NEGOTIATING THE ENDODONTIC MINEFIELD

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Introduction

In root canal treatment, every case poses its own unique challenge to the clinician. It could be in the arrival of a diagnosis to the more technical aspects of root canal treatment. The route to a successful outcome can sometimes be strewn with traps and obstacles-the endodontic minefield. This article highlights some of these minefields to help the clinician recognise where they lurk and how to avoid them, in order to achieve a predictably successful outcome.

Minefield No 1: Correct Diagnosis

The arrival of the correct diagnosis, whilst often straightforward, can in some instances be equally baffling. Yet without a correct diagnosis, definitive treatment to alleviate the patient's complaint cannot be initiated, and this can be frustrating for both the clinician and the patient. However, this very extensive area will not be covered in this paper.

Minefield No 2: Achieving Anaesthesia

In some cases of acute irreversible pulpitis, anaesthesia can be difficult to achieve. This is often referred to as a "hot" tooth. Some of the reasons cited for failure to achieve anaesthesia are:

- Missing the correct site in nerve blocks.
- Aberrant & accessory nerves (Chapnick 1980), for example, occasionally accessory nerves to the mandibular molars may arch round the buccal surface of the mandible. This would be not be anaesthetized by the IDN block, and additional buccal infiltration will be necessary.
- Recovering alcoholics (Kimbrough 1975).
- Inflammation of tissue.

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Inflammation of Tissue

Tissue inflammation has three main effects which makes anaesthesia difficult to achieve:

1. Sensitization of the nerves both locally and even further peripherally.
2. Ionization of the local anaesthetic solution.
3. Alteration of the sodium pump receptor sites in C-nerve fibres.

1. Sensitization of nerves

Inflammatory mediators cause fluid leakage from pulpal blood vessels in the affected site. The extravasated platelets produce serotonin, which act on the pulpal nerves. This results in the activation of silent nociceptive nerves (Byers & Närhi 1999) and sprouting of new nerve endings (Kimberely & Byers 1988) at the site of pulpal inflammation. The constant bombardment of pain transmitting signals toward the brain can even result in sensitization of 2nd order neurons. Therefore, sometimes nerve blocks at sites remote from the site of inflammation may not be successful.

2. Ionization of local anaesthetic solution

When local anaesthetic solution, for example, lignocaine ($R\text{-}NH^+$) is injected into normal tissue (pH 7.4), it ionizes approximately 25% to its ionic form (R-N) and it is this form which is lipid soluble and penetrates the lipid rich myelin sheath (Figure 1). Once through the myelin sheath,

