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Original Research Paper

Dental Science

THE ENDODONTIC ENIGMA: HOT TOOTH

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ABSTRACT The state of analgesia is a cornerstone for the successful completion of the modern endodontic procedure. Achieving profound anaesthesia, would not only be a helping hand in the patients overcoming their fears towards dental procedures, but also help the dentist work with a peace of mind, without constantly worrying about the patient's reaction. Toward this end, the successful use of local anaesthesia has changed the emotional appeal of clinical dentistry from earlier , being a painful and frightening experience to now, a much less painful and even satisfying experience. However, local anaesthetics frequently fail in endodontic patients with a hot tooth. In the recent years there has been much effort in understanding the various concepts and theories associated with this endodontic enigma which has led to a rise in the newer strategies for its management ,used by themselves or in conjunction with the traditional management methods.

KEYWORDS : Irreversible pulpitis; local anaesthesia; Inferior alveolar nerve block; photobiomodulation

INTRODUCTION

Perceived association of pain with endodontic therapy represents a source of fear for many of our patients and equally represents a meaningful challenge to many practitioners

And profound pain control starts with effective local anesthesia

The high clinical success rate in producing profound and prolonged local anesthesia along with its low potential for allergic reactions makes lidocaine (Xylocaine) the anesthetic agent of choice. [1]

Now, what happens when this trusted local anaesthetic ceases to perform to its full potential?

This renders the tooth to be a hot tooth. A tooth difficult to be anaesthetized.

Demonstatively, hot tooth refers to a pulp that has been diagnosed with irreversible pulpitis, with spontaneous, moderate-to-severe pain [13]

With irreversible pulpitis, the most common difficult to anaesthetize are the manidibular molars.

Followed by mandibular and maxillary premolars , maxillary molars , mandibular anteriors, maxillary anteriors.[1]

Inferior alveolar nerve block (IANB) is associated with a lapse ate of 15% in patients with normal tissue, whereas IANB fails in 44-81% of the time in patients with irreversible pulpitis[1]

Lapse rate of a maxillary infiltration injection is as high as 30% in teeth with irreversible pulpitis[1]

Hypotheses To Explain The Inability To Anaesthetize Hot Tooth [14,3,1]

NAME OF THEORY	
1.Ion trapping	according to this hypothesis, the low tissue pH will result in a greater proportion of the local anesthetic being trapped in the charged acid form of the molecule and, therefore, unable to cross cell membranes Some points that negate this hypothesis are: [3] • First, the acidosis may be minor in magnitude. • In addition, inflamed tissue possesses greater buffering capacity than normal tissue (possibly due to extravasation of protein or erythrocytes into the inflamed tissue). Thus, the actual pH change may not be large enough to produce substantial ion trapping of local anaesthetics. • In addition, a reduction in tissue pH is likely to be a localized event,so it can explain failures in infiltrations but not blocks.
2. Altered membrane excitability of peripheral nociceptors	hypothesis that nerves arising in inflamed tissue have altered resting potentials and excitability threshholds and that these changes are not restricted to the inflamed pulp itself but affect the entire neuron cell membrane in every involved fiber. histamine is released from cells. Kallakrein is activated, breaking down globulins to form kinins. Other substances, such as prostaglandins, are formed in injured tissues These are related to the concept of increased "sensitivity" of nerves that carry pain impulses
3. The central core theory	This theory states that the anatomical organization of the IAN where the "central core" of axons supplies the distal anterior teeth and the outer layer of axons supplies the posterior teeth might be the reason for anesthetic failure of mandibular anterior teeth And that the well described failure of the IAN block to anesthetize anterior teeth might be simply due to the lack of sufficient drug concentrations to block voltage-gated sodium channels (VGSC) in the central core axons. this hypothesis does not explain the failure to block posterior mandibular teeth.

