Electronic Dental Anesthesia in Contemporary Dentistry: A Narrative Review with Emphasis on Pediatric Applications

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Abstract—**Electronic dental anesthesia (EDA), most commonly delivered through transcutaneous electrical nerve stimulation (TENS), has been proposed as a non-pharmacological method for controlling dental pain and reducing anxiety associated with needle-based local anesthesia. The electronic anesthesia techniques centers on the history of pain control in dentistry, the evolution of electronic anesthesia techniques, and the application of EDA in clinical dental practice, with particular relevance to children and needle-phobic patients. A structured literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar using combinations of terms related to electronic dental anesthesia, transcutaneous electrical nerve stimulation, dental pain, local anesthesia, injection anxiety, needle phobia, pediatric dentistry, and behavior management. This review reorganizes the topic into a publication-oriented narrative review focusing on the historical basis, biological rationale, clinical applications, advantages, limitations, and future prospects of EDA in dentistry. The available literature suggests that EDA may be useful as an adjunct or alternative in selected minor procedures, especially in pediatric and behavior-management settings, but evidence remains heterogeneous and insufficient to support routine replacement of conventional local anesthesia across all operative indications.[1][2][3][4]**

Index Terms—**Electronic dental anesthesia; transcutaneous electrical nerve stimulation; TENS; pediatric dentistry; pain control; needle-free anesthesia**

I. INTRODUCTION

Pain control is fundamental to dental practice because anticipated pain and fear of injection can reduce patient cooperation, discourage attendance, and compromise completion of care. These issues are especially relevant in pediatric dentistry, where developmental stage, anxiety, and negative expectations can intensify procedural distress and make behavior guidance more difficult. Interest in minimally invasive and needle-free pain control methods has therefore persisted, particularly for procedures that cause mild to moderate discomfort or for patients who are unable or unwilling to tolerate conventional local anesthetic techniques.[10]
Electronic dental anesthesia (EDA) is a non-invasive, needle-free method of producing localized dental analgesia or anesthesia by applying controlled, low-intensity pulsed electrical currents through electrodes placed on the skin or oral tissues over the treatment area. In dentistry, EDA is essentially the clinical application of transcutaneous electrical nerve stimulation (TENS) for reducing pain during selected dental procedures.[25][26] However, this topic benefits from a more critical and clinically oriented review structure that distinguishes historical context from evidence-based application.[11][13][12][10]
This narrative review aims to synthesize the literature on EDA in dentistry with particular emphasis on pediatric use. The review discusses the historical evolution of dental pain control, the theoretical basis of EDA, current clinical indications, advantages and disadvantages, safety considerations, and future research needs. The goal is to provide a journal-style overview that is academically structured, clinically relevant, and suitable for adaptation to a dental clinical practice.[11][10]

II. HISTORICAL BACKGROUND

Electronic dental anesthesia (EDA) is a transcutaneous electrical nerve stimulation-based method used to reduce pain and anxiety during dental care.[18][19]

The mechanism is commonly explained by the gate-control theory of pain, in which stimulation of large nerve fibers can reduce transmission of painful impulses.[19][20]

In a 1994 pediatric study, children treated with EDA/TENS showed pain reduction comparable to 2% lignocaine, and patients were reported to be more comfortable with TENS.[21]

A 1999 study in children found that EDA reduced discomfort in restorative care, with no significant difference in success rate versus local anesthesia, and 53.6% of children preferred EDA for future treatment.[22]

Another clinical evaluation in pediatric dentistry reported favorable attitudes from both dentists and patients, suggesting safety and psychological benefits.[18]

However, the same body of evidence also shows limitations: a pediatric study reported EDA was less effective than local anesthesia for cavity preparation overall.[23] A later review of pediatric trials found variable results across studies, including some showing no significant difference and others showing lower effectiveness than local anesthesia.[24] The best-supported conclusion is that EDA may help as an adjunct for selected pediatric procedures, but it should not be treated as a full replacement for conventional local anesthesia.[23][24]

III. PHYSICAL PROPERTIES ELECTRONIC DENTAL ANESTHESIA (EDA)

Electronic dental anesthesia (EDA), transcutaneous electrical nerve stimulation (TENS)–style devices, and computer-controlled local anesthetic delivery (CCLAD) systems offer needle-averse pediatric patients non-- or less-invasive options by using low-power electrical pulses and controlled flow to reduce procedural pain. These systems are engineered for clinic practicality and child comfort: rechargeable lithium-ion batteries support portable handheld wands (approximately 15–25 cm length, 150–300 g) or compact tabletop units, permitting chairside mobility and rapid deployment in high-throughput pediatric clinics. Electrical architectures operate at safe low DC voltages (typically 3–12 V, well below 24 V), with internal converters and isolation to meet medical safety standards and prevent tissue injury.

