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Contents

2 Editorial Notes

3 President’s Report

Sara Jardine

4 Editorial

Tina Hauman

5 Local Anaesthesia in the Management of Painful Pulpitis

Kimmy Lin

16 Time Saving and Fatigue Reduction in Endodontics

Ala Al-Dameh and Lara Friedlander

23 Endodontic Retreatment – A Surgical Approach

Shalin Desai

27 News from the School

Front Cover: MTA root-end filling placed during surgical retreatment.
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All expressions of opinion and statements of fact are published on the authority of the writer under whose name they appear and are not necessarily those of the New Zealand Society of Endodontics, the Editor or any of the Scientific Advisers.

**Arrangement**
Articles should be typewritten on one side of A4 paper with double spacing and 3cm margins. The author’s name should appear under the title and name and postal address at the end of the article. If possible, the manuscript should also be submitted on computer disc, either Macintosh or PC compatible.

**References**
References cited in the text should be placed in parenthesis stating the authors’ names and date, eg (Sundqvist & Reuterving 1980). At the end of the article references should be listed alphabetically giving surnames and initials of all authors, the year, the full title of the article, name of periodical, volume number and page numbers.

The form of reference to a journal article is:

The form of reference to a book is:

**Illustrations**
Illustrations should be submitted as clear drawings, black & white or colour photographs and be preferably of column width. Radiographs are acceptable. However a black & white photograph is preferred. Illustrations must be numbered to match the text and bear the author’s name and an indication of the top edge on the back. Legends are required for all illustrations and should be typewritten on a separate page.
President’s Report

HAPPY NEW YEAR!

The year is once again starting off at speed, with January and February long gone and March in hot pursuit. I hope you all had a restful break over Christmas and New Year and are ready for the new decade.

As you know, our secretary Mike Jameson resigned last year due to other commitments, but I am pleased to welcome James Fairhall into the post. Thank you very much James for taking up the baton.

I hope you have all taken the opportunity by now to admire Hani’s handywork with our new website. It really does look great and is easy to navigate around. The journal will be available on the site to members only, along with information about upcoming meetings etc. The address is www.nzse.org.nz so get surfing.

Once again please don’t forget to mark in your diary The 2nd Trans Tasman Endodontic Congress in Christchurch from 4-6 November 2010. Only nine months to go. Some of the speakers are yet to be finalised, but it looks as if they already have a pretty good line-up. Thank you all once again for all your input and to the committee for giving up their time to help make the Society run smoothly.

Thanks again Tina for all your hard work with the journal.

All the best, Sara Jardine
Editorial

Dear members,

The current issue includes two review papers, one on the local anaesthetic management of painful pulpitis by Kimmy Lin and the other on time-saving and fatigue reduction in endodontics by Ala Al-Dameh and Lara Friedlander. Shalin Desai reports on a resurgery case with a successful outcome. Thank you all for your contributions to this edition of the journal.

I wish to thank Associate Professor Nick Chandler, who has agreed to act as co-editor for the journal. Nick has extensive experience in editing and refereeing for international journals, is responsible for Dental Research Review which you regularly receive by e-mail, and has been co-ordinating, teaching and supervising on both the undergraduate and postgraduate courses in endodontics for many years. Nick will be a very welcome addition to the team and will certainly contribute greatly to the scientific quality and standard of the journal.

Lastly, I would like to support Sara in thanking Mike Jameson for his service towards to the Society as secretary and Hani for setting up the website and thus allowing you to read this journal online.

My best wishes for the rest of the partly gone 2010!

Tina Hauman
Local Anaesthesia in the Management of Painful Pulpitis

Kimmy Lin

Introduction
The dental profession encounters patients with pain on a daily basis. A survey done by Lipton et al. (1993) revealed that 12% of Americans experienced toothache in the preceding six months. In addition, a majority of the population with dental pain preferred self-medication with analgesics rather than consulting a dentist (Crook et al. 1984, Sindet-Pedersen et al. 1985). Most of these people hoping for instant pain relief require endodontic intervention since pulpitis and acute apical periodontitis are the most frequent causes of dental pain (Sindet-Pedersen et al. 1985).

To improve the public image, erase negative perceptions of endodontic treatment and minimize operator stress, dentists need to create a pain-free operating environment with effective local anaesthesia. However, profound anaesthesia is often difficult to achieve in apprehensive patients with irreversible pulpitis (“hot” pulps) (Wallace et al. 1985). Wallace and colleagues (1985) reported that a majority of the diplomates of the American Association of Endodontists experienced difficulty in anaesthetizing acutely painful teeth in spite of managing to achieve clinically successful mandibular blocks. Other surveys reported that 90% of dentists have encountered similar anaesthetic challenges during restorative procedures (Kaufman et al. 1984, Weinstein et al. 1985).

Because profound local anaesthesia is the bedrock of pain management in endodontics, clinicians need to master a variety of techniques to treat patients with painful pulpitis. However, it is difficult to discuss these innovatory techniques without understanding the pharmacology of local anaesthetics and the background to local anaesthetic failures. This paper will therefore briefly address pain pathways, the pharmacology of local anaesthetics, rationale of ineffective local anaesthesia and current innovations to overcome the anaesthetic challenges in patients with painful pulpitis.

Detection, Procession, and Perception of Pulpal Pain
Pulpal pain is an unpleasant sensation derived from peripheral nociceptive nerve fibres (A-delta and C fibres) located in different regions of the dental pulp (Byers & Dong 1983, Hargreaves & Dubner 1992). The myelinated fast-conducting A-delta fibres are located at the pulp-dentine border, with the greatest nerve density in the pulp horn (Byers & Dong 1983). In contrast, the non-myelinated, slow-conducting C fibres are located in the pulp proper, with their free nerve endings penetrating into the cell-rich zone (Byers & Dong 1983). The intensity of pulpal pain is determined by the frequency of the sensory stimulation, the type of activated nerve fibres and the number of excited nerve fibres (Baart & Brand 2009).

In healthy normal pulps, neurovascular mediators are present in small amounts to maintain pulpal blood and nutrient supply, and to regulate the interstitial pulpal pressure (Fristad 1997). During pulpal inflammation, an increased amount of neuropeptides such as substance P, neurokinin A and calcitonin gene-related peptides are released from the peptidergic afferent fibers in an attempt to control the fluid exudates associated with the inflammatory process and to stimulate pulpal healing (Maggi 1995, Byers & Narhi 1999, Rodd & Boissonade 2000, Bowles et al. 2003).
Voltage-gated sodium channels are responsible for the maintenance of the resting membrane potential across the neuron cell membrane (Li et al. 1999). During pulpal inflammation, the increased concentration of inflammatory mediators activates the sodium channels, which allow an influx of sodium ions into the cytoplasm with a resultant local depolarization. Once the depolarization of the cell membrane reaches a certain threshold level, the threshold of excitability, an action potential is generated and propagated by A-delta and/or C fibres to the trigeminal nuclear complex and to the medullary dorsal horn, where processing of pain occurs (Sessle 1987). The output from the medullary dorsal horn is then conveyed to the thalamus (Light 1992). From the thalamus, secondary neurons relay this information to the cerebral cortex where perception of pain occurs (Guyton 1991).