	Collectively, these findings have prompted much research to increase the success of IAN nerve block injections
4.Central sensitization	Activation and sensitization of nociceptors in pulpal and periradicular tissue results in a barrage of impulses sent to the trigeminal nucleus and brain. This barrage, in turn, produces central sensitization. [3] The C fibers release neurotransmitters including glutamate and SP that act on post-synaptic NMDA and AMPA receptors or NK1 receptors, respectively. A signal transduction cascade is initiated in the central neuron involving numerous cellular signals of which nitric oxide and protein kinase C are particularly Central sensitization is the increased excitability of central neurons and is thought to be a major central mechanism of hyperalgesia and allodynia. Under conditions of central sensitization, there is an exaggerated CNS response to even gentle peripheral stimuli
5.Tetrodotoxin resistant channels	several types of sodium channels have been discovered over the last decade. One particular group of channels is characterized as being resistant to the puffer fish toxin, tetrodotoxin (TTX). At least two channels are members of the TTX-resistant class, including the PN3 (also known as SNS, or NaV 1.8) and NaN (also known as the SNS2 or NaV 1.9) sodium channels. [3] increasing concentrations of lidocaine provides increasing blockade of the sodium channels. However, the TTX-resistant channels are about four times less sensitive to lidocaine [3] In addition, their activity more than doubles after being exposed to prostaglandin E2 .
6. Psychological factors	Experienced clinicians understand that apprehensive patients have a reduced pain threshold and are more likely to report an unpleasant dental experience. Fear of seeing and/or feeling the needle and the sound of the dental handpiece are routinely cited as causative agents in the creation of anxiety in the dental patient Investigators have also demonstrated that patient anxiety predicts a poor outcome for clinical procedures involving local anesthetics applied to the arm before IV cannulation . Thus, patient anxiety should be considered when managing the endodontic pain patient

Traditional Management Strategies In Patients With A Hot Tooth

1. Conduction block anaesthetic
2. Supplemental anaesthesia
3. Pre medication

- **CONDUCTION BLOCK ANAESTHETIC** [9]

This was considered with the concept that, the length of nerve exposed to anaesthetic solution is significantly more in conduction anaesthesia than in conventional IANB

Types of conduction anaesthesia technique include:

1. Gow-Gates injection
2. High Vazirani-Akinosi injection

These pose risk of accidental injury to maxillary artery and pterygoid plexus which may lead to pain and hematoma. And also have the disadvantage of dependency on extraoral landmarks which leads to steep operator learning curves.

The well known alternatives in case of IANB failures include, the supplemental anaesthesia namely; intraligamentary anaesthesia, intraosseous anaesthesia and intrapulpal anaesthesia

- **Supplementary Injection**

Table 1 : Supplementary Injection Features [1,11*]

Type of injection	Onset of action	Duration of action	Amount of anaesthetic deposited	Success rate
Intraliga-mentary anaesthesia	30s/ immediate	23 min	0.2 ml each side (mesial and distal)	1st dose-63-72% 2nd dose-92%
Intraoosseous anesthesia	10s-120s/ immediate	45 min	(2% lidocaine with 1:100,000 epinephrine stabident) 0.45 to 0.9mL and volume of 1.8 mL.	79% 91%
Intrapulpal anesthesia	immediate	15-20 min*	0.2 ml	

Table 2: Advantages And Disadvantages Of Various Supplementary Injections [14]

Supplementary injection	advantages	disadvantages
Intraligamentary (periodontal ligament) anesthesia	1) Smaller doses are required (0.2 ml/root). 2) Overcomes failed conventional anesthesia. 3) Limited soft tissue anesthesia. 4) Mandibular anesthesia in patients with bleeding disorders.	1) Produce bacteremia (endocarditis). 2) There is rapid entry into circulation (cardio vascular effects). 3) Pre- and post-injection discomfort. 4) May damage periodontal tissues and pulp. 5) Injection equipment may be damaged.
Intra-osseous anesthesia	1) Smaller doses are used. 2) The amount of soft tissue anesthesia produced is less 3) Overcome failure after conventional techniques.	1) Technically more difficult. 2) Specialized equipment may be required. 3) Rapid entry of local anesthetic and vasoconstrictor into the circulation 4) Post-injection discomfort
Intrapulpal anesthesia	1) As mentioned above the method does not require a local anesthetic. 2) The method provides a useful means of overcoming failure in teeth where conventional techniques have been unsuccessful.	1) The injection may be painful. 2) Limited application as it involves pulpal exposure

	3) Although theoretically this technique uniquely could provide single-tooth anesthesia, the fact that it is normally administered after failure of another method precludes this possibility in most cases. 4) The systemic effects of intrapulpal anesthesia appear to be negligible.	3) Not indicated as a primary method.