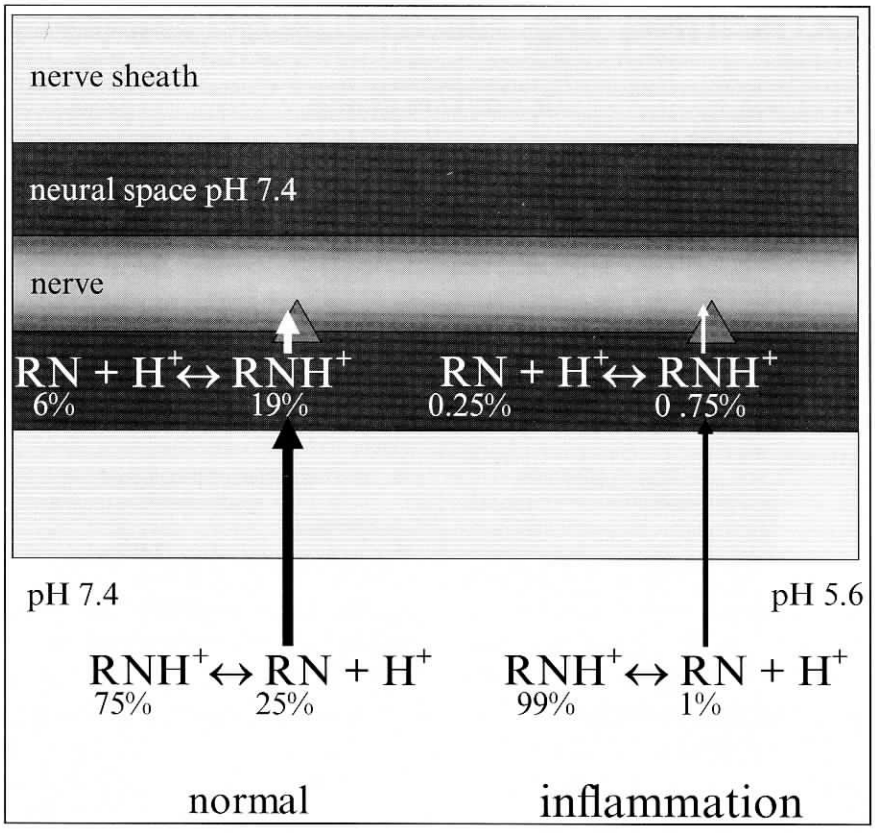

Figure 1

it re-equilibrates, and 75% changes back into its original cationic form, R-NH+ which attaches to the sodium pump receptor site, preventing transmission of nerve impulses.

Inflamed tissue is acidic, therefore, less anaesthetic requires to ionize before equilibrium is reached. At pH 5.6, only 1% converts to the ionic form R-N that is able to traverse the myelin sheath. In the neural space where the environment is stable at pH 7.4, 75% of the ionic form R-N re-equilibrates to its active form R-NH+ so that finally, only 0.75% of the original injected anaesthetic is available to block pain transmission, resulting in slower onset and poorer level of anaesthesia (Malamed 2002).

3. *Alteration in Sodium Pump Receptor Site*

C nerve fibers have a special class of sodium pump receptor sites known as tetrodotoxin sensitive (TTXs) receptors. These receptors are susceptible to the neurotoxin tetrodotoxin, produced by the puffer fish. However, in the presence of neuroinflammation, the TTXs receptor site alters and becomes tetrodotoxin resistant (TTXr). The result of this alteration is that it now takes five times more lignocaine to produce the same level of anaesthesia as normal tissue. However, the alteration of the receptor sites from TTXs to TTXr does not affect the efficacy of the long-acting anaesthetic bupivicaine. (Scholz *et al.*1998)

The physiologic background to the resistance of "hot" tooth to local anaesthetic above means that to overcome this problem there are two solutions:

- Use bupivicaine instead of lignocaine.
- If lignocaine is to be effective, a greater effective local concentration has to be achieved. One way is to increase the volume of lignocaine, or alternatively, select alternate methods of delivery to get local anaesthesia closer to the site so that there is less "loss" of anaesthetic solution from removal by the blood vessels. (See Meechan (2002) for a recent review of supplementary routes to local anaesthesia) Some of these alternative methods are:

Gow-Gates Mandibular nerve block. (Gow-Gates 1973) This is an effective alternative to the standard inferior dental nerve (IDN) block (Montagnese *et al.* 1984), with a higher success rate of 95% compared with 76% for standard block in achieving anaesthesia. Its better success could be related to the fact that the anaesthetic solution is deposited medial to the neck of the condlye, an area which is less vascular than the standard IDN block site. Therefore, anaesthestic washout is slower and consequently, anaesthesia will last longer. A 25G long needle is recommended. The patient should open wide and the barrel of the syringe comes from the opposing side at the angle of the mouth, and the needle is inserted into the mucous membrane just distal to the maxillary second molar just below its mesiopalatal cusp, and aimed towards the lower border of the tragus. The needle is advanced until contact with the condylar neck, and the anaesthetic deposited.

I find myself using this method more frequently when the standard IDN block does not work on a "hot" tooth following two instances of paraesthesia resulting from a second standard IDN block. Normally if the needle grazes the IDN, the patient's dramatic reaction to the feeling of "an electric shock" is indicative of nerve contact. The needle can be immediately withdrawn slightly and reinserted at a slightly different path. However, with the second IDN block, the nerve is already numb so one loses the benefit of the patient's reaction to accidentally hitting the nerve. One only finds out when the anaesthetic has worn out. Reported incidences of paraesthesia following IDN blocks are low at 1:785000 (Haas & Lennon 1995). The treatment is to give a steroid to reduce destructive inflammation of the injured nerve, for example, dexamethasone 8mg daily for 3-4 days and high dose Vitamin B complex, Neurobion, 1-2 tab tds to encourage regeneration, for the duration it takes to recover. This could be anywhere from 1-6 months. Lastly reassure the patient that healing will take time, although in a small proportion damage could be permanent (Pore & Thamby 2000).

