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CLINICAL PROFILE AND FACTORS ASSOCIATED WITH ADVERSE EFFECTS AND PROCEDURE-RELATED SYMPTOMS FOLLOWING DENTAL LOCAL ANESTHESIA: A PROSPECTIVE OBSERVATIONAL STUDY

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Abstract

Dental local anesthesia is generally safe, although transient adverse effects and procedure-related symptoms may occur, and our study evaluated the frequency and clinical profile of immediate and early events after dental local anesthesia and explored factors associated with patients and anesthesia. We conducted a prospective observational study in 63 adults treated in a specialized outpatient dental clinic, and demographic characteristics, medical history, clinically assessed preoperative anxiety, anesthetic agent, injection technique, and post-anesthetic events were recorded, and associations were evaluated using chi-square or exact Fisher tests, and unadjusted odds ratios with 95% confidence intervals were calculated. At least one event occurred in 22 patients (34.9%), and injection pain was the most common (19.0%), followed by palpitations (11.1%), dizziness (7.9%), prolonged numbness (6.3%), anxiety-related tremor (6.3%), hematoma (3.2%), transient trismus (3.2%), temporary paresthesia (1.6%) and a vasovagal episode (1.6%). Very important to note is the fact that no serious events occurred, and the events were more frequent among patients with moderate to high anxiety evaluated clinically, and no statistically significant differences were detected between articaine and lidocaine or between local infiltration and inferior alveolar nerve block. Most of the events we recorded were mild and self-limiting, and clinically assessed preoperative anxiety was associated with an increase in event reporting, support for individualized assessment, careful injection technique, and short-term monitoring.

Keywords: local dental anesthesia, adverse effects, articaine, lidocaine, anxiety.

Introduction

Local anesthesia is indispensable in contemporary dental practice because it permits restorative, endodontic, periodontal, and surgical procedures to be performed with acceptable comfort and procedural control, and although these agents have a favorable safety profile, adverse reactions may occur and range from transient injection pain or palpitations to uncommon neurological, ophthalmic, or systemic complications, and recent pharmacovigilance data have highlighted the diversity of events reported after dental local anesthetics and the importance of distinguishing expected, non-serious reactions from clinically significant adverse

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outcomes [1]. A broad literature review similarly showed that complications may arise from the pharmacological properties of the anesthetic solution, the vasoconstrictor component, injection technique, intravascular administration, tissue trauma, or patient-related susceptibility [2].

Neurological complications remain particularly relevant, as sensory disturbances can persist beyond the expected duration of anesthesia and affect quality of life, and reported manifestations include prolonged numbness, paresthesia, dysesthesia, and, rarely, motor involvement, with mandibular nerve blocks receiving particular attention because of their anatomical proximity to the inferior alveolar and lingual nerves [3]. Ophthalmic reactions are also uncommon but clinically important; diplopia, ptosis, visual disturbance, and transient amaurosis have been described after inferior alveolar nerve blocks, most likely through vascular or anatomical pathways that permit unintended spread of the anesthetic solution [4]. Permanent lingual nerve injury is rare, yet retrospective evidence confirms that local anesthetic injections may contribute to a subset of persistent sensory deficits after dental procedures [5].

The addition of vasoconstrictors improves anesthetic depth, prolongs duration, and limits systemic absorption, but it may also be associated with palpitations, tremor, anxiety, or transient hemodynamic changes, and available evidence suggests that local anesthetics combined with vasoconstrictors can generally be used safely in patients with controlled cardiovascular disease when appropriate doses, aspiration, and clinical monitoring are applied [6], and individual risk assessment remains essential, particularly in patients with cardiovascular comorbidities, marked dental anxiety, stimulant consumption, or previous adverse experiences.

Articaine and lidocaine are among the most frequently used agents in dental practice. Meta-analytic evidence indicates that articaine provides effective anesthesia for routine dental treatment and has an overall safety profile comparable to lidocaine [7]. Its physicochemical characteristics and tissue diffusion have supported its growing use, although questions regarding concentration, technique, and neurological safety remain a topic of discussion [8], and randomized clinical studies have compared articaine and lidocaine in challenging situations, including mandibular molars affected by molar–incisor hypomineralization [9], mandibular anterior extractions performed with buccal infiltration alone [10], and inferior alveolar nerve block in symptomatic irreversible pulpitis [11]. Other trials have examined articaine infiltration in maxillary molars with irreversible pulpitis, reinforcing the importance of procedure-specific and site-specific evaluation [12].

