impact of caffeine consumption on the occurrence of local anesthetic failure in dental practice, with the intention of determining whether this phenomenon is rooted in physiological factors or merely a manifestation of psychological apprehension.

## 2. MATERIAL AND METHODS

### The Study design

An epidemiological observational study employing a cross-sectional design was conducted between July and September 2022.

### Study area

The geographical location under investigation is the city. The subject under consideration is located in the northern part of Saudi Arabia. The estimated population of the region is roughly 600,000 inhabitants.

### Sampling design

Sample size: 131 patients

### Sampling procedure

The data was collected over a two-month period, encompassing people scheduled to attend dental facilities in the Hail region. The questionnaire underwent translation into Arabic and received approval from a single dentist. Subsequently, it was subjected to testing for reading and comprehension by a group of 20 individuals who were not part of the study. The questionnaire comprises a set of 15 inquiries that were prepared in accordance with the predetermined study objectives. The questionnaire comprises three distinct sections. The initial section of the questionnaire was dedicated to gathering demographic information through the inclusion of three specific questions. The subsequent section comprises a series of seven inquiries pertaining to the correlation between the consumption of caffeine and the efficacy of anesthesia. The third section comprises five inquiries pertaining to medical history data.

### Inclusive criteria

A collection of samples obtained by a random sampling method. Based on the aforementioned inclusive criteria:

All individuals who have been taking caffeine and are affiliated with the College of Dentistry in Hail.

Individuals who do not have disabilities and possess good physical health.

This study includes participants aged 18 years and older.

### Exclusive criteria

- All the patients from outside the college of dentistry in Hail
- Any person complains of medical problems especially heart diseases
- Any age under 18 years
- Disabled people

### Data collecting tools

The data was obtained from individuals seeking dental care in the Hail region by the administration of a questionnaire.

## 3. RESULTS

The data were obtained through the Google Forms service and afterwards entered into SPSS version 25.0 for the purpose of data analysis. The frequencies and percentages were calculated in order to describe the statements. A chi-square (X<sup>2</sup>) analysis was performed to examine the association between the absence of numbness following administration of a local anesthetic injection and coffee consumption patterns. A significance level of 0.05 was used to determine statistical significance.

**Table 1 Demographic information, these statements show different genders, age, Education level**

Statement	N	%
Gender	Male	47.69
	Female	52.31
	18-30	53.85

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Age	31-40	46	35.38
	41-50	13	10.00
	51-60	1	0.77
Education level	General education	66	50.77
	Bachelor	42	32.31
	Postgraduate studies	9	6.92
	Not educated	13	10.00

According to the data presented in Table 1, a total of 131 individuals were involved in the present investigation, with 47.69% being female and 52.31% being male. A majority of the participants (53.31%) fell within the age range of 18 to

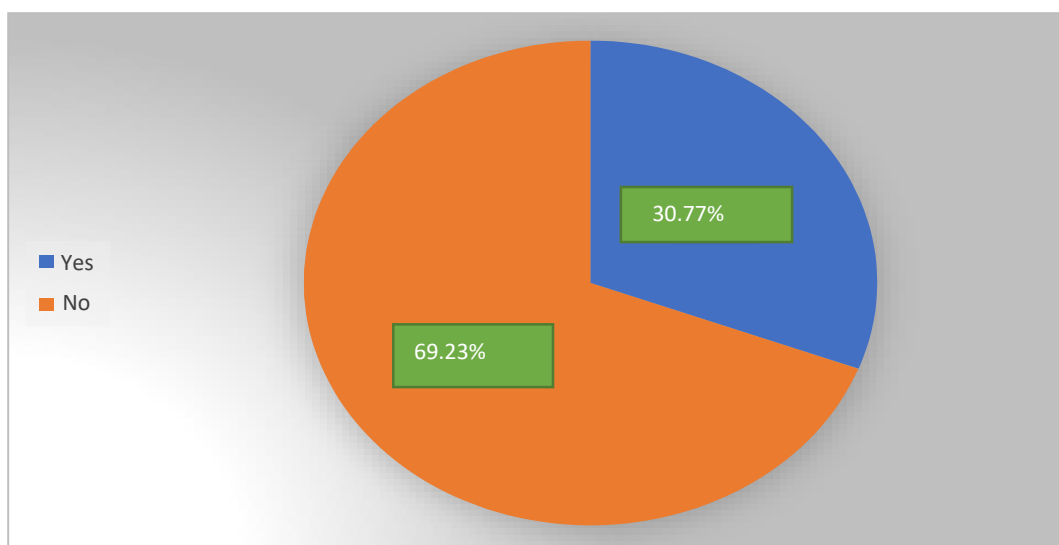
30, while the age group of 31 to 40 constituted 35.85% of the sample. The majority of individuals, specifically 50.77%, have a general education background, whereas 32.31% held a bachelor's degree.

