KEY WORDS
Local anaesthesia, inferior dental block, dental infiltration, articaine, lidocaine

LEARNING OBJECTIVES
- To challenge the assumption that inferior dental blocks are the "go to" local anaesthesia (LA) procedure for mandibular dentistry
- To challenge current LA practice
- To understand the importance of novel LA agents and techniques to optimise pain management during surgery whilst minimising risks of complications

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OPTIMAL LOCAL ANAESTHESIA FOR DENTISTRY

ABSTRACT
Dentistry is unique in that high-volume surgery is undertaken efficiently on conscious patients, an anathema to most other surgical specialties, who predominantly operate on unconscious patients. Local anaesthesia (LA) provides an efficient block to nociceptive pain (the first stage of the pain pathway) but only addresses one small part of the pain experience. Currently the inferior dental block is the "go to" standard for dental LA for mandibular dentistry, despite its significant short comings. Unfortunately, habit means that we continue to practise what is taught to us at dental school, thus, not developing safer modern LA practice.

The dental syringe and deep injections are also the main triggers for fear and anticipated pain by patients expecting their dental appointment. The uptake of infiltration dentistry has been swift in implant dentistry, despite lack of an evidence base, and now other branches of specialty dentistry, general practice is awakening to the advantages of infiltration or "smart" local anaesthetic practices.

Inferior dental blocks are inefficient in providing swift pulpal anaesthesia. Stanley Malamed stated: "The rate of inadequate anaesthesia ranged from 31% to 81%, which when expressed as success rates, indicates a range of 19% to 69%. These numbers are so wide ranging as to make selection of a standard for rate of success for inferior alveolar nerve block (IANB) seemingly impossible".

Any block injection is also associated with an increase in the risk of systemic and local complications (including nerve injury), possible heightened medical complications and patient discomfort and fear. Fear of deep dental injections is a key factor in dental anxiety and phobia.

This article may contain repetition when read in conjunction with other articles in this issue as they are designed to be read independently

What is the role of local anaesthesia in managing analgesia for dental patients?

Your patients want two main outcomes when they come to visit your practice: pain-free injections and painless procedures.[1] However, needles and tablets are but a small part of the holistic pain management in your dental patients.[2] The definition of pain is that it is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".[3] The brain overlays the pain sensation on the part of your body that's getting hurt to protect it from harm. There are four types of pain:[4] two healthy and two pathological. Healthy protective pain includes firstly; nociceptive pain, which is the conversion of tissue injury and release of algogenic factors (intracellular cellular components released due to cell damage) acting as '"foreign bodies" exciting pain receptors on nociceptive nerve fibres (C, A delta and A beta fibres), causing transduction from chemical inflammation into an action potential and transmission the progression of an action potential advancing up to the tertiary order neurones to the somatosensory cortex; once reached the "ouch" is acknowledged resulting in reflex withdrawal of the digit from danger. Inflammatory pain follows nociceptive pain, if tissue damage occurs promoting tissue healing. This process should usually resolve in days or weeks depending on the degrees of damage and persistent of infection.

Local anaesthesia blocks nociceptive pain very successfully, but, due to pain's multiple components, increasing evidence supports that educating patients in expected pain levels, being caring, empathetic, providing appropriate anxiolysis, distraction, and on occasions providing this alone, is not enough to manage perioperative pain. Some patients may be stoic types, able to cope with the anticipated and actual surgical discomfort, whereas others may be more susceptible to lack of coping and catastrophising, needing a lot more attention. Holistic patient management is all important in pain management, including alternative techniques i.e. hypnosis and acupuncture.

The patients' expectations are paramount and we know that all patients expect pain when visiting their dentist.[5] It is important to point out to your patient that you are not a magician but a surgeon and it is impossible to do complex surgery on patients without causing some minor discomfort intra operatively and occasionally moderate pain post operatively. Perioperative dental pain is not managed well in dentistry and is the most common adverse event reported by dentists[6,7] and by patients.[8] Sixty per cent of a representative sample of general population aged 15 years or older have reported pain at least once during a dental visit.[9]

Local anaesthetic injection plus analgesic tablets are not enough. Local anaesthesia is only a small part of operative pain management.[2] Pain and its management is complex, as the individual's pain experience is unique and based upon their gender, beliefs, religion, ethnicity, prior pain experience, psychological factors, nocebo and placebo effects etc.[5] There are many psychological factors driving the response to acute pain related to surgery and in relation to the development of chronic post-surgical pain.