Although there is no correlation between clinical symptoms and the histopathological status of the dental pulp, the pain descriptor still gives clinicians a reasonable indication of whether the dental pulp is reversibly or irreversibly damaged (Seltzer et al. 1963, Iqbal et al. 2007). Ideally, endodontic amputation, i.e. pulpectomy or pulpotomy, is the treatment of choice for patients with symptomatic pulpitis. However, treatment cannot be efficiently and humanely performed without the presence of satisfactory local anaesthesia.

**Mode of Action of Local Anaesthetics**

Local anaesthetics prevent and remove pain sensation by impeding the generation and transmission of the action potential by blocking the voltage-dependent sodium channels in the nerve cells (Nau & Wang 2004, Fozzard et al. 2005). Mutational molecular studies have localized the anaesthetic binding site to the intracellular side of the sodium channels (Nau et al. 1999, 2003, Kondratiev & Tomaselli 2003). To reach the intracellular binding site, local anaesthetics need to pass through the nerve membranes in the uncharged, lipophilic form (Hille 1977). The uncharged local anaesthetic molecules are then required to transform into ionized, hydrophilic form to bind to the site of action (Hille 1977).

To be able to exist as both lipophilic and hydrophilic forms, the common structural features of local anaesthetics involve a hydrophobic aromatic domain and a hydrophilic tertiary amine that are separated by an intermediate ester- or amide-containing linker (Subramaniam & Tennant 2005). The balance between hydrophilic (charged) and hydrophobic (uncharged) status is determined by the pH of the carrier solutions, the pH at the injection site and the pKa (dissociation constant) of the local anaesthetics (Haas 2002). The strength of the local anaesthetic effect is therefore strongly associated with the lipid solubility of the local anaesthetic, whereas the degree of protein binding determines the duration of local anaesthesia (Frankhuijzen 2009).

**Rationale of Local Anaesthetic Failures**

It is often a challenge to achieve pulpal anaesthesia in teeth with painful pulpitis (Wallace et al. 1985). Several theories have been suggested regarding the rationale of local anaesthetic failures.

**Psychological factors**

A substantial majority of the general population with toothache wait more than 24 hours before seeking emergency dental services (Sindet-Pedersen et al. 1985). These people tend to become apprehensive, tired and stressed as they are not able to function normally. This leads to a decreased pain threshold with subsequent unsuccessful anaesthesia and loss of confidence. This behaviour pattern will often repeat itself in future when dental pain is experienced with the subsequent development of a vicious pain cycle (Kaufman et al. 1984, Walton & Torabinejad 1992).

**Gender factors**

Gender has been considered an important variable in pain perception and the pharmacodynamics of local anaesthetics (Fillingim et al. 1999, Vallerand & Polomano 2001). However, a clinical study on healthy volunteers challenged this common belief by reporting that gender, menstrual cycle phases and the use of contraceptives do not have any effect on anaesthetic efficacy and injection discomfort (Tófoli et al. 2007).

**Anatomical factors**

Inaccurate needle placement, especially with the inferior alveolar block, is assumed to be the prime reason for anaesthetic failure. Contrary to this long-held belief, clinical studies with the use of radiographic and ultrasonic guidance to locate
Local Anaesthesia in the Management of Painful Pulpitis

the mandibular foramen, did not result in a higher incidence of successful pulpal anaesthesia (Berns & Sadove 1962, Galbreath 1970, Hannan et al. 1999). In fact, 25% of accurately placed inferior alveolar blocks produced ineffective anaesthesia (Berns & Sadove 1962). As the anaesthetic solution may follow the path of least resistance, complete diffusion of the targeted nerves may not happen even if the anaesthetic is deposited at the correct site (Galbreath 1970).

Tissue resistance has been shown to deflect bevelled needles away from the bevel side when they pass through tissues of varying densities (Robinson et al. 1984, Hochman & Friedman 2000). Davidson (1989) recommended that the bevel side of the needle be oriented towards the midline in order to take advantage of this lateral deflection toward the mandibular foramen. However, more recent studies noticed that needle deflection is not significantly associated with the efficacy of inferior alveolar nerve block (Kennedy et al. 2003, Steinkruger et al. 2006).

Accessory innervations to the mandibular teeth have also been implicated in failure to achieve adequate inferior alveolar nerve blocks (Rood 1977, Wilson et al. 1984). Clinical and anatomical studies suggested that the lingual, long buccal, auriculotemporal, transverse cervical and mylohyoid nerves may act as accessory nerves to supply afferent impulses from mandibular teeth (Frommer et al. 1972, Wilson et al. 1984, Nist et al. 1992). A study on cadavers showed that the mylohyoid nerve branched from the inferior alveolar nerve at an average of 14.7 mm above the mandibular foramen thus rendering it difficult to anaesthetize during the conventional inferior alveolar block (Wilson et al. 1984). Nevertheless, a clinical trial showed no significant enhancement of mandibular anaesthesia when combining the mylohyoid injection with the inferior alveolar block compared to the conventional mandibular block (Clark et al. 1999).

An anatomical study in cadavers revealed that the mental nerves overlapped in the midline, and re-entered the mandible to be distributed to the mandibular incisors (Starkie & Stewart 1931). Cross-innervation of mandibular incisors from the contralateral inferior alveolar nerves has also been associated with the inferior alveolar nerve block failure in mandibular anterior teeth.

Furthermore, the differences in thickness and density of alveolar bone surrounding the maxillary and mandibular teeth may affect the anaesthetic success of infiltrations (Haas 2002).

Effect of inflammation on local tissues
Inflammation-induced tissue acidosis may retard the hydrolysis of local anaesthetics. This leads to a reduced liberation of the free alkaloidal base which is essential for effective anaesthesia (Haas 2002). This popular theory of ion trapping of local anaesthetics due to low tissue pH has become the prime explanation for ineffective infiltration anaesthesia in inflamed tissues (Jastak et al. 1995, Malamed 2004). However, inflammation-induced tissue acidosis may be minor and localized, and cannot explain failure in nerve block anaesthesia (Punnia-Moorthy 1988, Hargreaves & Keiser 2002).