- **Pre Medication** [2]

Reasoning behind pre medication

- Firstly, decreasing pulpal nociceptor sensitization would mitigate an increase in resistance to local anesthetics .
- Secondly, it may diminish a prostanoid-induced stimulation of TTX-resistant sodium channel activity these channels also display relative resistance to lidocaine.

- **Dexamethasone**

Aggarwal et al., 2011a, 2021; Bidar et al., 2017; Shahi et al., 2013

Several investigations have used different doses (from 0.5 mg to 4 mg) and routes of administration of dexamethasone (oral, buccal and PDL injections) to evaluate its efficacy on IANB anaesthesia success rates

However, conflicting results have been reported regarding its efficacy when used in conjunction with IANB injections for teeth with irreversible pulpitis Kumar et al., 2021

A recent investigation reported that a combination of dexamethasone and ibuprofen provided significantly higher IANB success rates compared with the individual use of each of these medications for premedication

- **Tramadol**

Pulikkotil et al., 2018

A systematic review reported that premedication with dexamethasone, NSAIDs or tramadol can significantly improve anaesthesia success rates of IANB for teeth with irreversible pulpitis

The type of anaesthetic solution may affect the efficacy of tramadol for IANB anaesthesia success rates (better with articaine)

- **Magnesium sulphate**

Hargreaves & Keiser, 2002

It has been proposed that an increase in the N-methylD-aspartate (NDMA) receptor is one of the reasons for central sensitization

Magnesium sulphate is known as a non-competitive antagonist of NDMA receptors, and therefore, it may be useful for preventing central sensitization

Three studies have evaluated the use of magnesium sulphate either one hour prior to anaesthetic solution injection or in combination with anaesthetic solution for IANB technique.

Minimum dose of 75 mg magnesium sulphate has shown a significant impact on anaesthesia success, it can be considered as the preferred dose to be combined with an anaesthetic solution

Techniques Tested In The Recent Years

- **Cryotherapy** [5]

According to, Topçuoğlu HS et al. 2019

Nociceptors are stimulated by various chemical mediators, and this stimulation may result in pain28. When the cold temperatures used in cryotherapy are applied to the target areas, an analgesic effect is experienced. [4]

Cryotherapy slows down neural signals and reduces the release of the chemical mediators that are responsible for pain conduction.

Cryotherapy also induces a local anesthetic effect by lowering the activation threshold of nociceptors and the conduction velocity of pain signals. These effects could explain the increased effectiveness of the IANB in

- **Lasers** [15]

According to, Topçuoğlu HS et al. 2021

It has been postulated that photostimulation induces a thermal photochemical reactions that alter the pain threshold of nociceptors.

Evidence abounds that phototherapy modulates inflammation by reducing prostaglandin E2 concentrations, inhibiting cyclo-oxygenase 2 in vitro, and reducing tumor necrosis factor alpha.

It has also been shown that phototherapy enhances the release of endorphins.

A fourth mechanism is that it enhances local hemodynamics, thus aiding the removal of pain-causing substances from the site of lesion.

Yet, another mechanism relates to its capacity to increase cellular oxygenation and mitochondrial adenosine triphosphate; but how this mediates pain remains unclear

- **Benzocaine gel + hyaluronidase(enzyme)** [6]

According to, SOOrAPArAJU SG et al. 2015

benzocaine gel because it has been proved that they reach higher concentrations at the sensory nerve endings.[5]

Hyaluronidase increases the permeability of connective tissue and thus enhances the spread of local anaesthetics used in combination with them[5]

- **Acupuncture** [7]

According to, Jalali S et al 2015

acupuncture may cause the release of some mediators, which can inhibit substance P (a neurotransmitter that stimulates pain) and increase the release of cortisol, which helps the patients control their stress and anxiety .

In addition, brain imaging studies have revealed that acupuncture varies the activation patterns in the pain processing areas of the brain.[6]

It is assumed that the needle stimulation causes the endogenous pain modulation's mechanisms to reduce pain perception; these mechanisms are diffuse noxious inhibitory controls, segmental inhibition, and descending pain control pathways

CONCLUSION

1. Despite encouraging results for various approaches, there is still no unique method of choice that can predictably and completely overcome pain during root canal treatment, especially for teeth (and particularly mandibular molars) with irreversible pulpitis
2. But there are several factors that have to come together for the method to work

- Clinical experience
- Taking a thorough medical history
- Pre-operative condition of the lesion
- Combination of methods

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