Periodontal ligament injection. This is a good second line of attack as it introduces the anaesthetic locally around the tooth. To be effective the anaesthetic needs to be introduced under strong pressure (Walton & Abbot 1981) but slowly, otherwise there is a high incidence of post-operative tenderness from acute apical periodontitis. If this still fails to achieve anaesthesia, the intrapulpal injection can be used.

Intrapulpal Injection. This works well but first access to the pulp must be obtained. It is preferable that there is only a small access hole to the pulp so that the anaesthetic solution can be introduced under pressure into the pulpal tissue, or directly into individual canals. It will be more comfortable for the patient if topical anaesthetic is applied over the exposed pulpal site for at least one minute before this painful, but effective injection.

Intraosseous injection. This method delivers a good dose of anaesthetic close to the apices of the tooth, but the technique is usually fiddly, requiring drilling a hole through bone to the required site to perform the intraosseous injection, hence this technique has not been popular. A more recently introduced technique (Dentsply/MPL Technologies Hypo Intraosseous dental needle) has a retractable sleeve to provide stability for the 30G needle to be directly injected into the interproximal bone. This simplified technique will probably make this method a more popular alternative.

Minefield No 3: Preparation for root canal treatment and its effect on prognosis

- Removal of caries and defective restorations
- Determine whether tooth is restorable and root is not cracked
- Interim restoration to allow rubber dam isolation

Removal of caries and defective restorations

It is important for a successful outcome of root canal treatment that all caries and defective restorations are removed and replaced with a restoration that provides a good seal, otherwise microleakage between appointments or even after the completion of root canal treatment will compromise the final outcome. This will be discussed later.

Vertical root fracture

Where root fractures are present, the prognosis for root canal treatment is usually poor - therefore, extraction is indicated. When the root fracture is longstanding, a pathgnomonic sign is radiographic bone loss along the side of the root with the crack, which also extends to the periapical area. However where the crack is recent, there will be no radiographic indication of bone loss. Once pulp extirpation is performed and there is good visual accessibility, carefully inspect the walls of the pulp chamber and root canal, preferably under magnification.

Interim restoration to allow rubber isolation

The use of rubber dam for isolation is the standard of care for root canal treatment. Without a rubber dam in place, one will be fighting to keep the field dry, and irrigation may be reduced as the unpleasant tasting hypochlorite solution may accidentally trickle into the patient's mouth, not to mention the possibility of ingestion of a fallen instrument. All these little compromises may contribute to problems down the line, and even to eventual failure of treatment. Should there be insufficient tooth structure remaining to allow rubber dam isolation, the crown can be built up to allow rubber dam use. One simple method which is a good alternative to having to cement on bands is to use a capsulated glass-ionomer cement, for example, quick set Ketac Molar (3M ESPE, Seefeld, Geramany) which has the desired handling properties to allow coiling round the periphery of the root to build up the walls the way a potter would use coils of clay to build-up a pot.

Minefield No 4: Procedural Errors

- Knowledge of root canal system in three-dimension
  - Alterations to internal anatomy by:
    - Age
    - Irritants
    - Calcifications
    - Resorption
  - Anatomical and racial variations
- Access to root canal system
- Limitations of root canal instruments and preparation techniques

Knowledge of root canal system

It is essential to be very knowledgeable about the complex root canal systems and their spatial relationship with their external tooth contours. This will give an appreciation of the position of canals and what the common anatomical variations of each tooth are. In this respect, we need to be aware that the incidence of C-shaped canals is about 62% (Chen *et al.* 1992) of which true C shaped canals account for 27-28% in Singapore and Malaysian Chinese (Chen *et al.* 1992, Thong & Abu Kasim 1995). Some C-shaped canals are fused only in the coronal aspect whilst further apically they break out into individual canals. True C-shaped canals are fused all the way. Cleaning and obturation of these complex root canal configurations are difficult. Another Mongoloid variation is the extra disto-lingual root in mandibular molars, which is present about 44% of the time (Walker 1988), whilst in Caucasians, there are two distal canals in about 25% of cases (Skidmore & Bjorndal 1971).