Therapeutically, devices deliver intermittent pulse trains rather than continuous currents. Typical parameters span 2–150 Hz frequency and 50–300 µs pulse width, enabling clinicians to tailor stimulation to age, mucosal sensitivity, and procedure type. Amplitude usually starts at 0.1–0.5 mA for delicate intraoral sites and is capped by device safety circuitry (commonly 5–20 mA clinically, with absolute peaks kept below levels causing motor tetany). CCLAD systems complement electrical approaches by providing mechanically regulated injection flow (0.05–0.3 mL/min) and force limits (2–4 N), minimizing pressure pain during infiltration.

Electrode design and ergonomics are critical for pediatric use. Small intraoral tips (1–2 cm2, often gold-plated or stainless steel) or hydrogel-coated pads reduce contact impedance and improve comfort; current density is constrained to safe ranges (≈2–5 mA/cm2). Devices employ rugged, disinfectant-resistant housings (medical-grade ABS, IP54 or similar), intuitive controls or pediatric presets, and form factors that lessen patient anxiety (pen-style or pistol grips). Thermal management keeps surface temperatures near ambient (+2–5°C), avoiding mucosal heating during typical 10–20-minute sessions.

Safety features include galvanic isolation, leakage currents in the microampere range, impedance monitoring with auto-shutdown on fault, and compliance with IEC 60601 series norms for neuromuscular and TENS equipment. Connectivity options (Bluetooth, USB, Wi-Fi) enable data logging and firmware updates, supporting clinical audit and research tracking of stimulation parameters and outcomes.

Clinical reports indicate high acceptability and effectiveness in children, particularly when combined with topical anesthetics; CCLAD produces demonstrably reduced injection pain versus conventional syringes. While long-term adverse events are rare in published series, careful patient selection, adherence to manufacturer limits, and routine maintenance are essential.[27]

IV. MECHANISM OF ACTION

The principal theoretical basis of EDA is the modulation of nociceptive transmission through electrical stimulation of peripheral nerves. In practical terms, TENS delivers low-voltage electrical impulses through electrodes placed on the skin or, in some systems, in proximity to oral tissues, with the aim of reducing pain perception during treatment. This anesthetic process through gate control theory, according to which activation of large-diameter afferent fibers may inhibit transmission of pain signals carried by smaller nociceptive fibers at the spinal or trigeminal level.[1]

Additional mechanisms have also been proposed, including release of endogenous opioids, central modulation of pain pathways, distraction effects, and improved patient sense of control during treatment. The TENS technique for electrical nerve stimulation has been used not only for analgesia but also for conditions such as temporomandibular disorders and xerostomia-related applications, implying that its clinical effects may extend beyond a simple one-pathway model. Even so, the analgesic effect achieved during operative dentistry is variable and appears to depend on the procedure type, patient selection, device settings, and patient tolerance of the electrical stimulus.[1]

From a clinical perspective, the mechanism of EDA differs fundamentally from injectable local anesthesia. Conventional local anesthetics block sodium channels and interrupt nerve conduction directly, whereas EDA modifies pain signaling without producing profound pulpal anesthesia in the classical sense. This difference helps explain why EDA may be acceptable for some superficial or short procedures yet unreliable for procedures involving deeper dentin, pulp, or extensive tissue manipulation.[1]

Computer-Controlled and Alternative Local Anesthesia Delivery Systems in Dentistry: Devices, Mechanisms, and Clinical Applications [6][7]

