Contents

3 Editorial

4 Intracanal Medicaments Revisited

16 New Root Canal Filling Materials

25 2006 Annual General Meeting

26 Abstracts
   Root-end Filling Materials:
   Rationale and Tissue Response
   Surgical Preparation:
   Anaesthesia & Hemostasis
   Comparative Evaluation of
   Endodontic Irrigants against
   Enterococcus faecalis Biofilm

Peter Cathro
Jack Lin
Rajneesh Roy
Bun San Chong &
Thomas R Pitt Ford
Kenneth Hargreaves &
Asma Khan
Thomas R Dunavant,
John D Regan,
Gerald N Glickman,
Eric S Solomon,
Allen L Honeyman

Front Cover: Intracanal medicaments
EDITORIAL NOTICES

The New Zealand Endodontic Journal is published twice yearly and sent free to members of the New Zealand Society of Endodontics (Inc). The subscription rates for membership of the Society are $35 per annum in New Zealand or $45 plus postage for overseas members. Graduates of the University of Otago School of Dentistry enjoy complimentary membership for the first year after graduation. Subscription inquiries should be sent to the Honorary Secretary, Dr Mike Jameson, 2 Granville Terrace, Dunedin.

Contributions for inclusion in the Journal should be sent to the Editor, Dr Robert Love, PO Box 12025, Dunedin. Deadline for inclusion in the May or November issue is the first day of the preceding month.

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.

INFORMATION FOR AUTHORS

The Editor welcomes original articles, review articles, case reports, views and comments, correspondence, announcements and news items. The Editor reserves the right to edit contributions to ensure conciseness, clarity and consistency to the style of the Journal. Contributions will normally be subjected to peer review.

It is the wish of the Editor to encourage practitioners and others to submit material for publication. Assistance with word processing and photographic and graphic art production will be available to authors.

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.
EDITORIAL / PRESIDENT’S REPORT

There have been some exciting developments in Endodontics over the last few years, in particular the areas of irrigation, medication and obturation. Rajneesh Roy’s article details some of the new products available for obturation. Jack Lin’s article on intra-canal medication revisits the age-old dilemma – does Ledermix still have a place in our medication armamentarium? I am reminded by a comment made by Dr. Cliff Ruddle at the European Society of Endodontists meeting in Greece – “I hear so many different ways to clean, shape and fill canals. What does this mean? It means we still really don’t know what we’re doing. If we did, there would be one gold standard!” It remains the clinician’s job to interpret scientific results and apply them to their daily practice.

Obituary
Dr. Bernie Hoskin had a varied career from fighter pilot, to chartered accountant and then dentistry. Bernie’s contribution to Endodontics is enormous and he was founder of The New Zealand Society of Endodontics and a Life Member. Bernie gave a great deal of his time and energy to the profession, holding many positions in the NZDA and other special societies. Bernie was a highly respected practitioner and colleague and an inspiration to many.

Editor Retires
After a number of years of involvement as secretary then President and Editor I feel that it is time to stand aside. There will be an election of officers at the AGM in September, but I would be particularly interested in hearing from anyone who feels they would like to take on the role as editor. The team at Otago University Print is delightful and easy to work with and we are most fortunate to have a steady stream of material thanks to our post-graduate students who are producing excellent assignments.

Endodontic Lecture
In mid-march 2007, the Society will be bringing Ramachandran Nair on a tour with lectures in Auckland, Wellington Christchurch and Dunedin. Dr. Nair is a Senior Scientist in the Department of Oral Structural Biology, Centre of Dental Medicine, University of Zurich. He is also the Chairman of the Swiss Society for Endodontology Scientific Committee. He has numerous publications and is perhaps best known for his chapter in Pathways of the Pulp textbook and his long-term light and electron microscopic study on therapy resistant periodical lesions. The dates and venues are to be advised, but don’t miss out on this fantastic opportunity.

Peter Cathro
**INTRODUCTION**

Endodontic treatment is usually performed when apical periodontitis is present. The aetiology of pulpal and periapical tissue inflammation is microbial infection (Kakehashi et al. 1965; Paterson 1976; Gomes et al. 1996). Mechanical instrumentation and irrigation are the main methods of removing bacteria from the root canal space (Kettering & Torabinejad 1998). Microorganisms can survive after instrumentation and irrigation, and show an increase in numbers in empty canals between visits without any intracanal medicament (Bystrom & Sundqvist 1981, 1983, 1985). The complexity of the root canal system (Meyer 1970) and the ability of microorganisms to penetrate dentinal tubules and lateral canals (Love 1996; Siqueira et al. 1996) may account for this.