The key aspects for operative pain management include:

- Patient factors, including:
  - Managing the patients' expectations and anxiety. Education about pre and post-operative events with clear and frank two-stage consent allowing the patient some control of their treatment decisions
  - Appropriate anxiolysis (assessment and management) will elevate pain thresholds and improve pain management
- Medical aspects, including:
  - Optimal local anaesthetic practise
  - Appropriately prescribed analgesics
- Surgical factors: Good surgical practice minimises pain for the patient, including minimal access technique.
- Post-op advice with accessibility for the patient contacting the practice and/or surgeon with clear post-operative advice on mouth care maintenance and analgesics use.

How do we minimise systemic complications of dental local anaesthesia?

Over one billion dental local anaesthetic injections are given annually worldwide (communication Malamed S FDI lecture 2017). The reported adverse reaction rate is 1:1,000,000 and the mortality (death) rate from dental local anaesthetic injections has been stated at 0.000002%. Allergies are very rare and can often be psychosomatic.[10]

The definition of the term "adverse reaction" covers noxious and unintended effects resulting not only from the authorised use of a medicinal product at normal doses, but also from medication errors and uses outside the terms of the marketing authorisation, including the misuse and abuse of the medicinal product. The range of pharmaceuticals used in dental practice is relatively small, consisting primarily of sedatives, local anaesthetics, analgesics, and antibiotics. Adverse drug reactions are categorised as type A or type B.

- Type A: Reactions are more common and are generally attributable to known pharmacological or toxic effects of the drug.
- Type B: Idiosyncratic, unpredictable, acute/sub-acute, not related to known mechanism.

The most common adverse reactions to LA include:

- Vasovagal attack or faint. Nearly all patient related collapses during dental LA are faints allergies. A study carried out at Dundee Dental School showed that of 27 cases of "local anaesthetic allergies", only one was caused by the anaesthetic injection (and this was a sulphite allergy, not a drug allergy)".[11] This can be overcome by good chairside manner and observation of the patient. If a prolonged procedure is anticipated the patient should have eaten prior to the procedure or be provided with a glucose drink. Any patient who is anxious must be provided with suitable anxiolysis.
- Allergy to local anaesthetic agents. This is very rare and usually related to adjunctive agents including bung (latex),[12] the preservative (sodium metabisulphites), antiseptic, vasoconstrictor or, very rarely, the local anaesthetic agent. Most LA agents are now latex free. Esters are highly allergenic and there are no documented allergy to amides. The patient is more likely to be allergic to bisulphate preservative (needed for vaso-constricture). The least allergenic LAs are mepivicaine or plain prilocaine. Allergy is not dose dependent, unlike toxicity.[13] The signs of allergy include breathlessness, disorientation and distress, urticaria hypotension and collapse. Immediate action is required including: call for help, 1:1000 units epinephrine IM and provision of oxygen.
- Adverse effects usually caused by high plasma concentration of LA drug resulting from:
  - Inadvertent intravascular injection related to block injections
  - Excessive dose or rate of injection
  - Medically compromised patients
    - Delayed drug clearance
    - Drug interactions

Adverse events happen in relation to the concentration and dose of LA. Intravascular injections are more likely to occur with block than with intraosseous

TABLE 1
ADVERSE EFFECTS

Adverse effects are usually caused by high plasma concentration of either local anaesthesia (LA) drug or adjunctive content resulting from:

- Delayed absorption of LA
- Reduction of the systemic plasma levels of the LA
- Prolongation of the duration of action of the LA
- Reinforcement of the intensity of the LA's effects – not dependent on concentration
- Reduction of local blood perfusion

TABLE 2

MAXIMUM DOSES OF LOCAL ANAESTHETIC AGENTS

Drug	Max dose	1/10th cartridge
2% lidocaine	4.4mg/kg	3.6-4.4mg
2% mepivacaine	4.4mg/kg	4.0mg
3% mepivacaine	4.4mg/kg	6.0mg
3% prilocaine	6.0mg/kg	6.6mg
4% prilocaine	6.0mg/kg	8.0mg
4% articaine	7.0mg/kg	6.8-8.0mg

and periodontal injections. Minimising risk of overdose includes avoiding:

- All four quadrant treatment (staged treatment for elderly patients)
- Plain LA (no vasoconstrictor)
- Full cartridge injections (should commonwealth move to 1.7ml cartridges?)
- Exceeding maximum recommended dose (See Table 2).