**Table 2 Dental background, Shows the response of the patients to the anaesthesia concerning their caffeine intake**

Statement		N	%
Have you had an event in the dental clinic that you do not feel numbness after being given a local anesthetic injection?	Yes	40	30.77
	No	90	69.23
If the answer is "yes", do you believe that your excessive intake of coffee is the reason?	Always	13	32.50
	Often	14	35.00
	Sometimes	7	17.50
	Rarely	4	10.00
	Never	2	5.00
On average, how many injections do you take in each visit so that the doctor can work and feel the numbness?	1	68	52.31
	2	51	39.23
	3	11	8.46

According to the data shown in Table 2, a minority of patients (30.77%) reported not experiencing numbness following the administration of a local anesthetic injection. The prevailing belief among the majority of patients was that excessive consumption of coffee was the contributing factor. According to the data presented in Figures 1 and 2, it was found that

52.3% of patients indicated experiencing numbness after a single injection administered by the doctor. In contrast, 39.23% of patients required two injections, while a smaller proportion of patients, namely 8.46%, required three injections to get the desired effect.



**Figure 1 Shows the percentage of the people who felt numbness and those who didn't feel it after the local anesthesia was given.**

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Yes, means he didn't feel the numbness.

No, means he did

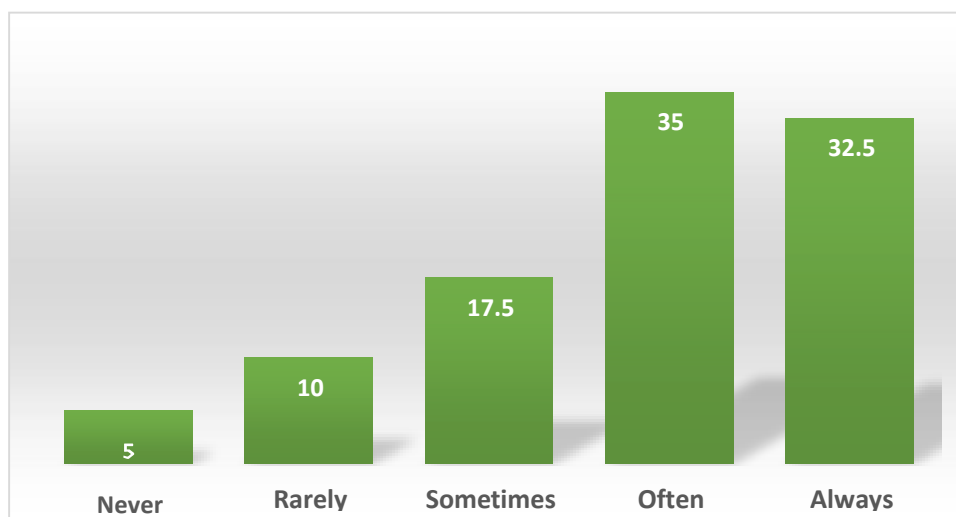


Figure 2. Shows whether the excessive intake of coffee is the reason (in %). feel the numbness.