Intracanal medication has been advocated individually or in combination to:

1. Eliminate remaining microbial populations in the root canal system after canal instrumentation.
2. Reduce inflammation of pulp remnants (and thereby reduce pain).
3. Prevent contamination between appointments.
4. Induce healing of calcified tissue.
5. Render canal contents inert and neutralise tissue debris.
6. Act as a barrier against leakage from the temporary filling.
7. Control inflammatory root resorption following traumatic injuries.

Antibacterial intracanal medicament is used to eliminate residual bacteria after chemomechanical instrumentation. The toxicity and potency of the antibacterial agent will eliminate microorganisms, but also has the potential to damage the periapical tissue. Therefore the biocompatibilities of medicaments need to be considered (Taylor et al. 1989; Abbott et al. 1990; Tepel et al. 1994). Medicaments with an anti-inflammatory agent are used to reduce postoperative pain and acute exacerbations. Corticosteroids have been used to reduce interappointment pain (Negm 2001; Ehrmann et al. 2003). This paper will review the current use of Ledermix® paste (Lederle Pharmaceuticals, Cyanamid GMBH, Wolfratshausen, Germany) and other current intracanal medicaments.

**LEDERMIX® REVISITED**

Ledermix can be classified as a setting (not to be reviewed here) or non-setting material. The non-setting Ledermix paste consists of two active compounds, which are an anti-inflammatory cortisone derivative triamcinolone acetonide (glucocorticosteroid 1%) combined with a tetracycline antibiotic, demethylchlortetracycline (demeclocycline 3.021%). The remaining components form a water-soluble cream base (Lederle Pharmaceuticals 1981). Non-setting Ledermix paste is used as an endodontic medicament.

**ANTIBACTERIAL EFFECT OF LEDERMIX**

The antibacterial action of Ledermix paste is from the broad-spectrum tetracycline antibiotic. This is effective against the Gram-negative and Gram-positive anaerobic microorganisms normally found in endodontic infections (Dahlen & Haapasalo 1998). Heling and Pecht (1991) reported that Gram-positive microorganisms were affected by lower concentrations of tetracycline than the Gram-negative microorganisms, and other antibiotics showed a more potent antibacterial effect than Ledermix. In experimental conditions, clindamycin was more effective in the agar diffusion test and showed on ability to penetrate dentinal tubules up to 400 µm (Lin et al. 2003). Thus the efficacy of the Ledermix paste as an ideal endodontic antibiotic may be suspect.

Demeclocycline is generally effective against common endodontic bacteria at concentrations ranging from 0.05 to 128mg/L (Abbott et al. 1990). Since Ledermix paste produces a demeclocycline concentration of 50,000 mg/L it should be able to inhibit bacteria (Sutter & Finegold 1976).
However, the concentration of demeclocycline achieved within the dentinal tubules, periodontal tissues and periapical tissues varies as a function of time and position. Abbott et al. (1988) used absorption spectrophotometric analysis in extracted human tooth roots which were endodontically prepared and dressed with Ledermix. They found the great majority of demeclocycline diffused through dentine, and little through the root apex. Within the first day the rate of the demeclocycline release was the highest and concentration adjacent to the root canal achieved the bacterial inhibitory level (Abbott et al. 1990). This level dropped within the first week to 21.1 mg/L (Abbott et al. 1988) and inhibited only three of thirteen strains of bacteria in another study (Abbott et al. 1990). The rate of release of demeclocycline at day one was about 10 times more than the rate after one week. Therefore demeclocycline might be effective against bacteria within the first few days after Ledermix placement, but would not be suitable as a long term dressing.

**MIXTURES OF LEDERMIX PASTE**

A mixture of Ledermix paste and calcium hydroxide has been used as a canal dressing. The aim was to produce a dressing that was anti-inflammatory and antibacterial in its action and also capable of inducing hard tissue formation. Mixing these two medicaments alters the release and diffusion of the active components of the Ledermix paste (Abbott et al. 1989a), but did not decrease their individual antibacterial potency when tested on *Lactobacillus casei* and *Streptococcus mutans* (Taylor et al. 1989). However, in Seow’s study reported that a mixture of calcium hydroxide and Ledermix paste decreased their individual antibacterial effectiveness when tested on *Streptococcus sanguis* and *Staphylococcus aureus* (Seow 1990).