Young and elderly patients must be suitably assessed for their weight. A child of five years weighs 18- 20kg, therefore, the maximum dose is 88mg (2 x 2.2ml lidocaine cartridges). Due to their size, children are at high risk of toxicity. Goodson and Moore have documented catastrophic consequences of this drug interaction in paediatric patients receiving procedural sedation, along with excessive dosages of local anesthetics.[14]

Medical issues: (See Table 3) any health aspects that include metabolising or excreting. The main medical risks are:

- Patients with cardiovascular diseases
- Patients with endocrine diseases
- Patients with CNS disorders
- Patients with lung diseases

Aspiration during dental LA is a legal requirement in the UK. Avoiding intravascular LA is possible by avoiding injection intra-vascularly by using aspiration and avoiding intraosseous injections and being aware of the increased vascularity of inflamed tissue whilst always observing clinical reactions by:

- Talking to the patient during the injection and monitor their ECG/ blood pressure to realise early symptoms of central-nervous and cardiovascular toxicity if they are at risk.
- Stopping the injection immediately when early symptoms are realised
- Considering the time course for development of toxic signs (five-ten minutes)
- Avoiding long acting and potent substances (bupivacaine is the most neurotoxic agent).

A recent survey of 2,731 patients undergoing LA for dental treatment reported that 45.6% pts had medical risk factors (mostly cardiovascular). The overall LA complication rate was 4.5% complications (5.7% in risk pts) non-risk patients 3.5% which were most commonly dizziness, tachycardia, agitation, bronchospasm. Severe complications including seizures, bronchospasm occurred rarely (0.07%). Overall there were fewer complications with articaine 4% I:100K epinephrine compared with articaine 4% I:200K epinephrine.[16]

Articaine is less toxic that lidocaine at the same concentration as it has high binding plasma rate reducing crossing the placenta or blood brain barrier. Metabolism of articaine occurs in tissue and plasma (rather than in the liver for lidocaine or bupivacaine) and lidocaine is only 50% degraded after 1.5-3 hours – much slower than articaine, of which 50% is eliminated after 20 minutes.

All suspected adverse events to local anaesthesia should be reported. This can be done online via the MHRA Yellow Card website (at www.mhra.gov.uk/yellowcard) or by calling the National Yellow Card Information Service on 0808 100 3352 (10am to 2pm Monday-Friday). In addition, dental practices should sign up to receive MHRA alerts. Subscribe at www.gov.uk/drug-device-alerts/email-signup.

TABLE 3

LIDOCAINE TOXICITY

At serum levels patients may complain of:

- **1-5mcg/ml**
  - Tinnitus
  - Lightheadedness
  - circumoral numbness
  - Diplopia
  - metallic taste
  - may complain of nausea and/or vomiting, or they may become more talkative
- **5-8mcg/ml**
  - nystagmus, slurred speech, localized muscle twitching, or fine tremors may be noticed. Patients also have been noted to have hallucinations at these levels
- **8-12mcg/ml**
  - focal seizure activity occurs; this can progress to generalised tonic-clonic seizures. Respiratory depression occurs at extremely high blood levels (20-25mcg/ml) and can progress to coma

What are the medical modifiers for dental LA?

There are very few absolute medical contraindications to local anaesthetic and these are listed in Table 4. There are some relative but not absolute contraindications for adrenaline use including:

- Hypertension, angina pectoris, heart failure
- Diabetes mellitus
- Bronchial asthma
- Regularly taken medication (TCAs, MAO inhibitors, beta-blockers)
- Pregnancy
- Narrow-angle glaucoma

However, prudent avoidance of blocks, or aspirating when using blocks and slow injection, low dosage, staged treatments allows the use of adrenaline in patients with these conditions. Use of low dose adrenaline LA agents can be used in these cases (See Table 5):[16]

- Specific systemic complications have been reported with dental local anaesthetics including: Methaemoglobinemia: benzocaine should no longer be used. Prilocaine should not be used in children younger than six months, in pregnant women, or in patients taking other oxidising drugs. The dose should be limited to 2.5mg/kg. At low levels (1-3%), methaemoglobinemia can be asymptomatic, but higher levels (10% to 40%) may be accompanied by any of the following complaints: cyanosis, breathlessness, tachycardia, fatigue and weakness.[17]
- Drug interactions:
  - Lidocaine can interact with CNS depressants and with H2 blocker (PPIs)
  - Epinephrine:
    - Propranolol is the only nonselective beta-blocker reported to have the potential to cause severe hypertension and reflex bradycardia in the presence of epinephrine.
    - A significant risk does not appear to be associated with the use of epinephrine and cardio selective beta-blockers.

