ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

Articaine in Dentistry: A New Age of Local Anaesthesia —A Narrative Revie

Dr. Althaaf Khan
BDS (SMU), AssocFCGDent (UK)
Private Practice, South Africa

Corresponding author

Abstract
Articaine hydrochloride has, over the past two decades, become one of the most widely used local anaesthetics in dentistry, distinguished from other amide agents by an additional thiophene ring and an ester side chain that confer enhanced lipid solubility and rapid hepatic and plasma hydrolysis. This narrative review synthesises current evidence on the pharmacology, clinical efficacy, safety profile and emerging delivery technologies associated with articaine, with the aim of clarifying its role as a "new generation" dental anaesthetic. A structured search of PubMed, Scopus and Google Scholar was used to identify systematic reviews, meta-analyses, randomised controlled trials and regulatory documentation published predominantly within the last two decades. Articaine demonstrates a rapid onset of action, superior diffusion through cortical and cancellous bone, and higher anaesthetic success rates than lidocaine for maxillary infiltration and as a supplemental buccal infiltration following failed inferior alveolar nerve block. For primary inferior alveolar nerve block, however, articaine does not show consistent superiority over lidocaine or mepivacaine, particularly in the presence of pulpal inflammation. Its short plasma half-life and rapid metabolism contribute to a favourable systemic toxicity profile, while chairside buffering and computer-controlled delivery systems have further reduced injection pain and shortened onset time. Concerns regarding a possible association between 4% articaine and paraesthesia following inferior alveolar nerve block remain unresolved by high-quality evidence, and caution is advised for block techniques involving direct nerve contact. Articaine's efficacy and acceptable safety profile support its continued and expanding use across general, paediatric, and geriatric dental practice, while future research should prioritise dose-finding studies, pharmacogenomic factors, and prospective safety surveillance in vulnerable populations.

Keywords
Articaine; Local Anaesthesia; Dentistry; Inferior Alveolar Nerve Block; Buffered Anaesthetics; Paraesthesia

1. Introduction

Effective control of intraoperative pain remains the cornerstone of patient acceptance and cooperation in dentistry, and the choice of local anaesthetic agent directly influences both the success of a procedure and the patient's overall experience of care[1]. Since its introduction into clinical practice, lidocaine has served as the reference standard against which newer amide anaesthetics are measured[2]. Articaine, first synthesised in 1969 under the name carticaine and later renamed articaine in 1984, was developed specifically to address the limitations of earlier amide agents, particularly their comparatively poor diffusion through bone[1]. The molecule is unique among clinically used amide local anaesthetics in possessing a thiophene ring in place of the conventional benzene ring, together

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

with an additional ester side chain that permits partial metabolism by plasma esterases rather than reliance on hepatic microsomal pathways alone[1,3]. This hybrid amide–ester structure is widely regarded as the pharmacological basis for articaine's short plasma half-life, rapid onset, and favourable systemic safety profile[1,4].

Regulatory approval of 4% articaine with epinephrine followed a gradual international trajectory: clinical use began in Germany in the early 1970s, followed by adoption in Canada in 1984, and the United States Food and Drug Administration approved a 4% articaine and 1:100,000 epinephrine formulation for dental use in 2000, with the 1:200,000 formulation approved in 2006[1]. Articaine is now among the most frequently used dental local anaesthetics worldwide, reportedly used by the majority of dental practitioners in several European countries and forming the anaesthetic of choice in Canada and much of continental Europe, while remaining the second most commonly used agent after lidocaine in the United States[1]. This rapid uptake, together with continuing innovation in buffering technology and computer-controlled delivery systems, has prompted its description in the literature as heralding a "new generation" of dental local anaesthesia[1].

Despite this popularity, several questions continue to generate debate among clinicians: whether articaine offers a genuine clinical advantage over lidocaine and mepivacaine for inferior alveolar nerve block (IANB) as opposed to infiltration techniques; whether the reported association between 4% anaesthetic solutions and postoperative paraesthesia reflects a true neurotoxic effect or a statistical artefact of increased overall usage; and how articaine should be used in specific populations such as children, pregnant patients, and the elderly[5,6]. The objective of this narrative review is to synthesise the current pharmacological, clinical and safety evidence relating to articaine in dentistry, to critically appraise its purported advantages over established agents, and to outline emerging delivery technologies that are shaping its contemporary clinical application.