**PENETRATION OF LEDERMIX THROUGH DENTINE**

Dentine is a calcified tissue traversed by dentinal tubules. The diameter of these tubules is approximately 1 µm at the dentinoenamel junction, reaching 3 µm at the pulp chamber surface (Tagger & Tagger 1998). The release and dentine diffusion characteristics of triamcinolone and demeclocycline have been investigated under different conditions (Abbott et al. 1988; Abbott et al. 1989b, 1989a). Abbott (1989a) demonstrated using tracer molecules from Ledermix paste and spectrophotometer analysis that the active components of Ledermix diffused through the dentinal tubules and neither a smear layer nor cementum completely blocks diffusion. However, the removal of cementum and the smear layer did increase dentinal permeation of the experimental tracer molecules (Abbott et al. 1989b).

**TISSUE TOXICITY AND BIOLOGICAL CONSIDERATIONS**

Ledermix paste was found to be non irritating to periapical tissues and a normal histological appearance of periapical tissues was observed 3 months after application (Barker & Lockett 1972). However, Tepel et al. (1994) found an infiltrate of inflammatory cells in the periapical tissue after the use of Ledermix in rats with experimentally induced apical periodontitis. The periapical lesions were larger than the untreated teeth with periapical periodontitis. Therefore the combination of a corticosteroid and an antibiotic appears to impair healing. In an *in vitro* study by Taylor et al (1989), it was found that Ledermix paste killed the fibroblasts of mice at a concentration of 10⁻³ mg/mL and above. It also killed *S. mutans* at the same concentration but required a one thousand-fold greater concentration to kill *Lactobacillus casei*.

The corticosteroid component of Ledermix, triamcinolone acetonide, was reported to be approximately five times more potent than cortisol on an effect/weight basis (Fauci et al. 1976). Shortly after the introduction of Ledermix, opposition arose to its use due to a perceived risk of systemic side effects (Klotz et al. 1965). Deus & Han (1967) reported that hydrocortisone applied directly to the dental pulp in hamsters could be detected in other organs within 2 minutes. Hargreaves (2002) and Seltzer (2000) state that the intracanal use of corticosteroids reduces the inflammatory response, suppresses vasodilation and limits neutrophil migration. They also interfere with phagocytosis and protein synthesis. As a result, infections became rampant and tissue repair was delayed. Abbott (1992) calculated that the highest possible amount of Ledermix paste can be used as an intracanal dressing, and analysed the release and diffusion characteristics, making comparisons with known endogenous levels of corticosteroids. He suggested that the intracanal use of Ledermix paste is unlikely to result in any systemic side effects.
POST-TREATMENT PAIN AND FLARE UPS

Triamcinolone could be used effectively to reduce or eliminate inflammation and control postoperative endodontic pain (Wolfsohn 1954; Schneider 1968; Hargreaves & Seltzer 2002). Abbott (1992) demonstrated that triamcinolone released from Ledermix in the root canal, enters the systemic circulation via diffusion through dentinal tubules, lateral canals and the apical foramen. He also found 30% was released after the first 24 hours, and the remaining 70% by the end of 14 weeks. The Ledermix dressing was found to be most effective in controlling postoperative pain associated with acute apical periodontitis, with a rapid onset of pain (Negm 2001; Ehrmann et al. 2003).

Researchers have found that an asymptomatic tooth with a necrotic pulp (with or without radiographic radiolucencies) treated endodontically with the accepted methods may have an acute exacerbation of symptoms (“flare-up”) (Bystrom & Sundqvist 1985). Matthews et al (1994) described the effectiveness of pain relieving treatments provided for acute dental pain from irreversible pulpitis and acute apical periodontitis and evaluated these after 24 hours. By using five different treatment modalities, including extraction, Ledermix was shown to give the greatest pain relief (Matthews et al. 1994). Rimmer (1991) found that the mean flare-up scores of the intracanal medicaments that contained corticosteroid/antibiotic mixtures were significantly lower in both systemic antibiotic and non-antibiotic groups than the flare-up score of the control groups. Trope (1990) revealed that postoperative flare-ups were clinical manifestations of an acute periapical inflammation associated with infection. Importantly, he found the incidence of flare-ups was independent of the intracanal medicament used. In the study, the patient’s responses to various clinical manifestations were purely subjective. Pain described as severe and very distressful by one patient may be described as mild or moderate by others. Therefore “flare-up” is a subjective term for which the psychological effect cannot be eliminated (Rimmer 1991).