Access to root canal system

Access to the root canal system is an extremely important procedure, and if not properly shaped will have undesirable consequences, especially during the course of root canal preparation. The objective is to obtain straight-line access to the apex, by removing the waist that is usually present at the orifice level (Figure 2). This also straightens out the coronal portion of the canal, facilitating root canal preparation. There has to be a balance between making the access too large as to weaken the tooth

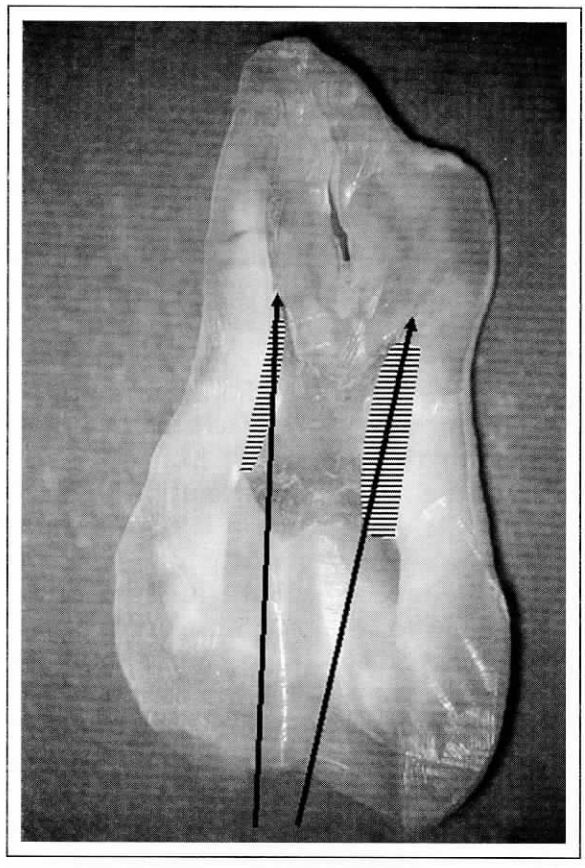

Figure 2

or too small, so that pulpal remnants are left behind causing coronal discolouration or more importantly, obscuring access to canals. The most commonly missed is the second mesiobuccal canal in maxillary molars or the lingual canal in lower incisors. Recent studies show that the incidence of the second mesiobuccal canal in maxillary molars for Asians is 53-65% (Alavi *et al.* 2001, Wasti *et al.* 2002), whereas in Europeans it is approximately 80% in the first molar. For mandibular incisors, an access which extends onto the buccal surface will allow improved access to the lingual canal. The reason there have not been more failures with upper molars and lower incisors teeth is that in the majority of teeth, the two canals join to a single foramen.

While creating access to the root canal system, accidental perforation through the furcation or the side of the tooth could occur. Accidental perforation through the furcation usually occurs in instances of calcification of the pulp chamber. Accidental perforations through the side of the tooth may occur in teeth where the natural crowns are angulated with respect to the root, or where a cast prosthesis realigns a misaligned tooth. To minimise this risk, the following steps can be taken:

- Remove existing restorations to improve visual access
- Do not isolate with rubber dam till after locating pulp chamber
- Mark access approach on buccal surface of teeth
- Take radiographs to check depth or path taken is correct

Knowledge where the canals are to be found is essential. Some tips for locating canals are:

- Floor darker than chamber walls
- Natural contours of the floor lead to canals so do not flatten out the natural contours.
- Locate the easiest canal first
- Visual access to locate canals using an ultrasonic tip is far superior to a conventional slow speed handpiece, reducing the risks of perforations.
- Magnification using loupes or microscopes. There is a learning curve to working under magnification. However, studies show that loupes are only marginally better than working without them; microscopes are definitely useful (Yoshioka *et al.* 2002).
- Use dyes - caries disclosing dyes or methylene blue can help identify canals.
- Transillumination
- H_2O_2 will bubble on contacting pulpal tissue.

Root canal preparation techniques and limitations of various instruments

There is unfortunately no perfect instrument or root canal preparation technique. In very curved canals particularly, knowledge and familiarity with the physical limits of different type and materials of instruments and the different root canal techniques are extremely important, otherwise if exceeded, will result in file

separation and other procedural errors like ledging, perforation etc. It is important to master a technique rather than move from one technique to another on encountering a problem, as every technique or instrument has its limitations. As mechanical nickel titanium instrumentation is now the most popular, some aspects related to this material and techniques are discussed below.