Table 3. Coffee drinking habits, it illustrates the number of cups, type of coffee, whether or not the patients consumed other caffeinated drinks, and how many times do they take it daily

Statement		N	%
How many cups of coffee do you drink per day?	1	49	37.69
	2	43	33.08
	3 or more	28	21.54
	I don't daily drink coffee	10	7.69
What type of coffee do you usually drink?	Saudi coffee	79	60.77
	Espresso	18	13.85
	Cappuccino	33	25.38
	Black coffee	46	35.38
Do you usually drink other caffeinated drinks, forexample: (Pepsi, tea, energy drinks)?	Yes	86	66.15
	No	44	33.85
If yes, how many times a day do you drink this typeof drink?	1	57	65.52
	2	23	26.44
	3	3	3.45
	4 or more	3	3.45

According to the data presented in Table 3, it can be observed that 37.69% of the participants consumed a single cup of coffee every day. Additionally, 33.08% of the participants reported consuming two cups, while 21.54% indicated consuming three or more cups of coffee daily. The findings of the study indicate that Saudi coffee was the preferred choice among the participants, garnering a majority of 60.77%. Following closely after was black coffee, which accounted for 35.38% of the participants' preferences.

Cappuccino, on the other hand, received a lower percentage of 25.38%. Lastly, espresso was found to be the least favored option, with a mere 14.85% of participants expressing a preference for it. A majority of participants (65.62%) indicated that they typically use various other caffeinated beverages, such as Pepsi, tea, and energy drinks. Furthermore, 65.52% reported consuming these beverages once a day, while 26.44% reported consuming them twice a day (Figure 3).

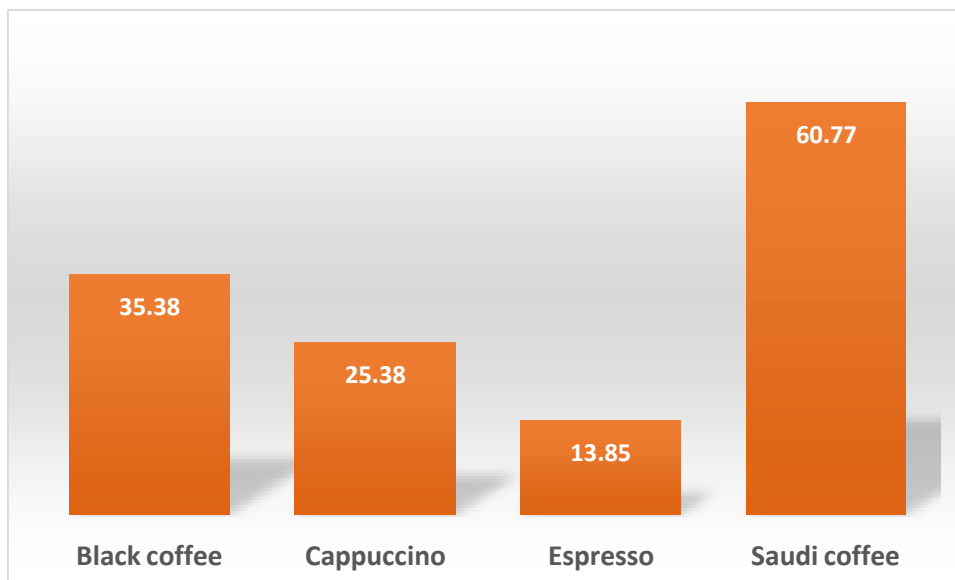


Figure 3 Consumption of different coffee types

Table 4. Problem history, it shows different medical status responses

Statement		N	%
Are you a smoker?	Yes	38	29.23
	No	92	70.77
If the answer is yes, mention the problem you suffer from?	Yes	1	2.63
	No	37	97.37
If the answer is yes, mention the problem you suffer from?	Not given	129	99.23
	Diabatic	1	0.77
Do you think that any of the medications you	No	11	8.46

According to the data presented in Table 4, a total of 29.23% of the participants were identified as smokers. Among this group, only one individual reported having a diabetic condition, while none of the participants indicated the use of any medications that could potentially impact the efficacy of dental anesthetics.