Despite this expanding evidence, relatively few prospective outpatient studies have simultaneously documented immediate symptoms, early local complications, anesthetic agent, injection technique, patient anxiety, and relevant medical history under routine clinical conditions. We therefore conducted a prospective observational study in 63 patients treated at a specialized dental outpatient clinic. We aimed to determine the frequency and clinical profile of immediate and early adverse effects and procedure-related symptoms following dental local anesthesia and to explore whether patient-related and anesthesia-related factors were associated with their occurrence.

Materials and Methods

Study design and setting

We conducted a prospective observational study in patients who received local anesthesia for dental treatment in a specialized outpatient dental clinic, and our study was designed to assess the frequency and clinical characteristics of immediate and early adverse effects and procedure-related symptoms under routine clinical conditions and to explore potential associated factors.

Patients were enrolled consecutively throughout the study period and monitored from administration of anesthesia to completion of the dental procedure, and subsequently, we performed a structured follow-up assessment to identify symptoms that developed or persisted

after discharge from the clinic, and our study was conducted in accordance with the principles of the Declaration of Helsinki, and all participants were informed about the study's purpose and procedures and provided written informed consent prior to enrollment, and patient data were anonymized prior to analysis.

Participants

A total of 63 adult patients treated in our specialized outpatient dental clinic were included in the study, and the eligible participants we considered were patients 18 years of age or older who required local anesthesia for tooth extraction, minor dentoalveolar intervention, restorative treatment, or endodontic therapy and who were able to understand and complete the follow-up assessment.

We excluded patients if they refused to participate, were unable to provide reliable clinical information, required general anesthesia or intravenous sedation, presented with an acute medical condition that required postponement of treatment, or had incomplete perioperative or follow-up data, and patients with stable systemic disease were not excluded, provided that dental treatment under local anesthesia is considered clinically appropriate.

Preoperative assessment

We, prior to the administration of local anesthesia, recorded demographic and clinical information using a standardized data collection form, and variables included age, gender, relevant medical history, controlled cardiovascular disease, clinically assessed preoperative dental anxiety, and type of planned dental procedure.

Preoperative dental anxiety was classified as low or absent versus moderate to high, and this classification included patient self-reported concern and observable behavior prior to treatment, and physiological manifestations were documented separately and were not used as an exclusive basis for assigning the anxiety category.

Local anesthetic administration

Local anesthesia was administered in accordance with the requirements of the dental procedure and the anatomical region involved, and the anesthetic agents evaluated were 4% articaine with epinephrine and 2% lidocaine with epinephrine, and the treating clinician selected the anesthetic solution based on the patient’s medical history, planned intervention, and routine clinical judgment.

We classified this anesthetic technique as a local infiltration technique or inferior alveolar nerve block, and for each patient we recorded the anesthetic agent, injection technique, injection site, and type of dental procedure, and all injections were performed using sterile disposable needles and standard dental cartridges.

To reduce the risk of intravascular administration, aspiration was performed before deposition of the anesthetic solution whenever technically feasible and the solution was injected slowly, and the patient was observed continuously for behavioral, cardiovascular, neurological, or allergic manifestations.

Outcome assessment

The primary outcome was the occurrence of at least one procedure-related adverse effect or symptom after administration of local anaesthesia, and the events recorded were classified according to timing and clinical presentation, and immediate events were defined as symptoms occurring during the administration of anesthesia or before the completion of the dental procedure, and injection pain was considered a symptom related to administration, while palpitations, dizziness, tremor, vasovagal symptoms, nausea, respiratory discomfort and suspected allergic manifestations were classified as systemic or clinically relevant reactions.

Early local effects were assessed after the procedure and included hematoma, trismus, prolonged soft tissue anesthesia, paresthesia, localized swelling, and soft tissue injury, and prolonged numbness was defined as anesthesia that persisted for more than 4 hours after administration. Our patients were contacted or clinically reassessed within 24 hours to document the persistence of symptoms, resolution, or the onset of delayed manifestations.

Pain during the injection was recorded as present or absent immediately after the administration of anesthesia, and palpitations, dizziness, tremor and vasovagal symptoms were documented and confirmed by the patient report, and a patient could experience several events; therefore, the individual categories were not mutually exclusive.

We also classified adverse events as non-serious or serious, and we defined serious events as those that led to emergency medical intervention, transfer to hospital, hospitalization, life-threatening manifestations, persistent neurological deficit or death.

Data management

We entered all clinical information into an electronic database and assigned a unique study code to each participant, and no directly identifiable personal data was included in the analytical dataset, and the database was checked for missing information, duplicate entries, implausible values, and inconsistencies between the clinical record and the follow-up assessment, and when necessary, the original clinical form was reviewed before the dataset was finalized.