Minefield No 5: Mechanical Nickel Titanium Instrumentation

Nickel titanium instruments, unlike the traditional stainless steel instruments, we are generally used to fracture very suddenly when fatigued, with no warning signs. Stainless steel instruments are more user friendly in that they usually provide warning signs of fatigue like unwinding or increased winding of the files. Therefore, it is important to note the following guidelines to prevent the frustration of file separation in using nickel titanium files:

- Use at a speed of $\leq$ 300 rpm or as recommended by the manufacturer.
- Use each instrument $\leq$ 6 x or as recommended by the manufacturers. Some studies show it may be safe to use instruments for up to 10 cases (Gambarini *et al.* 2001) Again, it depends on how abrupt the curvatures involved in each case is, and these numbers can only act as guides.
- Abrupt curves. Where there are abrupt curves, I would generally discard the instrument after one use only, or alternatively use mechanical instrumentation short of the curvature and use hand instrumentation around the abrupt curvature to working length.
- Practice new techniques on extracted teeth or models first! A study on general practitioners and endodontists concluded that when learning a new root canal preparation technique, both groups had significantly higher file separation rates in their first 13 attempts compared with the next 12. (Mandel *et al.* 1999).

Since mechanical root canal preparation with nickel titanium instruments typically take a few minutes to shape the canal, the root canal will still not be sufficiently cleaned for immediate obturation, as we are accustomed to when using the more tedious hand filing. If this fact is not appreciated, then these nicely shaped canals could be filled when it has not been sufficiently cleaned. This could adversely affect the eventual success of root canal treatment. The only irrigant that can dissolve remnant pulpal tissue and disinfect the canal currently is sodium hypochlorite. It takes about 30 minutes for sodium hypochlorite to dissolve pulpal tissue. Heating the hypochlorite solution to 50 °C increases its efficacy but at the apical third where the volume of solution is small and the exchange of irrigant less effective, there seems to be no significant difference in cleanliness when using heated solutions (Berutti & Marini 1996). There is no consensus on what concentration to use as in vitro studies show that in general, 2.5% to 5.25% seem to be equally effective for flushing (Baumgartner & Cuenin 1992), disinfectant (Siquera *et al.* 2000) and tissue dissolution (Cunningham & Balekjian 1980). However, in these *in vitro* studies, there is a large volume of hypochlorite available for action, whereas clinically, in the apical portion of the root canal, the volume of irrigant is very small and fluid exchange likely to be poorer than further coronally. Probably more important than the concentration of hypochlorite used, is the necessity for frequent and copious irrigation to enable regular exchange of irrigant, and to provide sufficient contact time for its action.

For finishing, I usually use EDTA solution for 1 minute to remove the smear layer formed during mechanical root canal preparation. This opens up the dentinal tubules to allow deeper tubule penetration for the subsequent copious irrigation with hypochlorite. Studies show that the removal of the smear layer allows hypochlorite to disinfect root dentine to a depth of 300 microns instead of 130 microns (Berutti *et al.* 1997).

Degradation of Sodium Hypochlorite

Undiluted 5.25% household bleach, when properly stored in opaque containers away

from direct sunlight has a shelf life of approximately 2 years. When diluted, however, there is a slow degradation over time. While this degradation does not appear to compromise its disinfectant properties over a 30 day period, (Rutala *et al.* 1998) its tissue dissolving properties remain relatively stable for only 1 week after dilution, and then there is a significant decrease in tissue dissolving ability after two weeks. (Johnson & Remeikes 1993). Therefore, if diluted hypochlorite is used, for optimal properties to be maintained, a fresh batch will have to be made every week.

Minefield No 6: Securing Your Success

A fact not fully appreciated for a long time is the role of microleakage of the restoration, whether interim or final, and its role in the failure of root canal treatment. Studies have shown that when the restoration is displaced or is deficient:

- Bacteria in saliva will traverse and contaminate the root filling in 30 days (Khayat *et al.* 1993)
- Endotoxins can traverse root filling in 20 days (Trope 1995)

Therefore, it is important to:

- Change any restoration suspected of leakage.
- Place a definitive restoration as soon as practical.

Conclusion:

This article highlights some areas where the clinician may encounter hidden minefields that may affect the successful outcome of root canal treatment. Each individual will be on different points of the learning curve, and no one reaches the end point, as there is always something new to learn or discover. Hopefully, one is able to identify ones own strengths and weaknesses, and where a case is deemed to have too many minefields for ones own level of experience and expertise, to refer the case.....after all, that is what friends are for!

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