EXTERNAL INFLAMMATORY AND ROOT RESORPTION

The action of the triamcinolone component of Ledermix can biologically inactivate clastic cells associated with root resorption (Heithersay 1994). The corticosteroid directly inhibits the spreading of dentinoclasts, suggesting that it acts by detaching resorption dentinoclasts from the root surface (Pierce et al. 1988).

Other studies showed that replanted teeth after extraction followed by mechanical instrumentation and medicated with Ledermix inhibited inflammatory root resorption or inflammation of the periodontal membrane (Pierce & Lindskeg 1987; Thong et al. 2001). Wong and Sae-Lim 2002 in an in vivo study showed that immediate replantation of extracted teeth had a high occurrence of complete healing, and 1 hour delayed (bench dry) teeth were shown to have a high occurrence of replacement resorption with the associated inflammatory root resorption. The study also suggested improved healing and reduced root resorption with roots treated with Ledermix paste compared to untreated dried replanted teeth, but the difference was not statistically significant (Wong & Sae-Lim 2002). Bryson et al (2002) in an in vivo study also used dogs teeth with extended dry times. They found that Ledermix treated roots had significantly more healing and less resorption than the roots treated with calcium hydroxide. Immediate intracanal placement of Ledermix paste was therefore recommended at the emergency visit after an avulsion injury to decrease resorption and increase favourable healing (Abbott et al. 1990; Bryson et al. 2002).

DISCOLOURATION

Discolouration of teeth dressed with Ledermix paste may be due to the tetracycline antibiotic. It was initially thought that the uptake of tetracycline into hard tissues required active calcification. However, a study has shown that tetracycline uptake may take place in a fully mineralised tooth (Kim & Abbott 2000). Further studies demonstratedLedermix paste used as an intracanal medicament may cause discoloration of both mature and immature teeth after it had been in the canals for more than 4 weeks (Kim et al. 2000b, 2000a). Immature teeth had a greater degree of discoloration than mature teeth. Exposure Ledermix paste filled teeth to sunlight caused teeth to become dark. Therefore when using Ledermix paste clinically in anterior teeth especially those of the young, caution should be taken. Ledermix paste should not left in the coronal portion of the tooth or another intracanal medicament should be considered.
CURRENT RECOMMENDATIONS

RETREATMENTS
The microorganisms present after endodontic treatment failure are different from those normally found in an untreated necrotic dental pulp. *E. faecalis* appears to be highly resistant to medications used during treatment, and is one of the few microorganisms that have been shown in vitro to resist the antibacterial effect of calcium hydroxide (Stevens & Grossman 1983; Byström & Sundqvist 1985; Haapasalo & Orstavik 1987; Orstavik & Haapasalo 1990; Safavi & Nichols 1993; Sundqvist et al. 1998). *E. faecalis* was commonly recovered from previously endodontically treated teeth (Molander et al. 1998; Sundqvist et al. 1998; Pinheiro et al. 2003). *E. faecalis* has also been reported to have the ability to survive in root canals as single organisms without the support of other bacteria (Fabricius et al. 1982), and it also survived in an environment with restricted nutrient supply (Sundqvist et al. 1998). The virulence of *E. faecalis* in root canals associated with endodontic failures might be related to the ability of *E. faecalis* cells to maintain a capacity to invade dentinal tubules and adhere to collagen in the presence of human serum (Love 2001). When retreating failed cases alternative intracanal medicaments and intracanal irrigants should be considered.

CALCICUM HYDROXIDE
Calcium hydroxide has been used for various endodontic procedures since it was first described in 1920 as an endodontic adjunct (Hermann 1920, 1930). Calcium hydroxide pastes can be classified as setting pastes (not reviewed here), generally used as cavity liners or endodontic sealers. Non-setting calcium hydroxide pastes are used primarily as intracanal medicaments. Other successful applications are as a pulp capping and pulpotomy dressing (Spångberg 1998). The efficacy of calcium hydroxide in endodontic therapy is from its bactericidal effects (Hermann 1930; Byström & Sundqvist 1985), its destructive effect on bacterial cell membranes and protein structures (Gordon et al. 1985; Safavi & Nichols 1993), inhibition of tooth resorption (Tronstad 1988), and induction of repair by hard tissue formation (Foreman & Barnes 1990).