Classification	Device / Manufacturer	Operational Mechanism	Clinical Applications	Primary Advantages
CCLAD	The Wand / Compu Dent (Milestone Scientific)	Microprocessor-controlled flow rates that keep fluid dynamics below the somatic threshold.	Palatal infiltrations, pdl injections, and routine regional blocks.	Eradicates tissue distension pain; enhances ergonomic tactile precision.
CCLAD	QuickSleeper 5 (Dental Hi-Tec)	Motorized cortical perforation combined with automated internal intraosseous delivery.	Direct bone-stratum anesthesia, pulpitis, and quadrant therapy.	Instantaneous pulpal numbness; prevents collateral lip/tongue paresthesia.
CCLAD	StarPen (Woodpecker)	Cordless motorized plunger propulsion utilizing uniform pressure feedback loops.	Inferior alveolar nerve blocks and localized submucosal infiltration.	Maximizes chairside mobility; features autonomous, reliable aspiration cycles.
TENS / EDA	J5 Dental Stimulator (Myotronics)	Low-frequency periodic microcurrents that disrupt nociceptive signaling via afferent gate control.	Myofascial pain tracking, MD therapy, and needle-free minor operative analgesia.	Completely non-invasive; mitigates muscle hypertonicity and anxiety.
Digital Sedation	Matrx Sedation Unit (Midmark)	Integrated electronic mass flow sensors regulating precise fractional gas combinations.	Moderate conscious sedation for pediatric or highly phobic patients.	Real-time digital telemetry; instant hypoxic guard fail-safes.

Newer Techniques:

Comparative overview: SOAN, Smart Inject Pro, and StarPen for intraosseous injection

Feature	SOAN (Dentalhitec / NuSmile)	Smart Inject Pro (DDI)	StarPen (Woodpecker)
Device concept	Wireless electronic injection pen designed to replace the manual syringe, with special emphasis on pediatric comfort and intraosseous protocols. [1,2]	Wireless, pen-style computer-controlled anesthesia system with selectable speed gears and built-in aspiration for routine and 10 techniques.[3]	Cordless, algorithm-controlled anesthesia pen with multiple preset speeds and aspiration modes; marketed as an affordable, general-purpose electronic syringe.[4]
Main clinical focus	Pediatric and mixed-dentition cases; fast, localized anesthesia	General dental use including infiltration, blocks, PDL, and 10;	Broad use across infiltration, blocks, and 10; strong focus on