Despite its limitations, the potential clinical implication of the local pH hypothesis is that pulpal anaesthesia in teeth with irreversible pulpitis may be enhanced by adjusting the tissue pH and the pKa values of local anaesthetic molecules (DiFazio et al. 1986, Subramaniam & Tennant 2005). The low pH (4–6) of local anaesthetic solutions is due to the addition of hydrochloric acid in an effort to improve the stability and water solubility of the anaesthetic molecules (Frankhuijzen 2009). Theoretically, alkanization of the local anaesthetic formulation would enhance its performance (DiFazio et al. 1986). This was not the case in a clinical study by Rood (1977) who found no significant difference between a standard 2% lignocaine (1: 80,000 adrenaline) and a buffered lignocaine formulation used to infiltrate inflamed maxillary teeth.

Moreover, acute inflammation is characterized by marked vascular changes, including vasodilation, increased permeability, and the slowing of blood flow, which are induced by the actions of various inflammatory mediators. It is assumed that the peripheral vasodilation would reduce the concentration and impact of local anaesthetics at the proposed site of action due to the increased rate of systemic absorption.
Effect of inflammation on peripheral nociceptors
The neurodegenerative changes occurring along the inflammation-associated nerve fibres may explain why impulse transmission in inflamed tissues is still possible even in the presence of local anaesthetics (Najjar 1977). Inflammatory mediators, such as bradykinin and prostaglandins, play a key role in altering the status and threshold level of peripheral nociceptors (Byers et al. 1990).

Moreover, the increased expression of prostaglandin E2 during inflammation enhances the expression and activity of the anaesthetic-resistant sodium channels on nociceptors and thus impairs local anaesthetic performance (Roy & Narahashi 1992, Gold et al. 1996, Catterall 2000).

Furthermore, the increased release of inflammatory mediators, as a response to inflammatory stimuli, can sensitize and activate normally quiescent nociceptors to the point where innocuous stimuli can activate the neurons (Rood & Pateromichelakis 1981). The inflammatory mediators also enhance the size of the receptive field by stimulating the growth (sprouting) of peripheral nerve terminals into the site of inflammation (Byers et al. 1990).

Effect of inflammation on central sensitization
Inflammation associated sensitization and activation of peripheral nociceptors results in a series of impulses firing to the central nervous system. This leads to an increased excitability of the trigeminal nucleus and the brain, the so-called “central sensitization” (Latremolierie & Woolf 2009). During central sensitization, local anaesthetics are not able to completely block the impulse transmission as the central neurons can easily be excited by innocuous peripheral stimuli.

The Central Core Theory
The central core theory can be used to explain the common anaesthetic failure in mandibular anterior teeth with inferior alveolar nerve block. It is suggested that the anaesthetic solution may not be able to diffuse into the inner core of the nerve trunk which supplies the mandibular anterior teeth (Strichartz 1967). Instead, the anaesthetic solution may only act on the outside nerve bundles which supply molars, even if the anaesthetic is deposited at the target site (Strichartz 1967). Therefore, the onset and depth of anaesthesia tends to be better in posterior teeth than anterior teeth during mandibular block application. Further, the selective diffusion pattern may explain why local anaesthetic can inhibit the symptoms of teeth with irreversible pulpitis but cannot alleviate the pain during endodontic procedures such as access preparation and/or pulp extirpation (Malamed 2004).

Tachyphylaxis effect of local anaesthetics
When repeating administration of the same drug, timing determines whether the drug performance will be improved (augmentation) or reduced (tachyphylaxis) (Hargreaves & Keiser 2002). If the clinician administers the local anaesthetics before the initial administration wears off, augmentation is likely to occur (Jensen et al. 2008, Scott et al. 2009). However, tachyphylaxis will normally occur if the supplemental administration is given some time after the initial dosage wearing off.

Management of local anaesthetic failures
Conventional injection techniques cannot guarantee 100% success. The success rate in symptomatic teeth with irreversible pulpitis ranges from 19% to 55% with inferior alveolar block (Reisman et al. 1997, Nusstein et al. 1998, 2003, Claffey et al. 2004). To improve the anaesthetic efficacy, the following management approaches have been suggested in the literature.

Psychological Management
To provide effective pain management, clinicians should preidentify patients with apprehension, anxiety, fatigue, and previous history of local anaesthetic failure. These people are likely to have a lower pain threshold, less confidence in dentists and are more likely to develop the vicious pain cycle (Kaufman et al. 1984, Walton & Torabinejad 1992). Early psychological intervention, including effective communication and sympathetic concern, is essential to raise the patients’ pain threshold and treatment tolerance (Fiset et al. 1985).

As dental fear is often related to the unpleasant feeling and experience associated with dental injections, the use of a topical anaesthetic together with slow injection speed can achieve a close to painless injection (Meechan 2002, Kanaa et al. 2006, Whitworth et al. 2007).

Since topical anaesthetic is primarily used
for its psychological benefit rather than its actual anaesthetic effect on the mucosa, a five-second application of a refrigerant (1,1,1,3,3-pentafluoropropane/1,1,1,2-tetrafluoro-ethane) was suggested as an alternative to conventional topical anaesthetics (Kosaraju & Vandewalle 2009). The authors claimed that the use of a cold refrigerant has more benefits than conventional topical anaesthetics in pain reduction, shortening application time and avoidance of an unpleasant taste (Kosaraju & Vandewalle 2009). Occasionally, the use of parenteral sedation or oral triazolam in combination with inhalation anaesthetic may be considered for preoperative patient management (Kaufman et al. 1993).

Time Factor
Traditionally, dentists rely on oral communication and soft tissue signs as indicators of effective local anaesthesia. Sufficient time should be allowed for the anaesthetic solution to diffuse and block the targeted nerves. Although the absence of soft tissue signs implies anaesthetic failure, results from a clinical study showed that positive soft tissue signs do not guarantee successful pulpal anaesthesia (Hsiao-Wu et al. 2007). Moreover, the interpretation of soft tissue signs can be complicated by the past experience and/or emotional status of the patient. Clinicians are therefore advised to measure the level of pulpal anaesthesia with the use of cold testing or electric pulp tester before commencing operative procedures (Certosimo & Archer 1996, Hsiao-Wu et al. 2007).

Increased Volume of Anaesthetics
The anaesthetic effect on sodium channels can cumulate along the associated nerve fibre and result in gradual reduction in impulse conduction velocity and subsequent blockage (Raymond et al. 1989). The degree of pulpal anaesthesia may therefore be improved by increasing the volume of local anaesthetic during the initial administration or by repeating the injection (Yared & Dagher 1997). However, the anaesthetic efficacy is not affected if more than 2 mL anaesthetic is injected into the pterygomandibular space (Nusstein et al. 2002). Nevertheless, an increased volume of local anaesthetic results in augmentation of the anaesthetic effect in maxillary infiltrations and intraosseous injection as well as prolonging the duration of pulpal anaesthesia in maxillary infiltration (Jensen et al. 2008, Mikesell et al. 2008, Scott et al. 2009).