CHEMICAL AND ANTIBACTERIAL CHARACTERISTICS OF CALCIUM HYDROXIDE
Calcium hydroxide is a strongly alkaline substance, which has a pH of approximately 12.5 (Tronstad et al. 1981; Estrela et al. 1994; Beltes et al. 1997). The main actions of calcium hydroxide come from the ionic dissociation of Ca²⁺ and OH⁻ ions. These ions acted on vital tissue and bacteria to initiate the induction of hard tissue deposition and the antibacterial effects (Holland et al. 1979). Calcium hydroxide needs to diffuse through tissues and the hydroxyl concentration is decreased because of the dentine hydroxyapatite buffering property (Nerwich et al. 1993; Haapasalo et al. 2000). Tronstad et al. (1981) found the placement of calcium hydroxide in a root canal will increase the pH of root dentine. Furthermore, the pH values around the canal space decreased toward the peripheral dentine, which indicates the hydroxide ion diffuses through the dentine. However, a larger apical foramen size allows more calcium hydroxide to diffuse through the apical region and results in a higher pH value around the apical tissues (Robert et al. 2005).

Intracanal medicaments might prevent the penetration of bacteria from saliva to the root canal by their antibacterial properties acting as a chemical barrier against leakage and killing bacteria. Siqueira et al. (1998) in an in vitro study evaluated the calcium hydroxide paste as more effective than camphorated paramonochlorophenol (CMCP) in preventing root canal recontamination by bacteria from saliva. Despite the vehicle used, calcium hydroxide is an effective physical barrier, which can kill remaining microorganisms by withholding substrates for growth and by limiting space for multiplication (Dahlen & Haapasalo 1998; Siqueira & de Uzeda 1998). Studies have shown that after 7 days of calcium hydroxide dressing, the highest pH value was reached and maintained (Pacios et al. 2004, Camoes 2003), which gives the most antibacterial effect (Estrela et al. 1998).

INHIBITION OF CALCIUM HYDROXIDE
Calcium hydroxide’s antibacterial effectiveness might be reduced or impeded by dentine, acids, proteins and carbon dioxide (Siqueira et al. 1996; Siqueira & de Uzeda 1998; Haapasalo et al. 2000; Portenier et al. 2001). When Ca²⁺ ions come into contact with carbon dioxide (CO₂) or carbonate ions (CO₃²⁻) in tissue, calcium carbonate was formed which alter the mineralisation process by the overall consumption of the Ca²⁺ ions (Holland
Intracanal Medicaments Revisited

et al. 1979). However, calcium carbonate has neither biological nor antibacterial properties (Estrela 1994). Kwon et al. (2004) used Fourier transform – (FT) Raman spectroscopy to identify the calcium hydroxide converted into calcium carbonate at the apical region. They also reported that calcium hydroxide reduced its pH in the apical regions which might be neutralised by carbon dioxide dissolved in body fluids that had penetrated through the apical foramen (Kwon et al. 2004).

An in vitro study investigating the efficacy of intracanal calcium hydroxide paste found it might be affected by carbon dioxide (Cohen & Lasfargues 1988). Microorganisms require carbon dioxide for survival within necrotic pulps. By altering the carbon dioxide concentration an environment may be created which was unfavourable for the microorganisms (Kontakiotis et al. 1995). A natural agent that had the capability of influencing the pH value was carbon dioxide. It might originate from the bacterial metabolism in the canals or dentinal tubules. An in vitro study by Fuss et al. (1996) revealed the calcium hydroxide pH value was decreased when examined by introducing carbon dioxide gas in sealed receptacle. However, the pH value was decreased to a mean of 12.54, which was still bactericidal according to Bystrom et al. (1985).

Haapasalo et al. (2000) used dentine powder to investigate the inactivation of antibacterial activity with various root canal medicaments. They concluded the dentine powder model was an efficient tool that interacted between endodontic medicaments, dentine, and microbes. They also found that calcium hydroxide and dentine powder reduced the effectiveness against E. faecalis. They indicated that dentine acts as an effective buffer of the alkalinity of calcium hydroxide and inhibited a deeper penetration of hydrogen ions into the dentinal tubules (Haapasalo et al. 2000). Similar findings were reported by Portenier et al. (2001), concluding that calcium hydroxide was sensitive to inhibition by both inorganic and organic compounds (Portenier et al. 2001).