2. Materials and Methods

This is a narrative review and did not require ethical approval or informed consent, as no original human or animal data were generated or accessed. A structured literature search was conducted in PubMed, Scopus, Google Scholar and the Cochrane Central Register of Controlled Trials for articles published predominantly between 2000 and 2026, using the search terms "articaine" combined with "dentistry," "local anaesthesia," "lidocaine," "mepivacaine," "inferior alveolar nerve block," "paraesthesia," "buffered anaesthesia," and "computer-controlled delivery." Priority was given to systematic reviews, meta-analyses of randomised controlled trials, and regulatory prescribing information, supplemented by individual randomised controlled trials addressing questions not covered by existing syntheses[1,2,5,6,7]. Reference lists of identified reviews were hand-searched for additional relevant primary studies. Articles not available in English, case reports without comparative data, and non-peer-reviewed sources were excluded other than for historical or regulatory context. Given the narrative design, no formal risk-of-bias scoring or meta-analytic pooling was undertaken by the author; where quantitative pooled estimates are cited, these are drawn directly from the source systematic reviews and meta-analyses referenced.

3. Results and Discussion

3.1 Pharmacology and Mechanism of Action

Like other local anaesthetics, articaine acts by reversibly binding voltage-gated sodium channels on the intracellular aspect of the neuronal membrane, stabilising the channel in an inactive state and preventing the influx of sodium ions required for the generation and propagation of an action potential[3]. Because smaller, unmyelinated nerve fibres subserving pain and temperature are generally blocked before larger fibres responsible for proprioception and motor function, patients characteristically retain a sensation of pressure or touch even once profound pulpal anaesthesia has been achieved[3]. What differentiates articaine from lidocaine, mepivacaine, prilocaine and bupivacaine is its molecular structure: articaine is the only amide local anaesthetic in routine clinical use that contains a thiophene ring rather than a benzene ring, together with a carboxylic ester side chain[1,3]. This additional ester linkage allows a substantial proportion of an administered dose to be hydrolysed by non-specific plasma esterases into the inactive metabolite articainic acid, in parallel with hepatic microsomal metabolism[3]. The result is a plasma half-life of approximately 20–30 minutes, shorter

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

than that of lidocaine, which is thought to underlie articaine's comparatively low potential for systemic accumulation and toxicity even with repeated dosing[1,3]. The greater lipid solubility conferred by the thiophene ring is also proposed to enhance diffusion through cortical and cancellous bone, a property with direct clinical relevance to infiltration anaesthesia in the mandible[1].

3.2 Comparative Anaesthetic Efficacy

The clinical literature comparing articaine with lidocaine and mepivacaine is extensive but heterogeneous, and the balance of evidence differs considerably according to injection technique and anatomical location. For maxillary infiltration anaesthesia, systematic review and meta-analysis have consistently shown articaine to achieve a higher likelihood of anaesthetic success than 2% lidocaine, a finding reproduced across subgroup analyses by tooth type and by the presence or absence of pulpal inflammation[6]. For mandibular buccal infiltration, articaine similarly outperforms lidocaine, an effect attributed to its superior bone penetration[1,7]. Notably, articaine buccal infiltration has also been reported to be at least comparable to, and in some paediatric studies more effective and better tolerated than, a conventional lidocaine inferior alveolar nerve block for extraction of mandibular primary molars, raising the possibility of infiltration-only techniques in selected paediatric cases[1].

The picture for primary IANB is less clear-cut. A 2024 systematic review and meta-analysis of five randomised controlled trials (568 patients) comparing articaine with mepivacaine for IANB in teeth with symptomatic irreversible pulpitis found no statistically significant difference in anaesthetic success rate between the two agents (57.4% for articaine versus 52.8% for mepivacaine), although articaine was associated with a modest but statistically significant reduction in reported pain intensity[5]. A more recent umbrella review of twenty-five systematic reviews similarly concluded that articaine does not demonstrate consistent superiority over lidocaine or mepivacaine for IANB, particularly in the presence of pulpal inflammation, although it significantly improves anaesthetic success when used as a supplemental buccal infiltration following a failed block, and as a primary infiltration technique in the posterior mandible, thereby reducing the need for reinjection[7]. This pattern is consistent with the recognised failure rate of IANB in general, which has been estimated in some series to range as high as 30–90% in the presence of irreversible pulpitis regardless of the anaesthetic agent selected, reflecting anatomical variability and the influence of inflamed tissue on nerve fibre excitability rather than a deficiency specific to any one drug[5]. Taken together, the evidence supports a technique-specific rather than a universal advantage for articaine: its principal clinical value lies in infiltration anaesthesia and supplemental infiltration, rather than as a replacement for lidocaine or mepivacaine in primary mandibular block anaesthesia.