TABLE 4

ABSOLUTE MEDICAL CONTRAINDICATIONS FOR LA

Include:	
Pheochromocytoma	Adrenaline producing tumour of the adrenal gland
Hyperthyroidism	Elevated levels of thyroxine which lead to sensitisation of adrenaline receptors
Tachycardic arrhythmias	Unstable ventricular fibrillation
Sulphite allergy	Anaphylactic reaction

Many complications or adverse events arise during dental local anaesthetics due to the patient being overly anxious or not well informed. Thus, your LA technique must address several aspects including:

- Recheck medical history at every visit:
  - Patient's recent prescription chart (< two weeks)
  - Patient's blood pressure
  - Care with small patients:
    - Children
    - Elderly (sacropenia – the loss of muscle mass – reduces body mass significantly after 60 years)
- Good preoperative assessment of medical history and anxiety levels
- Reassurance/warnings (avoid showing patient the syringe)
- Give your patient a feeling of control
- Distraction
- Topical LA
- Place fingertip near region where you are about to inject
- Warm LA cartridges
- Slow injections are less painful and more effective[10]

A key factor in patient satisfaction is a sense that the care giver is doing their best and is genuinely concerned that therapy is adequate.[18]

How do we minimise regional complications of LA?

Avoiding failed LA

There are many myths regarding failed LA in dentistry.[19] Local anaesthesia failure is often assumed to be the fault of the

TABLE 5

LOW DOSE ADRENALINE LA AGENTS CAN BE USED IN THESE CASES

Articaine 4% with adrenaline 1: 400,000	12.5ml
Articaine 4% with adrenaline 1: 200,000	8ml
Articaine 4% with adrenaline 1: 100,000	4ml
Articaine 4% without adrenaline	7ml
Mepivacaine 3% without adrenaline	10ml
Mepivacaine 2% without adrenaline	15ml

clinician due to the general over estimation of the effectivity of block anaesthesia providing pulpal anaesthesia in the mandible. The onset of lip numbness occurs usually within five to nine minutes of injection and pulpal anaesthesia follows (15-16 minutes).[20-22] Slow onset of pulpal anesthesia (after 15 minutes) occurs approximately 19% to 27% of the time in mandibular teeth and approximately 8% of patients have onset after 30 minutes.[23] Lip numbness does not guarantee pulpal anaesthesia and failure to achieve lip numbness occurs about 5% of the time with experienced clinicians.[24,25]

Inferior dental blocks are remarkably inefficient at providing pulpal anaesthesia for dental procedures.[26-28] Malamed stated the rate of inadequate anaesthesia ranged from 31% to 81%. When expressed as success rates, this indicates a range of 19% to 69%. These numbers are so wide ranging as to make selection of a standard for rate of success for IANB seemingly impossible.[10]

There are many myths regarding failed LA in dentistry:

- Inferior dental blocks are remarkably inefficient at providing pulpal anaesthesia for dental procedures particularly in mandibular premolars, canines and incisors.[10]
- Numbness (anaesthesia or "lip sign") of the patient's lip does not indicate pulpal anaesthesia
- The optimal pulpal anaesthesia rates occur 12-15 minutes after an inferior dental block (IDB). (Are we waiting long enough)?
- Articaine 4% IDBs are no more efficient than lidocaine 2% IDBs and have the additional potential risk of increased nerve injury rates.
- Accuracy of injecting near the inferior alveolar nerve does not improve analgesia (therefore we should not be aiming to "stab" the nerve).[29,30]
- Speed of IDB injection: a slow inferior alveolar nerve block injection (60 seconds) results in a higher success rate of pulpal anaesthesia and less pain than a rapid injection (15 seconds).[31]
- Pathological (infection):[32,33] pulpitis is a challenging clinical problem, and can only be overcome by increasing the dose of anaesthetic in the area, with increased accuracy of the placement of the anaesthetic solution.[34]
- Choice of technique, insufficient dose, poor technique, damaged LA due to poor storage.[35]
- Giving another inferior alveolar nerve block does not help the patient if they feel pain during operative procedures. The second injection does not provide additional anaesthesia – the first injection is just "catching up".[36]
  - Increasing the volume to two cartridges of lidocaine or increasing the epinephrine concentration from 1:100,000 to 1:50,000 will not provide better pulpal anesthesia.[37,38]
  - Using higher concentration agents for block injections is not evidenced to improve efficacy.[39-41] Specifically articaine compared with lidocaine IDBs has no or limited additional efficacy.[42,43]
  - Computed techniques do not ad advantage for IDB efficacy.[44]
  - There is no evidence to support using direct or indirect Halstead IDB technique or the improved efficacy of using Gow-Gates of Akinosi techniques.