Statistical analysis

The statistical analysis was performed using the GraphPad Prism software, with version 10.2.3 (GraphPad Software, Boston, MA, USA), and continuous variables were assessed for normality using the Shapiro–Wilk test and were expressed as mean and standard deviation or median and interquartile range, as appropriate, and the categorical variables were summarized as absolute frequencies and percentages.

The frequency of patients with at least one recorded event was calculated using the total number of participants included as the denominator, as patients could report multiple events, the sum of the individual event frequencies could exceed the number of affected patients, and associations between the occurrence of at least one recorded event and categorical variables, including gender, clinically assessed dental anxiety, anesthetic agent, anesthetic technique, cardiovascular history, and type of procedure, were assessed using the chi-square test or the Fisher's exact test, as appropriate, and unadjusted odds ratios with 95% confidence intervals were calculated for selected comparisons.

Age was summarized using mean and standard deviation or median and interquartile range, depending on the distribution of data, and all statistical tests were bilateral, and a p-value below 0.05 was considered statistically significant, and due to the limited sample size and relatively small number of adverse events, subgroup analyses were considered exploratory and hypothesis-generating, rather than confirmers.

Results

Patient and anesthesia characteristics

A total of 63 consecutive patients who received local anesthesia in the specialized dental outpatient clinic were included in the analysis, and the study population comprised 36 women (57.1%) and 27 men (42.9%), with a mean age of 42.6 ± 15.1 years, and twenty-eight patients (44.4%) reported moderate-to-high dental anxiety before treatment, while 12 participants (19.0%) had at least one controlled cardiovascular condition.

Articaine 4% with epinephrine was administered in 39 cases (61.9%), whereas lidocaine 2% with epinephrine was used in 24 cases (38.1%). Local infiltration was the most frequently

used technique, being performed in 38 patients (60.3%), while an inferior alveolar nerve block was administered in 25 patients (39.7%). The majority of procedures were dental extractions or minor dentoalveolar surgical interventions (Table 1).

Table 1. Demographic, clinical, and anesthesia-related characteristics of the study population

Variable	Category	n	%
Sex	Female	36	57.1
	Male	27	42.9
Age	Mean ± SD, years	42.6 ± 15.1	—
Clinically assessed dental anxiety	Moderate-to-high	28	44.4
Cardiovascular history	Controlled cardiovascular condition	12	19.0
Local anesthetic	Articaine 4% with epinephrine	39	61.9
	Lidocaine 2% with epinephrine	24	38.1
Anesthetic technique	Local infiltration	38	60.3
	Inferior alveolar nerve block	25	39.7
Procedure	Dental extraction	31	49.2
	Minor oral surgery	18	28.6
	Restorative/endodontic treatment	14	22.2

Frequency and clinical profile of adverse effects and procedure-related symptoms

At least one local or systemic adverse effect or procedure-related symptom was observed in 22 of the 63 patients, corresponding to an overall frequency of 34.9%. All recorded events were transient, and no patient required hospital admission or emergency medical transfer.

Pain during anesthetic administration, classified as a procedure-related symptom, was the most common event, reported by 12 patients (19.0%). Palpitations occurred in 7 cases (11.1%), and 5 patients (7.9%) experienced transient dizziness. Prolonged soft-tissue numbness lasting more than four hours and anxiety-related tremor were each reported by four participants (6.3%). Hematoma and transient trismus occurred in two patients each (3.2%). One patient developed temporary paresthesia, and one experienced a vasovagal episode. All symptoms resolved spontaneously or after routine supportive management, and because several patients reported more than one event, the cumulative number of recorded events exceeded the number of affected participants (Table 2).

Table 2. Adverse effects and procedure-related symptoms following dental local anesthesia

Recorded event	n	% of total sample
Pain during injection	12	19.0
Palpitations	7	11.1
Dizziness	5	7.9
Prolonged numbness >4 h	4	6.3
Anxiety-related tremor	4	6.3
Hematoma	2	3.2
Transient trismus	2	3.2
Temporary paresthesia	1	1.6
Vasovagal episode	1	1.6
Serious adverse events	0	0.0

Exploratory factors associated with recorded events

Recorded events were more frequent among patients with clinically assessed moderate-to-high preoperative dental anxiety, and at least one adverse effect or procedure-related symptom occurred in 15 of the 28 anxious patients (53.6%), compared with seven of the 35 patients with low or absent anxiety (20.0%), and this exploratory association was statistically significant and corresponded to an unadjusted odds ratio of 4.62, suggesting that patients with higher preoperative anxiety were more likely to report immediate or early symptoms after dental local anesthesia, this finding supports the clinical relevance of identifying anxiety before treatment, as anxiety may amplify pain perception, autonomic symptoms, and subjective post-anesthetic discomfort.