	with minimal collateral numbness; dedicated 10 workflows. [1,2]	emphasis on uniform low-pressure delivery and safety via aspiration.[3]	consistent, low-pain delivery through pressure-feedback algorithm.[4]
Handpiece design	Very compact, lightweight pen-grip; ergonomic "real pen" holds to improve precision and reduce patient anxiety. [1,2]	Lightweight cordless pen; simple one-button or minimal-button interface for easy operation.[5]	Pen-style, ~85 g; onboard LCD showing injection progress, speed, plunger position, and battery.[4]
Power & control	Rechargeable battery with charging base; Slow/Fast modes with adaptive flow based on tissue resistance; configurable light/sound indicators. [1,2]	Rechargeable battery with charging cradle; three speed gears (High, Low, PDL/IO); aspiration mode on/off.[5]	Rechargeable Li-ion battery with wireless charging base; High/Low ranges each with 3 sub-speeds (total 6 speeds); auto- or manual aspiration modes.[4]
Needles & cartridges	Uses proprietary Effitec (Fitech) needles (e.g., green 9 mm, white 16 mm, gray 35 mm) with marked "D" orientation; standard dental cartridges. [2,6]	Uses standard dental needles and standard 1.8 mL cartridges; no proprietary consumables in most setups.[5]	Uses standard dental needles and standard 1.8 cc cartridges; no proprietary needles/cartridges.[4]
Cartridge holder / sterilization	Single-use proprietary needles; handpiece surface-disinfected; holders/needles handled per IFU (no full autoclave of handpiece). [2,7]	Cartridge holder/adapter designed for standard cartridges; holder typically autoclavable or disinfectable; handpiece surface-disinfected only. [5,7]	Multiple transparent cartridge holders supplied; holders autoclavable up to ~134 °C; handpiece surface-disinfected only.[7]
Intraosseous technique support	Dedicated 10 workflow with Slow mode, support-point pen grip, and tissue-resistance feedback; green 9 mm needle commonly used for pediatric 10. [1,2]	PDL/low-speed mode for 10; clinician performs cortical penetration with appropriate needle; device provides uniform low-pressure delivery into cancellous bone. [3,8]	Low-speed modes for 10; clinician positions needle (PDL/IO trajectory) and device deliver controlled, low-pressure anesthetic into medullary space.[4]
Aspiration	Not highlighted as a primary feature in most summaries; focus is on adaptive flow and controlled quantity. [2,9]	Built-in aspiration mode with blood reflux indication to reduce intravascular risk.[5]	Auto-aspiration and manual one-button aspiration modes available.[4]
Speed control granularity	Two main modes (Slow, Fast) with real-time adaptive adjustment according to tissue resistance; clinician pre-selects volume.[2]	Three fixed gears (High, Low, PDL/IO) to match tissue density and technique.[5]	Six discrete speeds (3 in High, 3 in Low) plus aspiration options; fine-tuning for different tissues and patient types.[4]
Typical clinical advantages described	Very child-friendly design and workflow. - Minimal collateral numbness with 1O. - Immediate treatment start, reduced chair time. [1,2]	- Uniform, low-pressure injection for comfort. - Aspiration adds safety for 10 and deep blocks. - Simple, quick setup with standard consumables.[3]	Consistent, algorithm-regulated flow reduces pain spikes. - Multiple speeds allow customization for different tissues and patients. - No proprietary needles/cartridges lower running cost.[4]
Key limitations / considerations	Proprietary needles may increase consumable cost and limit flexibility. - Requires specific training for 10 and device protocols. [1,2]	- Fewer speed options than some competitors; less granular control. - Limited publicly available detailed IFU compared with larger systems.[3]	More complex interface with multiple speeds may need a short learning curve. - Multiple cartridge holders must be tracked and sterilized correctly. [4,8]
Best suited for	Pediatric-focused practices and clinicians who want a dedicated 10-oriented, child-friendly system with minimal collateral anesthesia.[2]	General practices seeking a straightforward, wireless computer-controlled system with aspiration and standard consumables for routine and 1O work.[3]	Practices wanting fine speed control, real-time feedback, and low running costs with standard cartridges/ needles across a wide range of techniques.[4]

Pictures			

V. SELECTION SHOULD BE GUIDED BY THE CLINICAL CONTEXT.

EDA Device selection should be based on the child's age, treatment needs, clinician experience, and the type of injection planned. Algorithm-controlled anesthesia pen (StarPen) may be appropriate when the clinician wants greater control over injection speed, aspiration, and pressure feedback while using commonly available cartridges and needles.

Pen-style computer-controlled anesthesia (Smart Inject Pro) can be considered for routine pediatric injections when a straightforward, easy-to-operate electronic syringe is preferred, although its role in dedicated intraosseous procedures may be more limited. When pediatric comfort and intraosseous anesthesia are the main priorities,Wireless electronic injection pen (SOAN) may be the most suitable choice because it provides a child-oriented workflow and specialized features intended to support controlled anesthesia while minimizing unnecessary soft-tissue numbness.Final selection should also consider device availability, consumable costs, maintenance requirements, operator training, and the manufacturer's instructions for use.

VI. CLINICAL APPLICATIONS IN DENTISTRY

The most frequently discussed role of EDA in dentistry is as a supportive method for minor operative and preventive procedures. According to the source document, EDA has been described for restorations, prophylaxis-related procedures, soft-tissue procedures, orthodontic adjustments, and selected pediatric interventions where fear of the needle is itself a major barrier to care. These indications are clinically plausible because such procedures may involve limited discomfort that can be reduced through behavioral support combined with electrical pain modulation rather than complete pharmacologic anesthesia.[1] TENS in dentistry also presents dental applications beyond operative pain control, including temporomandibular disorder management, salivary stimulation, and muscle-related indications, which suggests that dental electrical stimulation technologies have broader uses than chairside analgesia alone. Nevertheless, when the present topic is framed as "electronic dental anesthesia," the most relevant question for a review article is whether the technique can provide clinically sufficient analgesia for routine dental procedures. On that point, the literature remains mixed and appears strongest for adjunctive rather than replacement use.[1]