How do we manage failed IDB?

- There is increasing evidence that additional injections (buccal infiltration, intraseptal, intraligamental, intra osseous) can enhance and even replace IDBs. Supplemental injections can improve mandibular pupal anaesthesia.[33]
- Recent studies report that giving a buccal infiltration of a cartridge of 4% articaine with 1:100,000 epinephrine after an inferior alveolar nerve block significantly increased success (88%) when compared to a lidocaine formulation (71% success).[45,46] In a study of 182 patients, 122 achieved successful pulpal anaesthesia within ten minutes after initial IANB injection and only 82 experienced pain-free treatment. Additional Articaine buccal

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infiltration (ABI) and Intraosseous (IO) allowed more successful (pain-free) treatment.[47]

- The addition of intraligamental injections may assist in extractions.[48,49] However, intraligamental injections are unlikely to be as effective at IDB alone for other dental procedures.
- The addition of the intraosseous injection after an inferior alveolar nerve block, in the first molar, will provide a quick onset and a high incidence of pulpal anaesthesia (approximately 90%) for 60 minutes. Clinically, the supplemental intraosseous injection works very well but systemic cardiac effects are related to the "intravenous" nature of this injection.[51-52]
- Prescribing preoperative ibuprofen prior to dental treatment for pulpitic molar teeth is likely to significantly increase the effectiveness of the IDB local anaesthesia.[53]

The main issues appear to be the overestimation of the efficacy of IDBs in general, impatience and lack of awareness that one must wait over 15 minutes for maximum efficacy of a lidocaine block, in addition to the lack of use of alternative techniques that provide improved pulpal anaesthetic rates for anterior teeth.

TABLE 6

RISK FACTORS FOR NERVE INJURY RELATED TO DENTAL LOCAL ANAESTHESIA[32, 59-79]

Block anaesthesia	59
Lingual nerve > IAN	60
Blind block injections There is criticism of teaching the use of blind injections in dentistry	61-63
• Technique or Anatomy?	No evidence that direct Halstead causes more lingual nerve injuries than indirect technique
Concentration of LA agent	59, 60, 64-71
Speed of injection	
Multiple injections	59
Severe pain on injection	60% more likely to experience persistent neuropathy[59]
LA Agent toxicity	Increasing toxicity at same concentration Bupivicaine> Mepivacaine> Prilocaine>Lidocaine>Articaine
• Type of vasoconstrictor? • Sedated GA • Lack LA aspiration	No evidence No evidence No evidence

How do we minimise regional complications of LA?

Most of these complications can be avoided by careful technique and avoidance of intravascular injections but even when clinicians use the utmost care, by aspirating before the injection and noting anatomical landmarks, intra-arterial injections can occur during inferior alveolar nerve blocks.[54] Fortunately, permanent damage to nerves, facial and oral tissues, and eyes is rare.

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Possible regional complications related to IDBs include:

- Facial palsy likely due to poor IDB technique with too deep or superior injection through the coronoid process into the sheaths of the parotid gland through which the facial nerve travels.[55]
- Tissue trauma-haematoma trismus. In patients who have coagulopathies or platelet malfunction avoidance of block injections is advisable but occasionally unavoidable.
- Fracture of the needle is more likely to occur with 30 gauge needles, using needles too short leaving no additional space between the hub and tissues and pre-bending of the needle prior to injection.[56,57]
- Ophthalmic complications.[58]
- Nerve injury related to IDB injections may cause permanent neuropathy in lingual and inferior alveolar nerves often associated with combined numbness, paraesthesia and neuropathic pain. Though LA related permanent nerve injury is rare, once the injury occurs approximately 75% may resolve but the remaining 25% is untreatable. Most patients with trigeminal nerve injuries experience chronic pain in their lip, teeth and gums or tongue and gums, depending on which nerve is damaged. This is a lifelong burden that these patients find difficult to accommodate, especially when they were never warned about the possible risk. The risk of nerve injury can be mitigated by altering the block technique or by avoiding block anaesthesia altogether. The risk factors for nerve injury related to dental anaesthesia are listed in Table 6.