Regarding anesthesia-related variables, recorded events were numerically more frequent after inferior alveolar nerve block than after local infiltration, occurring in 12 of 25 patients (48.0%) and 10 of 38 patients (26.3%), respectively, and although this difference did not reach statistical significance, the observed trend may reflect the greater technical complexity, deeper anatomical target, longer duration of soft-tissue anesthesia, and higher patient perception of mandibular block procedures, and event frequency was also numerically higher among patients receiving lidocaine than among those receiving articaine, but the difference was not statistically significant, and similarly, no significant association was identified between sex and the occurrence of recorded events. Given the limited sample size and the small number of outcome events, these analyses were considered exploratory and should not be interpreted as evidence of causal relationships (Table 3).

Table 3. Unadjusted exploratory associations between patient- or anesthesia-related factors and the occurrence of at least one recorded event.

Variable	At least one event n/N (%)	No event n/N (%)	Unadjusted odds ratio (95% CI)	p-value
Moderate-to-high anxiety	15/28 (53.6)	13/28 (46.4)	4.62 (1.52–14.08)	0.006
Low/absent anxiety	7/35 (20.0)	28/35 (80.0)	Reference	—
Inferior alveolar nerve block	12/25 (48.0)	13/25 (52.0)	2.58 (0.88–7.55)	0.081
Local infiltration	10/38 (26.3)	28/38 (73.7)	Reference	—
Lidocaine	10/24 (41.7)	14/24 (58.3)	1.61 (0.56–4.66)	0.377
Articaine	12/39 (30.8)	27/39 (69.2)	Reference	—
Female sex	14/36 (38.9)	22/36 (61.1)	1.45 (0.50–4.20)	0.494
Male sex	8/27 (29.6)	19/27 (70.4)	Reference	—

The distribution of the most frequently recorded adverse effects and procedure-related symptoms following dental local anesthesia is presented in Figure 1. Injection pain represented the predominant event in the study population, confirming that discomfort during anesthetic administration was the most commonly reported procedure-related symptom, and among systemic or patient-perceived reactions, palpitations and transient dizziness were the next most frequent findings, suggesting that a proportion of post-anesthetic complaints may be related to autonomic response, anxiety, vasoconstrictor perception, or transient procedural stress.

Less frequent events, such as prolonged numbness, anxiety-related tremor, hematoma, and transient trismus, were also included in the graphical representation to illustrate the overall clinical profile of mild and self-limiting reactions, and temporary paresthesia and vasovagal episode were each recorded in one patient and are reported in Table 2, but were not included in Figure 1 because of their very low frequency.

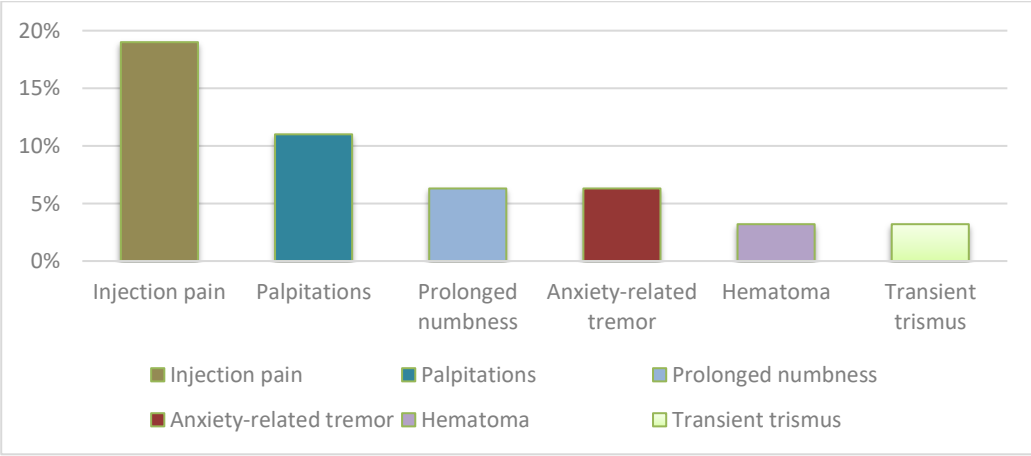

Figure 1. Distribution of the most frequently recorded adverse effects and procedure-related symptoms following dental local anesthesia.

The values represent the percentage of the total population of our study reporting each event, and multiple events may be recorded in the same patient, and temporary paresthesia and vasovagal episode (1.6% each) are not presented.