In oral and maxillofacial surgical procedures, including third molar extraction, articaine has been reported to demonstrate a faster onset of action with a duration of anaesthesia comparable to that of lidocaine, and a systematic review and meta-analysis specific to mandibular third-molar extraction confirmed acceptable efficacy and safety for this indication[4,7].

3.3 Systemic Safety and the Question of Paraesthesia

Overall adverse event rates for articaine are comparable to those of other amide local anaesthetics, and its rapid plasma hydrolysis is generally regarded as protective against dose-related systemic toxicity when maximum recommended doses are respected[1,3]. United States prescribing information for articaine hydrochloride with epinephrine specifies a maximum recommended dose of 7 mg/kg of articaine in healthy adults and in paediatric patients aged 4 to 16 years, equivalent to 0.175 mL/kg of either the 1:100,000 or 1:200,000 epinephrine formulation, with an absolute ceiling generally accepted at approximately 500 mg (7 mg/kg) for a healthy adult of average body weight; safety and efficacy in children below the age of four years have not been formally established in the United States labelling, although European regulatory documentation and subsequent equivalence trials have supported cautious use from four years of age with a similarly calculated maximum dose[8,9,10]. Dose reduction is recommended in debilitated, acutely unwell, hepatically impaired, or elderly patients, reflecting the drug's dependence on adequate plasma esterase activity and, to a lesser extent, hepatic metabolism[8].

The most persistent safety concern specific to articaine relates to case reports and retrospective cohort data suggesting a disproportionate association between 4% local anaesthetic solutions, most

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

commonly articaine and prilocaine, and postoperative paraesthesia of the inferior alveolar or lingual nerve following IANB. A mini systematic review identified seven relevant studies, comprising one double-blind randomised controlled trial and six retrospective cohort studies; the randomised trial and two cohort studies found no greater risk of nerve damage with 4% articaine compared with 2% lidocaine, whereas the remaining four cohort studies recommended caution with 4% solutions, without being able to establish a mechanistic explanation for their findings[9]. The authors concluded that the literature does not provide conclusive evidence that articaine causes more nerve damage than lidocaine, while nonetheless recommending caution pending higher-quality prospective research[9]. Subsequent correspondence on this review noted that, because articaine offers no consistent efficacy advantage over lidocaine specifically for IANB, the marginal and unproven risk of nerve injury may argue against its routine use for this particular technique even though its infiltration performance remains superior[11]. More recent high-level evidence synthesis, incorporating a broader base of surgical and block studies, has reported adverse event rates similar across anaesthetics with no evidence of an increased risk of persistent paraesthesia attributable to articaine[7]. On balance, the association between articaine and paraesthesia remains statistically unresolved rather than disproven; concentration, injection technique, needle trauma, and anatomical proximity to the lingual nerve are all plausible confounders that have not been fully controlled for in the available cohort data, and prudent practice favours careful technique and, where clinically equivalent alternatives exist, selective rather than routine use of 4% solutions for direct block anaesthesia in the mandible.

Articaine is classified as pregnancy category C under the former FDA system, reflecting an absence of adequate controlled human studies rather than documented harm, and is generally reserved for emergency dental treatment during pregnancy after risk–benefit assessment[10]. Use in older adults appears comparably well tolerated to use in younger patients: clinical trial data cited in regulatory documentation show a lower requirement for supplemental injections among patients aged 65 years and older compared with younger adults, without an excess of adverse events[8].

3.4 Buffering and the Chemistry of Onset

Commercial local anaesthetic cartridges are formulated at an acidic pH, both to maintain drug stability and, where a vasoconstrictor is included, to stabilise the accompanying sulfite antioxidant; this acidity slows the conversion of the anaesthetic to its lipid-soluble, membrane-permeant unionised form and is thought to contribute to the burning sensation frequently reported on injection[10]. Chairside buffering with sodium bicarbonate raises the pH of the solution immediately before injection, increasing the proportion of unionised drug available to cross the neuronal membrane. A randomised, double-blind, split-mouth study of fifty adult participants undergoing maxillary third molar extraction found that buffered 4% articaine significantly reduced both injection pain and postoperative pain compared with non-buffered articaine, while also producing a significantly faster onset of anaesthesia (mean 85.9 versus 126.9 seconds) and a longer duration of action (mean 70.4 versus 51.4 minutes)[12]. Similar findings have been reported for buffered articaine used as buccal infiltration in patients with symptomatic irreversible pulpitis, where buffering halved the mean onset time from 60 to 30 seconds and eliminated the burning sensation associated with injection[13]. While buffering has long been established for lidocaine, its adoption for articaine has historically been constrained by the practical difficulty of introducing a buffering agent into a pre-filled dental cartridge; purpose-designed delivery systems incorporating separate chambers for the buffering agent and the anaesthetic solution have been developed specifically to simplify chairside buffering within standard dental workflow[10]. Taken together, the available randomised evidence indicates that buffering represents a low-cost, technically simple adjunct capable of meaningfully improving both patient comfort and clinical efficiency when used with articaine.