In routine clinical practice, EDA may be best viewed as one component of a multimodal strategy. It can potentially complement tell-show-do, distraction, behavior shaping, topical anesthetics, or reduced-volume conventional anesthesia in carefully selected patients. Such a role is especially relevant in pediatric dentistry, where reducing the emotional burden of treatment can be as important as reducing nociceptive input.[1]

VII. PEDIATRIC DENTISTRY RELEVANCE

Children with injection anxiety show many distress behaviours. These increase when the needle is shown and during local anaesthetic delivery. Anticipatory fear appears as verbal protest, crying, or pleading. Children often try to delay treatment. They may cling to a parent or turn their head away. Some refuse to open their mouth. Others push the dentist's hand away.

During needle insertion, crying commonly increases. Facial grimacing and eye squeezing are frequent. Arm, leg, and torso movements often rise. These movements reflect acute pain-related distress. Children with behavioural challenges show stronger reactions. High-anxiety children display more disruptive behaviour. They have more pain-related movements and greater overall distress than low-anxiety peers.
Responses range from withdrawal to overt negativism. Forceful crying and refusal of anaesthesia can occur. These behaviours are well documented. Researchers use them as outcome measures in studies.[15][16][17]
EDA has particular appeal in pediatric dentistry because children commonly fear injections, show fluctuating tolerance to invasive procedures, and may react strongly to the sensation of prolonged soft-tissue numbness after local anesthesia. EDA is attractive in needle-phobic children and in minor procedures where avoidance of postoperative lip or cheek biting is desirable. These features align well with pediatric behavior-management goals, especially for cooperative children undergoing brief restorative care.[28]

VIII. ADVANTAGES OF EDA

Needle-free application: EDA delivers transcutaneous electrical stimulation through electrodes and does not require needle penetration. This makes it a potentially useful option for children who fear injections.[29]

Reduced anticipatory anxiety: Avoiding the syringe may reduce the visual and procedural trigger associated with injection fear. However, pediatric studies directly proving a consistent reduction in anticipatory anxiety are limited. Therefore, this should be described as a possible benefit rather than a confirmed effect.[1][6]

No pharmacological exposure: EDA provides analgesia through electrical stimulation and does not require injected local-anesthetic solution. This may be useful when avoiding pharmacological exposure is clinically desirable. However, EDA should not be assumed to eliminate all risks or contraindications.[13][29]

Rapid recovery: Unlike injectable local anesthesia, the numbness produced by EDA is reported to disappear when the unit is switched off. This avoids the prolonged paraesthesia commonly associated with local anesthetic injections.[13]

Lower risk of soft-tissue injury: Reduced postoperative numbness may theoretically decrease accidental lip, cheek, or tongue biting in young children. However, direct pediatric trials demonstrating fewer soft-tissue injuries after EDA are lacking. This claim should therefore be stated cautiously.[30]

Improved child acceptance: A pediatric clinical study reported favourable attitudes toward EDA among children and dentists. Another pediatric study found that EDA reduced discomfort according to behavioural observations and children’s self-reports. These findings support acceptability in selected children but do not prove superiority over local anesthesia.[11]

Potential parental acceptance: A needle-free method and absence of prolonged numbness may be attractive to parents. Nevertheless, direct evidence measuring parental acceptance of EDA is insufficient. This should be described as a plausible clinical advantage, not an established outcome.

Behavioural support: EDA may reduce the threatening appearance of treatment by replacing the syringe with an electrode-based device. One pediatric study described psychological advantages and favourable patient attitudes. However, evidence that EDA independently improves behaviour is limited.[11]

Support for minimally invasive care: EDA may be useful during selected restorative procedures, particularly when cavity preparation is limited. Clinical research has reported benefit during some restorative treatments, but effectiveness decreases when procedures become deeper or more invasive.[11][31][13]

Adaptability of TENS: EDA is based on TENS, a technique with established analgesic applications. However, its use in dentistry requires appropriate patient selection, correct electrode placement, suitable settings, and monitoring. It is contraindicated or unsuitable in some patients, including those with certain implanted electrical devices and those unable to cooperate adequately.[1][29]