Increased Concentration of Anaesthetic
Two percent lignocaine with adrenaline is commonly used in dental anaesthesia (Subramaniam & Tennant 2005). It was suggested that the concentration of anaesthetic molecules should be increased to compensate for the effect that inflammation has on peripheral nociceptors and central neurons (Rood & Sowray 1980). However, this view was challenged by Kaufman and colleagues (1994) who noticed no association between the concentration of the local anaesthetic and the pulpal anaesthesia efficacy.

Increased Vasoconstrictor Concentration
Although inflammation-induced vascular changes may not be evident at distant injection sites, clinical trials have been conducted in normal subjects to examine whether the use of higher concentration of vasoconstrictors may improve the onset time, duration and depth of local anaesthesia. Knoll-Köhler and Förtsch (1992) found a significant association between higher concentrations of vasoconstrictor and anaesthetic success and duration but not onset time, while other clinical studies could not confirm a dose-dependent relationship (Handler & Albers 1987, Dagher et al. 1997).

Alternative Local Anaesthetics
Articaine hydrochloride was introduced into clinical dentistry as a safe amide local anaesthetic with potentially better anaesthetic success than other anaesthetics (Malamed et al. 2001, Kanaa et al. 2006, Robertson et al. 2007, Evans et al. 2008). Nevertheless, the observed frequency of paresthesia (involving lip and/or tongue) following articaine administration was greater than other local anaesthetics (Haas & Lennon 1995, Haas 2006). In addition, the anaesthetic efficacy of articaine was found to be similar to the conventional local anaesthetics (Oliveira et al. 2004, Mikesell et al. 2005).

Hyaluronidase is an enzyme that can hydrolyze the intercellular ground substance with subsequent
Local Anaesthesia in the Management of Painful Pulpitis

reduced tissue viscosity and increased fluid distribution (Kirby et al. 1949). Earlier dental studies reported promising anaesthetic success with inferior alveolar blocks when hyaluronidase was added into the anaesthetic solution (Kirby et al. 1949, Looby & Kirby 1949). Contrary to these earlier findings, Ridenour and colleagues (2001) found no significant improvement in pulpal anaesthesia with the combination of hyaluronidase and local anaesthetic. Moreover, the authors claimed the potential tissue damaging effect of hyaluronidase may increase the incidence of postoperative pain and trismus.

An experimental trial based on the local pH hypothesis has shown that carbonated anaesthetic solutions have a direct ion trapping effect on the targeted nerves (Chaney et al. 1991). However, the authors were unable to demonstrate any superiority of carbonated anaesthetics over the conventional lidocaine formula in inferior alveolar nerve block (Chaney et al. 1991).

Mannitol (a hyperosmotic sugar alcohol), equipped with the ability to disrupt the perineurium of sensory nerves, has long been used as an osmotic diuretic agent and a weak renal vasodilator (Oddo et al. 2009). Theoretically, the addition of mannitol to local anaesthetic solutions will facilitate the entry of anaesthetic molecules into the inner part of the nerves. A pilot study with mannitol in combination with lidocaine significantly improved the anaesthetic efficacy in patients with irreversible pulpitis compared to conventional lidocaine formula in inferior alveolar nerve block (Reader 2000). This anaesthetic solution is currently undergoing further clinical trials.

Opioid receptors are present both in the central nervous and in the peripheral primary afferent nerve fibres (Twillman et al. 1999). Favourable anaesthetic success (24 hour pain reduction in untreated teeth with irreversible pulpitis) has been achieved with intraosseous steroid (methylprednisolone acetate) administration to halt central and peripheral mechanisms (Gallatin et al. 2000). Additionally, supplemental intraligamentary fentanyl injection results in relatively greater analgesia during endodontic procedures, compared to the conventional supplemental anaesthetics (Uhle et al. 1997, Elsharrawy & Elbarghdady 2007).

Increased Injection Speed
Slow anaesthetic administration not only enhances patient comfort, but also increases the anaesthetic distribution and improves anaesthetic efficacy (Rucci et al. 1995, Kanaa et al. 2006). However, this general belief has been challenged by Whitworth and colleagues (2007). Despite the authors demonstrating that slow injection is more comfortable to patients, they failed to notice any significant association between speed of injection and the anaesthetic efficacy.

Additional Pharmacology Approach
As the nonsteroidal anti-inflammatory drugs (NSAIDs) are able to block the COX pathways and decrease the prostaglandin level, they could be utilized as a supplemental pharmacology approach to inhibit both central and peripheral sensitization with subsequently satisfactory pulpal anaesthesia in teeth with irreversible pulpitis. A recent study has shown that preoperative administration of ibuprofen, one hour before local anaesthesia injection, is able to achieve profound pulpal anaesthesia in teeth with irreversible pulpitis during endodontic procedures (Modaresi et al. 2006).

Altered Injection Position
Previous anatomical evidence has shown that accessory and cross-innervation may be responsible for anaesthetic failures (Starkie & Stewart 1931, Frommer et al. 1972, Wilson et al. 1984). To overcome the anatomic challenges, researchers have examined the effectiveness of additional infiltration, alternative block techniques (Gow-Gates or Akinosi), and supplementary anaesthesia with contradictory results.

Despite the sharp learning curve, earlier studies claimed that the Gow-Gates and Akinosi block techniques improve anaesthetic efficacy and also avoid the need for supplementary injections, decrease positive aspiration rate, save operating time (faster onset) and reduce incidence of post-injection discomfort and complications (Gow-Gates 1973, Watson & Gow-Gates 1976, Akinosi 1977, Malamed 1981). However, a recent study by Goldberg and colleagues (2008) was unable to repeat the above findings. Nevertheless, it is generally accepted that the Gow-Gates and Akinosi techniques are useful in cases when the
Infiltration is the most common mode of injection in the maxilla and enjoys advantages such as high anaesthetic success, user-friendliness and minimal post-injection complications. Therefore, infiltration has been tested either as sole or supplementary anaesthesia with the inferior alveolar nerve block.

A recent clinical trial suggested buccal infiltration with articaine could be a useful alternative to the conventional inferior alveolar nerve block in achieving adequate anaesthesia in mandibular posterior teeth (Jung et al. 2008).

When the standard injection fails to provide sufficient pulpal anaesthesia, even in the presence of classic soft tissue signs, three supplementary injections (intraosseous injection, periodontal ligament injection, intrapulpal injection) are available.