The incidence of persistent neuropathy related to dental IDBs is rare, estimated to be between one in 14,000 temporary and one in 52,000 permanent (25% permanent),59 1:26,762 and 1:160,571,[63] one in 27.415 cases,[74] one in 785,000 injections, *to* one in 13,800.970.[66] The majority of nerve injuries are painful in patients seeking care, consistent with other surgical sensory neuropathies leading to a condition known as chronic post-surgical pain. Unfortunately for these patients the unforeseen complication of routine dental care leads to life changing orofacial pain with subsequent significant functional and psychological sequelae.

Management: there is no evidence based treatment for these nerve injuries – we have to sit and wait whilst caring for the patient. If pain is caused during an IDB, arrange to contact the patient the next day to exclude persistent neuropathy (pain, numbness and or altered sensation), reassure them that 75% recover, medical intervention including non-steroidal anti-inflammatory drugs (NSAIDs), vitamin B and steroids as used for spinal iatrogenic nerve injuries may be effective in reducing neural inflammation and irritation – but there is no evidence to support this, aside from patients being reassured that their clinician is trying to help them.

Should patients be warned of possible rare nerve injuries related to dental LA? Based upon the Montgomery ruling, clinicians must now ensure that patients are aware of any "material risks" involved in a proposed treatment, and of reasonable alternatives, following the judgment in the case *Montgomery v Lanarkshire Health Board*. This is a marked change to the previous "Bolam test", which asks whether a doctor's conduct would be supported by a responsible body of medical opinion. This test will no longer apply to the issue of consent, although it will continue to be used more widely in cases involving other alleged acts of negligence. Thus, one has to question when would a permanent burning tongue or elcited neuralgic pain of the face be caused whenever eating, kissing, speaking or out in the cold, is not material to a patient? Suggested routine consent was suggested in the US in 1939.[72] In Germany there is already a legal precedent to warn all patients undergoing dental LA of possible nerve injury, and any patient undergoing spinal or epidural injections in the UK must warn patients of possible permanent motor or sensory nerve injuries in one in 57,000.[73]

Thus, prevention of LA nerve injuries is paramount and most effectively achieved by avoiding block anaesthesia. Dentistry is the only healthcare profession taught

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to aim for nerves blindly during block injections. There is increasing pressure to use ultrasound neural location to minimise systemic toxicity and nerve injuries as practiced in regional block anaesthesia elsewhere in the body. Other strategies would include avoiding risk factors (Table 6[51-79]) but mainly avoid block anaesthesia and using infiltration techniques instead.

What is wrong with our current practice and how can we do better?

Proposed tailored smart LA practice:

- Technique
- Agent
- Volume

The limitations of IDB in providing swift mandibular pulpal anaesthesia is recognised and recent evidence supports the use of infiltration mandibular dentistry. Interestingly, for decades dentists have routinely undertaken maxillary dentistry with infiltrations, accepting that nerves within bone are accessible to submucosal local anaesthetic techniques. With respect to maxillary infiltration anaesthesia, some studies have found 4% articaine to be more effective than 2% lidocaine for lateral incisors but not molars,[74] while others reported no clinical superiority for this injection.[75,76] A recent randomised controlled trial found a statistically significant difference supporting use of 4% articaine in place of 2% lidocaine for buccal infiltration in patients experiencing irreversible pulpitis in maxillary posterior teeth.[77]

As mentioned previously, nerve blocks are related to nerve injury and there are no indications to use palatal, incisal or infraorbital nerve blocks for dentistry except in very rare exceptions; for example, spreading infection from canines or premolar use of block anaesthesia will prevent the need for general anaesthetic drainage and extractions. Several studies report the lack of indications for palatal block injections.[78,79] There is increasing evidence that additional injections (buccal infiltration, intraseptal, intraligamental, intra osseous) can enhance and even replace IDBS.[32,35,47,77] Lidocaine infiltration is likely as effective as articaine for maxillary