3.5 Computer-Controlled and Novel Delivery Systems

Computer-controlled local anaesthetic delivery systems (CCLADS) regulate the flow rate and pressure of anaesthetic solution electronically, in contrast to the variable manual pressure applied with a conventional syringe. A randomised controlled trial comparing CCLADS with a standard self-aspirating syringe and a conventional disposable syringe for restorative procedures found that onset of anaesthesia was significantly faster with CCLADS (mean 4.8 minutes) than with either the self-

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

aspirating (10.8 minutes) or conventional syringe (11.0 minutes) technique, that recovery from anaesthesia was also faster, and that patients receiving CCLADS reported no pain during administration compared with both syringe techniques[14]. CCLADS technology has been particularly well studied in combination with articaine for intraseptal and periodontal ligament anaesthesia, where a dose-finding study in 180 healthy volunteers demonstrated dose-dependent increases in anaesthetic success, onset and duration with escalating volumes of articaine and epinephrine, while cardiovascular parameters remained stable across all tested doses, supporting the cardiovascular safety of computer-controlled articaine delivery even at higher local doses[15]. These technologies are reported to be particularly well tolerated in paediatric and anxious adult patients, for whom the reduced injection pain and absence of visible syringe apparatus may improve behavioural cooperation[14].

3.6 Articaine in Special Populations

In paediatric dentistry, articaine buccal infiltration has been shown to be an effective alternative to conventional IANB for extraction of mandibular primary molars, with several trials reporting equivalent or superior success alongside improved behavioural acceptance, likely reflecting the avoidance of a technically more challenging block injection in a smaller and less cooperative patient[1]. United States labelling withholds a formal safety and efficacy determination below four years of age, while European regulatory data and dedicated equivalence trials have supported cautious use from four years with weight-based dosing[8,9,10]. In geriatric patients, the available clinical trial data summarised in regulatory documentation indicate that articaine is at least as well tolerated as in younger adults, with a numerically lower requirement for supplemental injection[8]. Dose reduction remains appropriate in patients with significant hepatic impairment, given articaine's dependence on adequate esterase and hepatic microsomal activity for clearance, although the drug's dual metabolic pathway is generally considered to confer a theoretical advantage over purely hepatically cleared agents in patients with mild to moderate hepatic dysfunction[3,8].

3.7 Synthesis: Is Articaine a “New Age” of Dental Anaesthesia?

The cumulative evidence supports the characterisation of articaine as a genuine pharmacological and clinical advance over earlier amide anaesthetics for a defined set of indications, principally infiltration anaesthesia in both arches and supplemental infiltration following block failure, rather than as a universally superior replacement for lidocaine or mepivacaine across all techniques[1,5,6,7]. Its favourable systemic safety profile, driven by rapid plasma hydrolysis, is well supported, whereas the specific question of a possible association with paraesthesia following IANB remains an area of genuine clinical uncertainty rather than settled fact[7,9,11]. The convergence of articaine's pharmacological properties with buffering technology and computer-controlled delivery systems represents the more unambiguous “new age” dimension of the field: each of these adjuncts independently improves onset time, patient comfort, or clinical predictability, and their combination with articaine appears additive rather than merely incremental[12,13,14,15]. Clinicians should therefore select articaine on a technique-specific basis, informed by anatomical site, patient age, and the presence of pulpal inflammation, rather than adopting it as a default replacement for all local anaesthetic requirements.