1. Periodontal ligament (PDL) injection
The periodontal ligament injection is the preferred supplemental technique (Bangerter et al. 2009) due to its high success rate, rapid onset, minimal side-effects and relatively simple technique (White et al. 1988, Nusstein et al. 2004). The injection technique involves wedging a needle into the PDL space and forcing the local anaesthetic through the cribiform plate into the surrounding medullary bone adjacent to the anaesthetized tooth (Dreyer et al. 1983). The intraligamentary injection can be utilized either as the primary form of anaesthesia or as a supplementary injection to the conventional approach (Childers et al. 1996, Nusstein et al. 2005).

Special pressure syringes have been commercially marketed but they have not been demonstrated to be superior to the standard syringe (Walton & Abbott 1981). Recently, a computer assisted local anaesthetic delivery system, the Wand® (Compudent, Milestone Scientific Inc. Piscataway, NJ, USA) has been introduced to facilitate intraligamentary injection. By forcing 1.5 mL anaesthetic solution into the surrounding cribiform plate over approximately 5 min, the Wand® system has the clinical advantage of developing significantly more anaesthesia in comparison to the conventional syringe or pressure syringe (Walton et al. 2009).

The major shortcomings of PDL injection are postoperative discomfort (especially to biting pressure), short duration of pulpal anaesthesia (4-20 minutes) and the need to use an anaesthetic with vasoconstrictor (Meechan 2002).

2. Intraosseous injection
The intraosseous injection directly delivers the anaesthetic solution into the surrounding cancellous bone adjacent to the anaesthetized tooth. It has a high success rate, an immediate onset with adequate operating time and with rare contraindications or transient side-effects (Nusstein et al. 1998, Parente et al. 1998, Gallatin et al. 2003). It can be used either as the primary anaesthetic approach in teeth with irreversible pulpititis or as a supplementary injection to conventional block/infiltration (Nusstein et al. 1998, Remmers et al. 2008). Despite its clinical advantages, only 43% of active members of the American Association of Endodontists utilized it (and less than twice a week) (Bangerter et al. 2009). The authors claimed this may be due to perceived difficulty, sharp-learning curve and lack of available training.

The current commercial devices for intraosseous injection are the Stabident™ System (Fairfax Dental, Inc., Miami, FL, USA), X-tip™ system (X-tip Technologies, Lakewood, NJ, USA) and the IntraFlow™ system (Intra Vantage, Plymouth, MN, USA). Despite the different design of each device, they all involve a perforator and a syringe needle.

After anaesthetizing the soft tissue via infiltration, the operator chooses the perforation site by mentally drawing a horizontal line on the gingival mucosa and a vertical line passing through the interdental papilla distal to the tooth to be injected (Gallatin et al. 2003). The perforation site is approximately 2 mm below the intersection of these two lines and is preferably within the attached gingiva. Consequently, the major contradiction of intraosseous injection is the availability of perforation site. The decision is dependent on the amount of attached gingiva, root proximity, and presence of active periodontal disease. An exception is normally in the second molars where a mesial perforation site is preferred (Gallatin et al. 2003). Moreover, it is essential to avoid anaesthetic solution squirting out of

conventional inferior alveolar nerve block cannot be applied, such as limited mouth opening.
the perforation site to avoid anaesthetic failure (Nusstein et al. 2003).

3. Intrapulpal injection
The intrapulpal injection normally acts as a last resort for managing local anaesthetic failure. It utilizes the principle of pressure anaesthesia by forcing the anaesthetic solution into the pulp in the presence of positive back-pressure (Birchfield & Rosenberg 1975). Consequently, the prime factor in determining the degree of pulpal anaesthesia is pressure rather than the type of anaesthetic solution (Birchfield & Rosenberg 1975).

The main advantages of intrapulpal injection are its immediate onset, high success rate and relatively simple technique (Meechan 2002). Its main disadvantage is that the pulp needs to be exposed while major anaesthetic failure normally occurs in dentine (Meechan 2002).

Conclusion
Painful pulpitis remains the most common cause of endodontic emergencies. Complete pulpal removal is the ideal choice of treatment to predictably relieve patient discomfort. However, the endodontic intervention cannot proceed unless the treated teeth have profound pulpal anaesthesia. Because of the persistent pulpal inflammation, an increased amount of inflammatory mediators can act on the vascular mechanisms, peripheral nociceptors and central neurons to reduce the excitability threshold and to impede local anaesthetic efficacy. To overcome the inflammation-associated anaesthetic challenge, clinicians should start with conventional injection techniques and assess the pulpal anaesthesia with either an electric pulp tester or a cold testing. If the test result is positive but the patient presents with classic soft tissue signs, clinicians should commence with either intraligamentary or intraosseous supplementary injections depending on the proposed operating time. In addition, pre-operative psychological and pharmacological management may need to be considered to enhance patient tolerance levels to anaesthetic administration and treatment procedures.

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Time Saving and Fatigue Reduction in Endodontics
What instruments and techniques actually help?

Ala Al-Dameh and Lara Friedlander

Introduction

The prevalence of musculoskeletal complaints, particularly disorders of the upper extremities; neck, shoulders, arms, elbows, wrists, hands and fingers, is high among dental health workers (Alexopoulos et al. 2004, Lindfors et al. 2006, Puriene et al. 2008). The occurrence of such complaints among dentists has been linked to their work-related physical load (Alexopoulos et al. 2004). Certain conditions, e.g. finger osteoarthritis, are more prevalent in dentists performing repetitive tasks compared to those performing varied tasks (Solovieva et al. 2006). In fact, repetitive hand and finger motions associated with some dental treatments puts dentists at risk of developing carpal tunnel syndrome, one of the most common occupational overuse syndromes (Fish & Morris-Allen 1998).

Work output, physical tension and mental exertion resulting from dental procedures are influenced by several factors. These include dentists’ skillfulness and experience with the procedures, the efficiency and teamwork of the dental team and the amount of cooperation given by the patient. Other technical factors include the length and type of the operation, and the availability of facilities and equipment. The use of new dental technologies reduces the duration of dental procedures, minimising stress and operator fatigue.

This paper will review instruments and techniques that may help to save time and reduce fatigue during non-surgical endodontic treatment.

Diagnosis and Treatment Planning

Digital radiography

Radiographs play an important role in clinical endodontics, from initial diagnosis through to post-treatment review. Developments in radiographic imaging systems have introduced benefits to endodontic practice with more clinicians choosing to use digital radiography in preference to conventional radiography (Lee et al. 2009). Some of the advantages of digital radiography include the instantaneous production of captured images with elimination of the development process and chemical waste, a reduction in radiation dose, the option of image enhancement, ease of data storage and communication with other clinicians (Wenzel & Grondahl 1995, Christensen 2004).