IX. CLINICAL IMPORTANCE

Useful for selected patients: EDA may be considered for cooperative, needle-phobic children and those with previous unpleasant injection experiences. It requires sufficient communication and cooperation because the child must tolerate and report the electrical sensation.[29]

Suitable procedures: Evidence supports its consideration mainly for brief, shallow, or minimally invasive restorative procedures. One study found EDA less effective than conventional local anesthesia during cavity preparation, particularly in permanent teeth, demonstrating that procedure depth is important.[13]

Patient-centred care: EDA allows the clinician to consider the child's anxiety, maturity, sensory tolerance, communication skills, and treatment needs. This is clinically reasonable, but direct trials validating each of these patient-selection factors are limited.

Improved treatment initiation: The absence of a needle may make treatment initiation easier for some children. Current evidence supports this as a potential behavioural benefit, but does not establish that EDA consistently increases mouth opening or treatment commencement.[11]

Preservation of trust: If adequate analgesia is achieved without pain, the child may experience the dental visit more positively. However, direct evidence showing improved long-term dental trust or future cooperation after EDA is not yet sufficient.

Operator-dependent success: EDA requires correct device operation, electrode placement, gradual adjustment of intensity, and continuous assessment of the child's response. The need for cooperation and technical familiarity is emphasized in clinical discussions of EDA.[29]

Need for careful case selection: EDA should not be selected when profound and predictable anesthesia is essential. Evidence showing lower effectiveness during cavity preparation supports restricting its use to appropriate cases.[13]
Risk of failed treatment: If EDA does not provide adequate analgesia, the child may experience pain and the procedure may be interrupted. Such failure may reduce confidence in both the technique and the dental team; however, this consequence has not been consistently quantified in pediatric trials.

Not a universal replacement: Conventional local anesthesia remains necessary for procedures such as deep caries treatment, pulpal therapy, extractions, and other invasive procedures requiring reliable profound anesthesia. The variable success of EDA supports this limitation.[31][13]

Evidence-based interpretation: EDA should be described as a selective, needle-free analgesic adjunct or alternative for appropriately chosen pediatric cases. Existing studies show potential benefits in discomfort reduction and acceptability, but the evidence is not sufficiently consistent to support universal use.[31][11][13]

X. LIMITATIONS AND CONTRAINDICATIONS

- Inconsistent depth of analgesia: EDA may not provide a predictable depth of analgesia.
- Limited pulpal anesthesia: Unlike injectable local anesthesia, EDA does not reliably produce profound pulpal anesthesia.
- Inadequate for deep caries removal: Its analgesic effect may be insufficient during the removal of deep carious lesions.
- Limited role in pulp therapy: Procedures such as pulpotomy and pulpectomy may require deeper and more reliable anesthesia.
- Unsuitable for forceful extractions: EDA may not provide adequate analgesia for extractions involving considerable pressure or force.
- Limited effectiveness during tissue trauma: Procedures involving extensive soft-tissue manipulation may exceed the analgesic capacity of EDA.
- Variable patient response: Children and adults may perceive electrical stimulation differently.
- Possible unpleasant sensations: Tingling or electrical stimulation may be uncomfortable, distracting, or anxiety-provoking for some patients.
- Influence of electrode placement: Incorrect or inconsistent placement may reduce the effectiveness of EDA.

- Effect of current settings: Inappropriate intensity or frequency settings can affect analgesic outcomes.
- Operator dependence: The clinician's familiarity with the device may influence treatment success.
- Effect of patient expectations: Anxiety, cooperation, and expectations may alter the perceived effectiveness of EDA.
- Difficulty in standardization: Differences in patient response, device settings, electrode placement, and clinical technique make comparison between studies difficult.
- Need for medical screening: Patients should be assessed for relevant medical conditions before EDA is used.
- Pacemaker precautions: EDA may be unsuitable or require specialist consultation in patients with pacemakers or other implanted electronic devices.
- Neurological conditions: Caution may be necessary in patients with certain neurological disorders.
- Need for informed consent: The clinician should explain the expected sensations, possible limitations, and alternative anesthetic options.
- Risk of treatment failure: Inadequate analgesia may cause pain, distress, or interruption of treatment.
- Requirement for careful case selection: EDA should be used mainly in appropriately selected patients and procedures.
- Not universally benign: EDA should not be described as risk-free or suitable for every pediatric patient.
- Selective clinical role: EDA is best considered an adjunct or alternative for selected indications.
- Conventional anesthesia remains important: Injectable local anesthesia is still preferred when profound and predictable anesthesia is required.