TABLE 7

VOLUME RECOMMENDATION FOR MAXILLARY LOCAL ANAESTHESIA IN DENTISTRY

Technique	Volume (ml)
Supraperiosteal (infiltration)	0.6
Posterior superior alveolar (PSA)	0.9-1.8
Middle superior alveolar (MSA)	0.9-1.2
Anterior superior alveolar (ASA)	0.9-1.2
Anterior middle superior alveolar (AMSA)	1.4-1.8
Platal approach-anterior superior alveolar (P-ASA)	1.4-1.8
Greater (anterior) palatine	0.45-0.6
Nasopalatine	0.45 (max)
Palatal infiltration	0.2-0.3
Maxillary (V_2) nerve block	1.8

Taken from Malamed SF Techniques of maxillary anaesthesia in *Handbook of local anaesthesia* Malamed SF 6th edition Mosby Elsevier 2013, St Louis Page 223.[104]

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dentistry.[80] A recent systematic review highlighted that there is no benefit in using articaine infiltration for maxillary dentistry but articaine is 3.6 more times effective than lidaocaine for mandibular infiltration dentistry.[81]

Can articaine 4% infiltration replace lidocaine 2% IANBs for routine dentistry?

Undoubtedly, using infiltration and not IDBs improves patient comfort as patients will undoubtedly prefer having full lingual sensation and shorter duration LA anaesthesia after dental treatment.[32] Not only are buccal infiltration techniques proving as or more effective than IDBs but intraligamental injections can also be used effectively for exodontia as intraligamental injections are effectively intravascular with more likely systemic effects but in addition there is reported higher post restorative pain levels.[82-83]

IANBs are unnecessary to treat the following:

- pulpitic mandibular molars in adults [84-85]
- exodontia in adults and children [86-87]
- implant surgery: 88120 patients requiring the placement of a single implant in order to replace a missing first mandibular were randomly allocated to two groups comparing crestal with infiltration. No nerve damage occurred using either anaesthesia types, therefore the choice of type of anaesthesia is a subjective clinical decision. However, it may be preferable to use a low dose (0.9 ml) of subperiosteal anaesthesia, since it is unnecessary to deliver 7.2 ml of articaine to anaesthetise a single mandibular molar implant site.[89]
- restorative mandibular care in kids:[90] however, in a recent study of 57 paediatric patients undergoing restorative mandibular treatment reported a higher success and less painful treatment with IANB. There was no statistically significant difference in local analgesia success between articaine and lignocaine when delivered via buccal infiltration.[91]

TABLE 8

VOLUME RECOMMENDATION FOR MANDIBULAR LOCAL ANAESTHESIA IN DENTISTRY

Technique	Volume (ml)
Inferior alveolar (IANB)	1.5
Buccal	0.3
Gow-Gates (kind of IANB)	1.8
Vazirani-Akinosi (kind of IANB)	1.5-1.8
Mental	0.6
Incisive	0.6-0.9

Taken from Malamed SF Techniques of maxillary anaesthesia in *Handbook of local anaesthesia* Malamed SF 6th edition Mosby Elsevier 2013, St Louis Page 223.[104]

Benefit of computerised systems for infiltration techniques

There is limited evidence to support that computerised infiltration systems are more effective but those regularly using these systems empirically report better patient acceptance and comfort during injections.[92]

What is the best agent?

Articaine (4-methyl-3-[2-(propylamino)-propionamido]-2-thiophene-carboxylic acid, methyl ester hydrochloride) is a unique amide LA in that it contains a thiophene, instead of a benzene ring. The thiophene ring allows greater lipid solubility and potency as a greater portion of an administered dose can enter neurons. It is the only amide anaesthetic containing an ester group, allowing hydrolysation in unspecific blood esterases. About 90% of articaine

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metabolises quickly via hydrolysis in the blood into its inactive metabolite articainic acid, which is excreted by the kidney in the form of articainic acid glucuronide. Its metabolism is age dependent, where clearance and volume of distribution decreases with increasing age. The elimination serum half-life of articaine is 20 minutes and of articainic acid it is 64 minutes.[93-95] Articaine at three different comparative lidocaine concentrations prove more effective in providing mandibular pulpal anaesthesia;[96] however, articaine is 3.6 times more effective for mandibular infiltration dentistry[97] and a recent study demonstrated that 2% articaine is as effective as 4% articaine using IDB for mandibular dental extraction in adults.[98,99] In summary, more research is needed before recommending replacing 4% with 2% articaine for all dental procedures.

Concentration of epinephrine may be reduced from one in 100 to one in 200 and equally effective for third molar extraction 100 and epinephrine concentration of one in 400 may only be required for paediatric extractions using 4% articaine.[101]

So is the future agent for dental anaesthesia 2% articaine with 1:200K-400K epinephrine for all LA techniques and dental procedures in adults? Could we use epinephrine free LA for paedodontic dentistry? Further research is needed.