Digital radiography has led to faster, safer, and more efficient endodontic radiography. In conventional radiographic techniques, clinicians would usually stop the procedure while waiting for the image to be processed. The ability to instantly view images on a screen saves time and allows dentists to make more timely treatment modifications. Some studies have shown that digital images are inferior to conventional film radiographs for the detection of small endodontic instruments (Sanderink et al. 1994, Ellingsen et al. 1995, Fuge et al. 1998, Friedlander et al. 2002). Other studies concluded that digital radiography systems have improved, and can be used to estimate canal lengths including curved canals with accuracy comparable to that of conventional radiographs (Lamus et al. 2001, Mentes & Gencoglu 2002). New image enhancement features have been developed to improve the diagnostic quality of digital radiographic images. The quality of enhanced digital images has been shown to be superior to the original and the conventional film images (Akdeniz & Sogur 2005, Woolhiser et al. 2005). Furthermore, image enhancement is an effective patient education tool. Storing patient records electronically is also convenient, easier and allows rapid retrieval of data when needed.

Computed tomography (CT) technology overcomes the disadvantage of conventional radiography in which 3-D structures are presented as 2-D images. High-resolution limited cone-beam volumetric tomography (CBVT) has been designed for dental applications. This new
imaging modality uses a cone beam instead of a fan-shaped beam as in CT imaging. Potential applications of CBVT in endodontics include the diagnosis of endodontic pathosis and canal morphology, assessment of pathosis of non-endodontic origin, analysis of root resorption and presurgical planning (Cohenca et al. 2007, Cotton et al. 2007, Patel et al. 2007). Better preoperative assessment results in better anticipation and management of any problems that may occur during the treatment, increases the outcome of the therapy and avoids further complications, which in turn reduces the overall time of the operation. Considering the cost and the availability of the equipment, however, it is wrong to suggest that all patients should be examined with CBVT. CBVT should only be considered when conventional radiographs are yielding limited information and when additional radiographic details are required for diagnosis and treatment planning (Patel et al. 2007, Stavropoulos & Wenzel 2007). This would be of particular use for diagnosis of non-healing apical pathology.

Electronic apex locators
Initial use of the electronic apex locator (EAL) for working length determination saves time by minimizing the need for additional radiographs. The EAL allows for greater accuracy of working length control if used with appropriate radiographs (McDonald 1992, Segura-Egea et al. 2002, Haffner et al. 2005). Several studies reported that the accuracy of apex locators is higher for working length determination when compared with radiographic methods (Pratten & McDonald 1996, Kim & Lee 2004, Shamiraj et al. 2007, Krajczar et al. 2008). The number of radiographs taken during root canal treatment of a molar is reduced when an EAL is used (Chandler and Koshy 2002). The use of apex locators alone without a preoperative radiograph is not recommended due to variations in tooth morphology, as well as medico-legal record keeping requirements. Furthermore, the radiograph provides valuable diagnostic information and assessment of canal form and curvature. The EAL is very helpful in patients with structures or objects that obstruct visualization of the apex and patients who cannot tolerate films and have a strong gag reflex.

The most important advantage of EAL over radiography is that it can measure the length of the root canal to the apical foramen, and not to the radiographic apex (Kobayashi 1995). In the primary dentition, small areas of physiological resorption will often not be visible radiographically, especially when resorption occurs on the buccal or lingual aspect of the root, and an increased risk of over-instrumentation will result (Mente et al. 2002). EALs are able to determine the root canal length of primary teeth accurately, with and without physiological root resorption (Mente et al. 2002, Leonardo et al. 2008).

EALs can also provide a quick and time saving method for diagnosis of perforations and horizontal root fractures (Fuss et al. 1996, Kaufman et al. 1997, Azabal et al. 2004, Ebrahim et al. 2006). The presence of perforations or any communications between the root canal and the periodontal membrane, as in root fractures, cracks and internal or external resorption, will give an EAL reading of beyond the ‘apex’.

Transillumination
The use of transillumination, placing a fibreoptic light at various locations on the crown or root, can provide an easy and quick method for locating cracks. Placement at right angles to the fracture plane can result in the beam being interrupted by the fracture, resulting in illumination of the ipsilateral side of the tooth, with the contralateral side remaining dark.

Magnification
Loupe and the operating microscope provide excellent visibility and improved posture and comfort, with the consequent reduction in operator’s fatigue. Magnification increases the incidence of canal location resulting in better treatment outcomes with less time and fatigue for the operator (Coelho de Carvalho & Zuolo 2000, Gordusus et al. 2001, Buhrely et al. 2002, Maggiore et al. 2002, Yoshioka et al. 2005, Coutinho Filho et al. 2006).

Preparing the Root Canal System
Rotary instruments
Repetitive hand and finger motions associated with dental treatment puts dentists at risk of developing carpal tunnel syndrome (Fish & Morris-Allen 1998). Few studies have evaluated the effect of hand versus rotary instrumentation of the root
canal and the development of musculoskeletal disorders. However, several studies have reported time reduction in the preparation of root canals using rotary instrumentation. One showed that the mean working time using hand instruments was almost five times longer than when using rotary instruments (Pasqualini et al. 2008).


The removal of gutta-percha (GP) with hand files is time-consuming, especially when the filling material is well condensed (Sae-Lim et al. 2000, Hulsmann & Bluhm 2004). New rotary instruments have been specifically designed for removing filling materials. Studies show that these are safer and less time-consuming than hand files for the removal of root filling materials (Giuliani et al. 2008, Gu et al. 2008, Somma et al. 2008). Regardless of the technique used, it is impossible to remove all traces of GP or sealer from root canals (Wilcox et al. 1987, Hulsmann & Stotz 1997, Sae-Lim et al. 2000, Bueno et al. 2006, Kosti et al. 2006, Zmener et al. 2006, Gu et al. 2008, Hammad et al. 2008, So et al. 2008). Authorities recommend the use of rotary files in combination with hand files to achieve optimal cleanliness of root canal walls. Rotary instruments remove most of the canal filling quickly, and then hand instruments refine and complete its removal.

Although rotary instrumentation reduces the time during root canal preparation (Molander et al. 2007) it has the disadvantage of producing only circular preparations (Rodig et al. 2002). Peters and colleagues (2001) reported that nickel-titanium instruments left 35% or more of the canal’s surface area unchanged. Therefore, irrigation with antibacterial solutions or chelating agents is recommended for thorough debridement of the root canal system. In addition, the incidence of broken instruments has risen with the increased use of rotary NiTi files (Ruddle 2004, Terauchi et al. 2006), which increases treatment time with the removal of the separated instrument.