Discussion

In the present study, we evaluated the frequency and clinical profile of immediate and early adverse effects, as well as procedure-related symptoms, following dental local anesthesia in 63 patients treated in a specialized outpatient setting, and our principal finding was that approximately one-third of participants experienced at least one transient event, while no serious adverse events, hospital transfers, or persistent neurological deficits were recorded. Injection pain was the most frequent manifestation, followed by palpitations, dizziness, prolonged numbness, and anxiety-related tremor, and these results suggest that most events observed in routine dental practice are mild and self-limited, and careful clinical assessment remains necessary because uncommon but potentially important complications have also been described.

The pattern identified in our study is consistent with recent pharmacovigilance and review data showing that dental local anesthetics are generally safe but may be associated with a broad spectrum of reactions [1,2]. Injection pain should be interpreted primarily as an administration-related symptom rather than a pharmacological adverse reaction; it may result from needle penetration, tissue distension, injection pressure, solution temperature, and patient anxiety. Palpitations and tremor may reflect the systemic action of epinephrine, inadvertent intravascular administration, or an endogenous adrenergic response triggered by fear. Although vasoconstrictor-containing solutions may produce transient cardiovascular symptoms, current evidence supports their cautious use in patients with controlled cardiovascular disease when dose limitation, aspiration, slow injection, and monitoring are applied [6].

Neurological effects were uncommon in our cohort, and only one case of temporary paresthesia was recorded, and no permanent sensory deficit occurred. This observation is compatible with the low overall frequency of neurological complications reported in the literature, and however, prolonged numbness, paresthesia, dysesthesia, and lingual nerve injury remain recognized outcomes after mandibular injections [3,5]. Likewise, no ocular complication was observed in our patients. Such events are rare, but diplopia, ptosis, visual disturbances, and transient amaurosis have been described after inferior alveolar nerve block, most likely due to vascular spread or unintended diffusion of the anesthetic solution [4].

We also explored whether recorded events differed according to anesthetic agent and technique, and events were numerically more frequent after an inferior alveolar nerve block than after local infiltration, but the difference did not reach statistical significance, and this finding may reflect the greater anatomical complexity of nerve-block procedures, the injection volume, or the likelihood of vascular contact; however, the limited sample size and non-random treatment allocation prevent definitive interpretation. Similarly, no statistically significant difference was detected between articaine and lidocaine in this sample, and this observation is broadly consistent with evidence indicating that articaine has an efficacy and safety profile comparable to lidocaine in routine dental care [7,8]. Randomized studies have shown that both agents can provide effective anesthesia across different procedures and anatomical sites [11–15], although our observational data cannot establish equivalence or comparative safety.

Clinically assessed anxiety was the factor most strongly associated with event reporting in our sample. Patients with moderate-to-high preoperative anxiety reported symptoms more frequently than those with low or absent anxiety, and this association may be explained by increased sympathetic activity, heightened pain perception, hypervigilance, and difficulty distinguishing pharmacological reactions from anxiety-related somatic sensations, and because anxiety was not measured using a validated psychometric instrument, this finding should be interpreted with caution. From a clinical perspective, our study supports identifying anxious patients before injection and using clear communication, slow administration, appropriate positioning, and short observation periods.

Several limitations should be considered. Our study included a relatively small, single-center sample, which limits generalizability and statistical power, and event assessment was partly based on patient reporting and may therefore be influenced by perception or recall bias. Preoperative anxiety was classified clinically rather than with a validated scale, and treatment allocation was determined by routine clinical judgment rather than randomization, and the observational design precludes causal inference, while the low number of uncommon or serious events prevents robust risk estimation. Moreover, potential confounding by procedure type, injection site, anesthetic dose, vasoconstrictor concentration, and number of cartridges cannot be excluded, and nevertheless, our study provides a clinically grounded overview of early events in routine outpatient dentistry, and it reinforces the importance of individualized risk assessment, careful injection technique, anxiety management, and standardized post-anesthetic monitoring.

Conclusions

Dental local anesthesia was associated predominantly with mild, transient adverse effects and procedure-related symptoms, most commonly injection pain, palpitations, dizziness,

prolonged numbness, and anxiety-related tremor, and at the same time, no serious events or persistent neurological complications were recorded, and however, no statistically significant differences were detected between articaine and lidocaine or between local infiltration and inferior alveolar nerve block. Clinically assessed preoperative anxiety was associated with increased event reporting, supporting individualized risk assessment, careful injection technique, anxiety management, and standardized monitoring in routine outpatient dental practice.

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