Table 5. The association between not feeling numbness after being given a local anaesthetic injection and coffee habits

Statement	Not feeling numbness after being given a local anesthetic injection						Chi squared	p value	
	Yes		No		Total				
	N	%	N	%	N	%			
How many injections do you take in each visit so that the doctor can work and feel the numbness?	1	5	12.50	63	70.00	68	52.31	40.74***	<0.001
	2	26	65.00	25	27.78	51	39.23		
How many cups of coffee do you drink per day?	3	9	22.50	2	2.22	11	8.46	27.90***	<0.001
	1	4	10.00	45	50.00	49	37.69		
	2	16	40.00	27	30.00	43	33.08		
	3 or more	18	45.00	10	11.11	28	21.54		
Do you usually drink other caffeinated drinks, for example: (Pepsi, tea, energy drinks)?	I don't daily drink coffee	2	5.00	8	8.89	10	7.69	14.67***	<0.001
	Yes	36	90.00	50	55.56	86	66.15		
	No	4	10.00	40	44.44	44	33.85		

\*≤0.05; \*\*≤0.01; \*\*\*≤0.001, ns (not significant)

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Table 5 presents the results of a Chi-squared analysis that was performed to examine the association between the absence of numbness following a local anesthetic injection and coffee consumption patterns. A substantial correlation was observed between the number of injections administered and the absence of numbness. Specifically, 70% of individuals who experienced only one injection reported feeling numbness, whereas 65% of those who did not experience numbness required two injections ( $\chi^2=40.80$ ,  $p<0.001$ ). A notable correlation was observed between the consumption of coffee and the absence of numbness. Specifically, 45% of individuals who did not experience numbness reported consuming three or more cups of coffee, but only 11.11% of those who reported feeling numbness had coffee at a similar frequency ( $\chi^2=40.80$ ,  $p<0.001$ ). A notable correlation was seen between the consumption of carbonated beverages and the absence of numbness. Specifically, 90% of individuals who did not experience numbness reported consuming fizzy drinks, whereas 55.55% of those who felt numbness said the same ( $\chi^2=40.80$ ,  $p<0.001$ ). In conclusion, it may be argued that consuming a greater quantity of caffeinated beverages is associated with a decreased sensation of numbness.

### 3. DISCUSSION

Numerous patients encountered in routine clinical practice often report a medical background involving unsuccessful administration of local anesthetic, which they attribute to their presumed excessive consumption of coffee. Due to a lack of empirical confirmation for this hypothesis, the goal of this study was to explore the patients experience, knowledge, and consciousness of coffee drinking and its effect on the local anaesthetic. Caffeine, a psychoactive stimulant, is the main compound found in coffee and has been extensively studied as a food component. It is commonly consumed in the form of beverages. Despite the existence of a substantial body of published literature on the pharmacokinetics of caffeine and its impact on human health. However, while conducting an assessment of patients' knowledge and perspectives, it was found that 32% of participants expressed agreement with the potential positive impact of coffee on the failure of local anaesthetics. A mere 10% of individuals exhibited limited awareness regarding the scientific evidence that establishes a connection between the use of coffee and the diminished efficacy of local anesthetics. The single existing data, as presented by Wang et al. (2014), suggests that caffeine has the ability to counteract the effects of general anesthesia.