Laser irradiation

The first laser use in endodontics was reported by Weichman & Johnson (1971). Laser technology has made rapid progress in the last decade. The acceptance of this technology among endodontists has remained limited. Thermal injury to the periodontal tissues is one of the main concerns in using lasers in endodontics (Armengol et al. 2000, Shoji et al. 2000, Kimura et al. 2002).

Several in vitro studies have investigated lasers for endodontic applications. All require a fiber or guide tube to direct the laser beam into the narrow root canal system. Shoji and colleagues (2000) reported that root canal enlargement and debridement by Er:YAG laser using a cone-shaped irradiation tip may have the advantage of decreasing the preparation time.

Controversial findings regarding the use of laser irradiation for disinfecting root canals are reported in the literature. Jha and colleagues (2006) reported that the use of a laser to disinfect root canals was not effective. This was contradicted by the study of Gordon and colleagues (2007), where 99.7% disinfection was achieved using the same laser. The authors attributed the differences in the results to different methodology used in the two studies. They concluded that the use of laser may be a valuable tool for root canal disinfection that would minimize the length of the procedure and dependence on mechanical instrumentation, and fatigue on the operator.

Obturation of the Root Canal System

Single Visit Therapy

Single visit root canal treatment reduces operator working time and simplifies treatment scheduling. In a survey of the members of the American Association of Endodontists, single visit therapy was conducted by more than half of the respondents. In cases of infected root canals, 34.4% of respondents stated they would complete the treatment in one visit (Inamoto et al. 2002). Single visit therapy is more appropriate for
busy or itinerant patients, patients under general anaesthesia, and in the management of traumatized teeth, when no infection is present.

Several authors report that completing obturation immediately after preparing and irrigating the canal space at the same visit eliminates any remaining microorganisms via the antimicrobial action of the sealer or the gutta percha (Moorer & Genet 1982, Kaplan et al. 1999, Fuss et al. 2000, Siqueira et al. 2000) or render them harmless by depriving them of nutrition and space to multiply (Peters et al. 1995, Weiger et al. 2000).

Studies evaluating canal disinfection and periapical healing of endodontically treated teeth found no statistically significant difference between single and multiple therapy visits (Trope et al. 1999, Weiger et al. 2000, Peters & Wesselink 2002, Vivacqua-Gomes et al. 2005, Gurgel-Filho et al. 2007, Penesis et al. 2008). Although single visit therapy reduces operation times, the incidence of post-operative swelling following single visit therapy appeared to be more common than in multiple visit therapy. These differences however, did not reach statistical significance (Mulhern et al. 1982, DiRenzo et al. 2002, Ghoddusi et al. 2006). Postoperative pain and the use of analgesics were reported to be higher in single visit therapy (Soltanoff 1978, Ng et al. 2004, Yoldas et al. 2002). Single visit therapy is more feasible in selected cases of teeth with apical periodontitis, such as teeth that are asymptomatic with no pain, swelling or draining sinus tract (Lin et al. 2007).

**Single-cone technique**

The conventional root-filling technique taught in many dental schools is the cold lateral compaction technique, using a 0.02 tapered gutta percha point as the master cone supplemented with accessory cones. This method is considered time-consuming. The tapered single-cone technique is faster and easier to operate. Manufacturers of tapered gutta percha cones that match canal shapes created by similarly tapered rotary instruments claim that the tapered prepared canals can be filled effectively. Studies have reported that the quality of root canal fillings performed with the single cone technique is comparable with the lateral compaction technique (Gordon et al. 2005, Horsted-Bindslev et al. 2007), and that the single cone technique is significantly faster (Gordon et al. 2005).

**Warm Gutta Percha techniques**

The original technique of vertical condensation is time-consuming (McRobert & Lumley 1997). New technologies in thermostatic obturation have made the downpack and backfill procedures simpler, faster and easier (Buchanan 2004, West 2006). The manufacturers of the Elements Obturation Unit (SybronEndo) claim that their micro-motor-driven extruder automates the backfill process and therefore eliminates operator hand fatigue. Although no studies have been published comparing fatigue reduction in different obturation techniques, several studies report that the continuous-wave technique can reduce the time needed for obturation of the canal system (Silver et al. 1999, Buchanan 2004, Kececi et al. 2005).

**Conclusion**

Methods that effectively reduce the duration of dental operations may lead to less clinician and patient fatigue. The elimination of infection and prevention of subsequent infection is the main goal of root canal therapy. New techniques and instruments that reduce operation times without jeopardizing the goals of therapy should be implemented for maximum benefit to patients and endodontists.

**References**


Time Saving and Fatigue Reduction in Endodontics

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New Zealand Endodontic Journal Vol 41 April 2010 Page 21
Time Saving and Fatigue Reduction in Endodontics


Endodontic Retreatment – A Surgical Approach
Shalin Desai

Introduction
Persistence or emergence of periapical disease following non-surgical endodontic therapy is not uncommon. Intra-radicular or extra-radicular microbial or non-microbial causes of such lesions have been discussed in the literature (Desai 2008). Conventional retreatment and apical surgery are treatment options for root-filled teeth with persistent disease. Retreatment offers a better chance of reducing the bacterial load in intra-radicular infections as it is an attempt to remove all bacteria from the root canal system. Surgery can only attempt to confine the bacteria within the system. If the infection or cause of failure is of an extraradicular nature, apical surgery will be the only way of eliminating it.

Intra-radicular infections are far more common than exclusive extra-radicular infections (Nair et al. 1996, Sundqvist & Figdor 2003). This is important when considering the treatment of persistent endodontic disease. Retreatment should always be the treatment of choice as it offers greater benefits in being able to eliminate the cause of infection with less post-operative discomfort and a lower risk of injuring anatomical structures. The importance of retreatment is emphasized by the work of Grung and co-workers (1990) who showed a difference in success rate of 24% when retreatment was performed before apical surgery. It suggests that a higher success rate can be expected when intra-radicular infections are addressed with non-surgical retreatment prior to the removal of extra-radicular infections by means of apical surgery.

Treatment options are limited in the case of persistence of periapical disease following apical surgery. Most practitioners opt for extraction of the tooth in such cases but re-surgery can be a viable option. Information regarding the outcome of endodontic re-surgery is limited. The following case reports apical re-surgery following initial surgery performed 33 years ago.