4. Conclusion

Articaine's distinctive thiophene-ring, ester-containing structure confers rapid onset, superior bone diffusion and a short plasma half-life that together underpin its favourable efficacy and systemic safety profile in dentistry. The evidence base most strongly supports its use for maxillary and mandibular buccal infiltration and as a supplemental infiltration following failed inferior alveolar nerve block, while its advantage over lidocaine and mepivacaine for primary mandibular block anaesthesia is less consistent, particularly in the presence of pulpal inflammation. The unresolved question of a possible link between 4% articaine and postoperative paraesthesia warrants continued caution with direct block techniques and further prospective research. Chairside buffering and computer-controlled delivery systems represent complementary innovations that meaningfully enhance patient comfort and clinical efficiency when combined with articaine, and together with

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

articaine's expanding role across paediatric and geriatric populations, support its designation as a central component of the current era of dental local anaesthesia.

Acknowledgements
The author declares no acknowledgements beyond those normally due to the authors of the primary and secondary sources cited in this review.

Funding Statement
This review received no specific grant or funding from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest
The author declares no financial, professional, institutional or personal conflicts of interest related to the content of this review.

References
1. Luo W, Zheng K, Kuang H, Li Z, Wang J, Mei J. The potential of articaine as new generation of local anesthesia in dental clinics: a review. Medicine (Baltimore). 2022;101(48):e32089.
2. Rodrigues GA, Bronzato JD. A narrative review on local anesthetics in dentistry: mechanism of action, characteristics, and clinical considerations. J Oral Maxillofac Anesth. 2025.
3. Mathison M, Pepper T. Local anesthesia techniques in dentistry and oral surgery. Treasure Island (FL): StatPearls Publishing; 2022 [updated 2025 Jan 23; cited 2026 Sep 15]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK610935/
4. DrugBank Online. Articaine: uses, interactions, mechanism of action [Internet]. Wishart Research Group; [cited 2026 Sep 15]. Available from: https://go.drugbank.com/drugs/DB09009
5. Alkandari M, Alshammari M, Ghaleb A, Alshammari T, Alenezi R, Almutairi S. Articaine versus mepivacaine in inferior alveolar nerve block for patients with irreversible pulpitis: a systematic review and meta-analysis of randomized controlled trials. Cureus. 2024;16(11):e73360.
6. Kämmerer PW, Palarie V, Daubländer M. Articaine in dentistry: an overview of the evidence and meta-analysis of the latest randomised controlled trials on articaine safety and efficacy compared to lidocaine for routine dental treatment. BDJ Open. 2021;7:26.
7. Articaine in oral and maxillofacial anesthesia: what does high-level evidence reveal about nerve block and infiltration strategies? [Internet]. PubMed; 2025 [cited 2026 Sep 15]. Available from: https://pubmed.ncbi.nlm.nih.gov/42150609/
8. Prescribing information: articaine hydrochloride and epinephrine injection [Internet]. Pfizer Labeling; [cited 2026 Sep 15]. Available from: https://labeling.pfizer.com/ShowLabeling.aspx?id=4345
9. Stirrup P, Crean S. Does articaine, rather than lidocaine, increase the risk of nerve damage when administered for inferior alveolar nerve blocks in patients undergoing local anaesthesia for dental treatment? A mini systematic review of the literature. Br Dent J. 2019;226(3):213–223.
10. Health Products Regulatory Authority (Ireland). Septanest with adrenaline 1:100,000, solution for injection: summary of product characteristics, licence PA0196/017/002 [Internet]. 2022 Oct 28 [cited 2026 Sep 15]. Available from: https://assets.hpra.ie/products/Human/37247/Licence_PA0196-017-002_28102022125200.pdf
11. Currie C, Corbett I. Why take the risk? [correspondence]. Br Dent J. 2019;226:541.
12. Buffered 4% articaine reduces pain and enhances anesthesia in maxillary third molar extractions: a randomized, double-blind split-mouth study. J Clin Med. 2024 [cited 2026 Sep 15]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11673001/
13. Langade DG, et al. Buffered articaine in symptomatic irreversible pulpitis: a randomized controlled trial. Cited in: Buffered local anesthesia may be a game changer [Internet]. DrBicuspid.com; [cited 2026 Sep 15]. Available from: https://www.drbicuspid.com/dental-specialties/orofacial-pain/anesthesia/article/15822865/buffered-local-anesthesia-may-be-a-game-changer

ISSN:2584-2706 DOI: https://doi.org/10.67317/IJMSRT26SEP080

14. Assessment of computer-controlled local anesthetic delivery system for pain control during restorative procedures: a randomized controlled trial. J Conserv Dent. 2020 [cited 2026 Sep 15]. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7072086/
15. Efficacy and safety of intraseptal and periodontal ligament anesthesia achieved by computer-controlled articaine + epinephrine delivery: a dose-finding study. Clin Oral Investig. 2012;16(4):1101–8.