XI. EVIDENCE APPRAISAL

Sr no.	Author	Title of study	Conclusion
1.	Munshi, A. K., Hegde, A. M., and Girdhar, D. in 2000	the clinical evaluation of electronic dental anesthesia for various procedures in pediatric dentistry	electronic dental anesthesia may be useful as an adjunct for selected pediatric procedures, but it should not be considered a full replacement for conventional local anesthesia.
2.	Esposito, C. J., Shay, J. S., and Morgan, B. in 1993	electronic dental anesthesia in a pilot study	technique was noninvasive and potentially effective for reducing pain perception during dental treatment.
3.	McKinnon, M., and colleagues in 1995	electronic dental anesthesia for control of pain caused by local anesthetic injection	may help reduce injection-related discomfort in mildly to moderately apprehensive patients, although the effect was not uniform across all clinical situations.
4.	A Cochrane protocol published in 2018	electronic dental anaesthesia for managing pain during dental anaesthesia	the evidence base remained insufficient and required further well-designed clinical trials before routine clinical recommendation.
5.	França AJB, Barbirato DDS, Vasconcellos RJH, Pellizzer EP, Moraes SLD, Vasconcelos BCDE.	Do Computerized Delivery Systems Promote Less Pain and Anxiety Compared to Traditional Local Anesthesia in Dental Procedures? A Systematic Review of the Literature.	computerized dental anesthesia devices tend to reduce pain and anxiety compared with traditional syringe techniques, but conventional local anesthesia remains necessary for procedures requiring deep analgesia.

XII. FUTURE DIRECTIONS

Future research on EDA should focus on well-designed clinical trials that distinguish between preventive, restorative, soft-tissue, and pulpal procedures. Studies should report patient age, behavior status, treatment complexity, device parameters, need for rescue anesthesia, and both patient-reported and operator-reported outcomes so that indications can be defined more precisely. This is especially important in pediatric dentistry, where procedural tolerance and anxiety reduction may be as clinically meaningful as pain scores alone.[4][2][1]

There is also scope for examining EDA within multimodal care pathways rather than as a stand-alone competitor to injection anesthesia. Combining EDA with behavioral guidance, topical anesthetics, audiovisual distraction, or minimally invasive treatment protocols may better reflect real clinical practice and produce more useful evidence for pediatric operators. In addition, future device development may improve electrode design, comfort, adjustability, and chairside integration, which could enhance acceptance and reproducibility.[1]

EDA should be interpreted neither as a failed replacement for conventional local anaesthesia nor as a universally superior alternative. Current evidence supports its role as a selective neuromodulatory adjunct with potential niche value in dentistry. Particularly for needle-phobic or cooperative patients undergoing minor and minimally invasive procedures. Although pediatric studies have reported favourable acceptance and reduced discomfort, its effectiveness remains variable. And is influenced by the procedure, patient characteristics, device settings, and operator experience. Therefore, EDA should be used selectively. With conventional injectable anaesthesia retained for procedures requiring profound and predictable pulpal or surgical analgesia.[4][2]

XIII. CONCLUSION

Electronic dental anesthesia (EDA) is an appealing approach because it addresses two major challenges in dentistry: procedural pain and injection-related fear. EDA as a non-invasive, patient-friendly technique with particular potential in pediatric dentistry and in clinical situations where behavioural cooperation is important. At present, EDA should be considered a selective adjunct or alternative rather than a complete replacement for conventional local anesthesia. Its greatest clinical value may be in carefully selected minor procedures, cooperative or needle-phobic patients, and multimodal pain-management protocols. However, its limitations remain important during deep caries treatment, pulp therapy, extractions, and other invasive procedures requiring profound and predictable anesthesia.

It may be clinically useful in selected situations and represents an important development in the evolution of dental pain-control strategies. Nevertheless, further well-designed randomized clinical trials are required before routine or broader recommendations can be justified.[2][4][1]

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