CASE REPORT
A 52-year-old-male visited the endodontic clinic in March 2007 with the complaint of the presence of an intra-oral sinus opposite tooth 25. The patient did not have pain associated with this tooth, was medically fit and had no known allergies. Tooth 25 was restored in 1971 with a porcelain-fused to metal (PFM) crown. The tooth had a history of root canal treatment and apical surgery in 1974. The patient was a regular visitor to the School of Dentistry and his clinical records showed a
detailed treatment history for tooth 25. This was as follows:

02/1971: Full coverage coronal restoration of tooth 25 due to gross caries or developmental defect
09/1974: Severe pain and later development of a draining sinus from tooth 25. Radiographically calcified root canals and periapical lesion can be seen.
10/1974: Tooth 25 received apical surgery and an apical amalgam restoration (without prior endodontic treatment).
10/1975: Post surgery recall. The draining sinus had healed though radiographically the periapical area was not showing any signs of resolution. There were no further recall appointments mentioned in the clinical notes.

Clinically, tooth 25 was asymptomatic with no tenderness to percussion and palpation. Mobility and periodontal probing depths around the tooth were within the normal range. An intra-oral sinus was present on the attached buccal gingival above tooth 25 (Photograph 1). There was no drainage. A periapical radiograph revealed satisfactory crown margins and a short root. Root canal(s) were obliterated and could not be traced on the radiograph. The root had been resected at a bevel, with an amalgam root-end filling and periapical bone loss. The apical radiolucency presented with indistinct borders and was approximately 7 mm in diameter. Some scattered amalgam particles were seen within the radiolucency (Radiograph 4 & 5).

A diagnosis of chronic periapical periodontitis was made. The planned treatment included non-surgical root canal treatment through the PFM crown followed by surgical curettage of the root-end lesion and replacement of the existing amalgam root-end filling with MTA.

Access to the pulp chamber was gained through the PFM crown but root canal orifice(s) could not be located. The access cavity was restored with composite resin. Apical surgery was performed (Photograph 2, 3 & 4, Radiograph 6). The post-operative phase was uneventful and the histological diagnosis was periapical granuloma. The 6, 12 and 24 month reviews showed resolution of the buccal sinus tract (Photograph 6) and the periapical radiolucency (Radiographs 7, 8 & 9).

Discussion

Tooth 25 received extensive dental treatment 33 years ago but unfortunately the periapical lesion never healed. The patient was enthusiastic to keep the tooth. The treatment aim was to eliminate persistent infection, remove chronic granulomatous tissue from around the root tip and to place a biocompatible root-end filling. The obliterated root canals could not be located but with the surgical approach, the periapical tissue was curetted and the amalgam root-end restoration was replaced with MTA.

Gangliani et al. (2005) in a 5 year prospective study comparing the outcome of initial apical surgery and re-surgery cases, concluded that the success rate was significantly lower for re-surgery but still a valid alternative to extraction. In more than 90% of initial surgery cases there were either

some signs of healing or complete healing present but only 40% of re-surgery cases showed positive outcomes. In a meta-analysis of 8 studies Peterson and Gutmann (2001) concluded that 36% of resurgery cases healed successfully, 26% healed with uncertain results and 38% did not heal. Persson in 1973 reported a similar success rate (35%) with 129 repeat apical surgeries.

The current case showed that re-surgery even without retreatment (as the canal(s) could not be located or negotiated) may result in healing and a successful outcome with the possibility of retaining the tooth.

References
Professor Robert Love became Discipline Head in Endodontics in late 2009. We currently have eight DClinDent postgraduate students studying endodontics. The three students who graduated in 2009 have returned to Australia. Abdul Aziz and Artika Soma (née Patel) are working in Melbourne and Shalin Desai is in Sydney. Their thesis titles were:

Abdul – Disinfection of the root-end cavity; a confocal microscope bacterial viability study
Artika – Effect of laser light on the root-end cavity and MTA root-end filling: a SEM and dye leakage study
Shali – Expression of Toll-like receptor-2 in periapical lesions of endodontic origin

The external examiner for the clinical components of the doctorate was Dr Stephen Harlamb of Sydney.

Three staff members and four postgraduate students from the School of Dentistry attended the 14th Biennial Congress of the European Society of Endodontontology in Edinburgh, Scotland in September 2009. Their presentations were:

Infection at the root apex: a confocal microscope study of bacterial viability

Effectiveness of MTA root-end fillings following cavity lasing
Keynote speakers included big names such as Dr Frances Andreasen, Professor Markus Haapasalo, Professor Kishor Gulabivala, Professor Thomas von Arx and many more.

Some of the more current topics included the role of biofilms in endodontic infections, cone-beam imaging and its potential uses in endodontics, and the design features and clinical advantages of “Twisted Files”. Adhesive post endodontic restorations with indirect ceramic and composite restorations were discussed as exciting alternatives to metal ceramic crowns.

Edinburgh was everything I hoped for, with much better weather (at least while the conference was going) than Dunedin and the familiarity of being home when walking down Great King Street, George Street, Hanover Street or many of the other streets with familiar names. The history of the city is enchanting with visits to the Royal Mile and Edinburgh castle being the highpoints for me during my short stay there.

The 2011 congress will be held in Rome, Italy for those of you want to plan ahead of time for a conference well worth attending while having the opportunity to visit Rome at the same time!

Tina Hauman
TABLE 3: Antibacterial regimen for dental procedures

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>Dose (child: 50mg/kg up to 2kg), administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxycillin</td>
<td>2g</td>
</tr>
<tr>
<td></td>
<td>Orally, 1 hour before the procedure, or</td>
</tr>
<tr>
<td></td>
<td>IV, just before the procedure, or</td>
</tr>
<tr>
<td></td>
<td>IM, 30 minutes before the procedure</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>600mg</td>
</tr>
<tr>
<td></td>
<td>Orally, 1 hour before the procedure, or</td>
</tr>
<tr>
<td></td>
<td>IV, over at least 30 minutes, just before the procedure, or</td>
</tr>
<tr>
<td></td>
<td>IM, 30 minutes before the procedure</td>
</tr>
<tr>
<td>Clarithromycin</td>
<td>500mg</td>
</tr>
<tr>
<td></td>
<td>Orally, 1 hour before the procedure</td>
</tr>
</tbody>
</table>

For penicillin allergy or if a penicillin or cephalosporin-group antibiotic is taken more than once in the previous month (including those on long-term penicillin prophylaxis for rheumatic fever):

- **Clindamycin 600mg (child: 15mg/kg up to 600mg), administered**
  - Orally, 1 hour before the procedure, or
  - IV, over at least 30 minutes, just before the procedure, or
  - IM, 30 minutes before the procedure

- **Clarithromycin 500mg (child: 15mg/kg up to 500kg)**
  - Orally, 1 hour before the procedure

Clindamycin is not available in syrup form in New Zealand. Beware potential interactions between clarithromycin and other medications.

If the antibacterial agent is inadvertently not administered before the procedure, it may be administered up to 2 hours after the procedure.

IV: intravenous, IM: intramuscular
(Adapted from Ellis-Pegier et al. 2008)