What LA volumes should we be using?

The most common LA cartridge volume used worldwide is 1.8ml.[102] Dentists in France and Japan use only 1ml cartridges and the Commonwealth 2.2ml cartridges. Dictation of LA volume to achieve effective pain control depends on diameter of nerve and accuracy of technique.

Infiltration techniques require significantly less LA volume compared with block techniques (0.6-9ml), Gow-Gates only block anaesthesia technique where full cartridge 1.8ml-2.2ml is recommended and infraorbital LA block requires 1.8ml-2.2 ml.[104]

Thus the continued use of 2.2ml cartridges should be questioned and changed to 1.8ml cartridges, which would improve patient safety and likely impact minimally on repeated injections,

The future interest is the possibility of development of newer improved agents (sensory blocking agents only) and devices and techniques for achieving profound sensory anesthesia. A nasal spray (http://clinicaltrials.gov/ct2/show/NCT01302483) has shown to anesthetise maxillary anterior six teeth is set to be tested in an FDA Phase 3 trial, which will assess the spray's effectiveness compared to the current "gold standard" treatment – painful anesthesia injections. Buffering of acidic local anaesthetics to more neutral physiological pH allows for speedier LA onset and is already in use in the US. A recent development is a syringe micro vibrator (SMV),[105] a new device being introduced in dentistry to alleviate pain and anxiety of intraoral injections.

Conclusion

Substantive evidence supports a transition from block anaesthesia to infiltration dentistry for most dental care.[106-108] A radical change in practice is required with regard so many aspects of patient safety based upon current evidence, whilst acknowledging further research would be ideal. With the current research legislation, undertaking simple efficacy studies of existing commonly used LA agents is prohibitively expensive and unlikely to be funded by pharmaceutical companies, limiting the provision of future robust supportive research. Infiltration LA for implantology is a good example where common sense and application of optimal technique has occurred without robust evidence base providing safer more effective patient care.

- A tailored approach to dental local anaesthesia should be recommended to prevent the continued unnecessary use of IDBs when infiltration

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FIGURE 1

SUMMARISING MANDIBULAR LA INFILTRATION TECHNIQUES

INFILTRATION DENTISTRY IS DEPENDANT UPON THE SITE AND PROCEDURE

- Maxillary dentistry can be performed entirely using Lidocaine 2% with adrenaline for all procedures
- Buccal infiltration with intra-septal injections
- No additional benefit using 4% Articaine
- No palatal or incisal blocks are indicated

- Posterior mandibular molar
- Endodontic procedures may require IDBs or higher techniques (Gow Gates or Akinoski)

Mandibular 7s and 8s for **perio, restorations or implants**
- Articaine 4% buccal infiltration and Lidocaine
- 2% lingual infiltrations OR for extractions intraligamental
- If fails, may need lidocaine IDB

Mandibular 1st molars for **perio, restorations or implants**
- Articaine 4% buccal +/- Lidocaine 2% crestal or lingual infiltrations OR for **extractions** add lidocaine lingual **of** intra-ligamental

Mandibular premolars, canines incisors for **perio, restorations or implants**
- Articaine buccal infiltration (incisal nerve block using 30% cartridge) adjacent not in the mental foramen and massage over region. If fails, repeat or add crestal or lingual infiltration OR for **extractions**, intra-ligamental

Illustration modified from figure courtesy of Andrew Mason, University Dundee

anaesthesia is likely more effective for most dental procedures. Tailored LA is dictated by the site and procedure. See Figure 1 summarising the optimal anaesthetic techniques.

- The lack of safety giving blind block injections with likely systemic and local complications (especially nerve injury) may be considered "indefensible".
- IDBs should be prescribed in limited cases when indicated (see tailored LA).
- Consent for LA: in the light of Montgomery consent recommendations, all patents should be routinely warned of a risk of nerve injury when routinely undergoing dental local anaesthesia, as already the case in Germany, and in the UK related to epidural or spinal injections.
- Reduction of epinephrine levels is likely possible for most dental procedures also improving patient safety and minimising systemic effects and reducing problems in medically compromised patients.
- Revalidation of the required cartridge volume is necessary and recommendation for the use of 1.8ml versus 2.2ml cartridges will improve patient safety.

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