The local anesthetic solution effectively inhibits the activity of sodium channels located on the nerve membrane. However, in this particular scenario, it is expected that the basic form (RN) of LA would successfully traverse the membrane, while the charged acid form (RNH<sup>+</sup>) would bind to the inner pore of the sodium channel. A study conducted by Lai et al. (2004) revealed the existence of at least nine distinct subtypes of voltage-gated sodium channels (VGSCs) within the field of molecular biology. These subtypes were

found to exhibit differences in their patterns of expression, biophysical characteristics, and roles in the alleviation of pain. Voltage-gated sodium channels (VGSCs) consist of two subunits, namely an alpha subunit and a beta subunit. Upon detection of an electrical field, the alpha subunit of the channel functions as a voltage sensor, leading to the activation of the channel and subsequent passage of sodium ions. Voltage-gated sodium channels (VGSCs) can be classified into two categories based on their susceptibility to inhibition by tetrodotoxin (TTX): TTX-sensitive (TTX-S) and TTX-resistant (TTX-R) channels. TTX-R channels also exhibit resistance to local anesthetics and can be readily sensitized by prostaglandin (Black et al., 2004). The activation of these channels in patients experiencing pre-endodontic symptoms leads to a reduction in the efficacy of anesthesia.

Research studies have demonstrated the efficacy of caffeine in expediting the recovery process following anesthesia, as well as its potential benefits when administered in high doses during anesthesia. Based on the findings of our study, it was observed that a mere 30.77% of participants did not experience numbness following the administration of a local anaesthetic injection. Furthermore, a substantial proportion of respondents attributed this phenomenon to the perceived consumption of excessive amounts of coffee. The primary mechanism of action of caffeine is the inhibition of adenosine receptors inside the central nervous system, hence exerting control over the release of neurotransmitters. Caffeine has the ability to counteract the effects of adenosine by functioning as an antagonist for adenosine receptors A1 and A2A. The mechanism of action of caffeine involves the elevation of intracellular cyclic adenosine monophosphate (cAMP) levels and the inhibition of adenosine receptors. The intricate pharmacological properties of caffeine render it particularly advantageous in expediting the process of recovery from anesthesia. According to recent studies, the administration of intravenous caffeine has been found to expedite the recuperation process following general anesthesia in individuals who are in good condition, as well as in patients diagnosed with trisomy 10 disorder. The use of intravenous caffeine has also been investigated as a potential intervention for assisting in the post-anesthetic recovery of pre-term babies (Hargreaves & Keiser, 2002).

When taking into account additional patient-related factors such as smoking status, medical condition, and drug intake, it was found that 92% of the participants did not have a smoking habit and did not exhibit any other notable medical problems or drug consumption. Consequently, these factors possess promise.

There are certain elements that can potentially exert a masking effect. Nicotine and caffeine both possess stimulant characteristics. However, the act of smoking enhances the elimination of caffeine from the body through affecting the activity of cytochrome P450 (CYP1A2), as stated by Temple et al. (2017). Consequently, the consumption of tobacco has

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the potential to attenuate the impact of caffeine on adenosine receptors, thereby safeguarding the efficacy of local anesthesia from being compromised or contested.

Numerous studies have provided evidence indicating that caffeine consumption leads to an elevation in stress hormone levels in the bloodstream, including catecholamines such as adrenaline and cortisol. In addition, long-term ingestion of caffeine results in the development of tolerance to its adenosine receptor-mediated effects, which is accompanied by an increase in the number of receptors. This upregulation of receptors is typically associated with symptoms such as headache, anxiety, and flushing. This factor may contribute to the inadequate administration of anesthesia in this particular cohort of individuals. The presence of anxiety and heightened alertness caused by caffeine consumption has been found to potentially impede the effectiveness of local anesthesia, as indicated by Wali's study conducted in 1984.

### 4. CONCLUSION

While there were individuals who held the belief that local anesthesia could potentially diminish the efficacy of the anesthetic solution, empirical evidence from dental clinics indicates that only 30.77% of patients perceived a correlation between their caffeine consumption and the success of their local anesthesia. Conversely, the majority of patients did not report any such association. Additional elements or variables that may influence the administration of anesthesia encompass smoking habits, patient age, bone thickness in the targeted region, the presence or absence of inflammation, and variations in pain tolerance across individuals. Dentists must possess knowledge regarding many elements that can influence the efficacy of local anesthesia, both positively and negatively. Consequently, in instances where local anesthesia fails, dentists should address the specific component that potentially hindered the successful administration of anesthesia.

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