Influence on Antibacterial Effect

Endodontic infections are multimicrobial and no medicaments can effectively eliminate all the bacteria found in infected root canals. A combination of two or more medicaments might be produced an additive or synergistic effect. Siqueira and Uzeda (1997) in an in vitro study using agar diffusion tests found calcium hydroxide/CMCP paste to be effective against all bacterial strains. They demonstrated that calcium hydroxide mixed with distilled water or glycerin failed to show a zone of bacterial inhibition due to the limitations of the diffusion test. Calcium hydroxide had a low solubility and does not diffuse well through an agar culture medium (Siqueira & de Uzeda 1997). Similar results were also reported in their earlier study (Siqueira & de Uzeda 1996) showing calcium hydroxide/glycerin/CMCP pastes effectively killed bacteria in the tubules. In contrast, Morrier et al. (2004) demonstrated that calcium hydroxide/glycerin mixes showed the largest zone of bacterial inhibition. Other studies revealed that calcium hydroxide was superior to CMCP against anaerobic microorganisms (Bystrom et al. 1985; Stuart et al. 1991; Georgopoulou et al. 1993). Overall, calcium hydroxide combined with CMCP has been reported to be more effective in eliminating Enterococci than calcium hydroxide paste used alone (Stevens & Grossman 1983; Haapasalo & Orstavik 1987; Siqueira & de Uzeda 1997, 1998; Gomes et al. 2002). Evidence suggests that the association of calcium hydroxide with CMCP has a broader antibacterial spectrum, a higher radius of antibacterial action and kills bacteria faster than if calcium hydroxide is mixed with inert vehicles. CMCP should be considered as an additional medicament with calcium hydroxide (Siqueira & Lopes 1999).

Siren et al. (2004) looked at the antibacterial effect of calcium hydroxide combined with chlorhexidine or iodine potassium iodide (IKI) in vitro. The model they used for dentinal tubule infection of root canals was originally described by Haapasalo and Orstavik (1987). Chlorhexidine/calcium hydroxide and IKI/calcium hydroxide combinations showed disinfection in 1 week. Fuss et al. (2002) and Lin et al. (2005) in in vitro studies demonstrated the addition of IKI or electrically activated copper to calcium hydroxide significantly increased its antibacterial activity and penetration in to the dentinal tubules (Fuss et al. 2002; Lin et al. 2005).

Behene et al. (2001) suggested that thick mixtures (high viscosity) of calcium hydroxide were not ideal for use as an intracanal antimicrobial agent. The degree of calcium hydroxide antibacterial levels depended on release of the hydroxyl ions. The ability of these ions to diffuse through dentine should exceed the buffering ability of the dentine. Therefore, the lower the viscosity of the paste, the
higher the ionic dissociation which allows it to penetrate deeper into the dentine tubules (Behnen et al. 2001).

**APEXIFICATION**

Apexification is a method of inducing a calcified barrier in a root with an open apex or the continued apical development of an incompletely formed root in teeth with a necrotic pulp (American Association of Endodontists 2003).

Induction of apical closure provides more favourable clinical conditions for conventional endodontic treatments. The most commonly used medicament in apexification was calcium hydroxide, however the introduction of mineral trioxide aggregate provides and alternative material which allows single-visit apexification (Rafter 2005).

Calcium hydroxide introduced into the periapical region appears to be well tolerated and subsequently resorbed (Martin & Crabb 1977). Holland et al. (1977) demonstrated that the reactions of the periapical tissues to calcium hydroxide were similar to the pulp tissues. Calcium hydroxide produced a multi-layered necrosis with subjacent mineralisation. Spångberg (1969) found that calcium hydroxide implanted in guinea-pig bone caused an inflammatory response with inhibited bone healing after 2 weeks of a calcium hydroxide dressing. It was replaced by new bone within 12 weeks. Supporting Spångberg’s finding, Cvek (1972) observed apical root closure and bone healing following intracanal placement of calcium hydroxide in 50 of 55 maxillary incisors with immature roots. The high pH of calcium hydroxide was an important factor to induce hard tissue formation. Javelet et al. (1985) compared the ability of calcium hydroxide (pH 11.8) and calcium chloride (pH 4.4) to induce formation of hard tissue barriers in pulpless immature monkey teeth. He found more rapid periapical repair and apical barrier formation in the presence of calcium hydroxide.

An in vitro study using calcium hydroxide demonstrated an increased inhibition of attached human gingival fibroblasts, although this was not statistically significant. The authors also proposed that calcium hydroxide should be avoided as an interim medicament when trying to regenerate or establish new attachment in tissues adjacent to endodontically involved teeth (Breault et al. 1995). On the other hand, calcium hydroxide did not affect the healing of reimplanted monkey teeth with intact cementum and only temporarily in those undergoing cemental repair (Hammarström et al. 1986). Similar findings also revealed that periodontal healing associated with infected root canals filled with calcium hydroxide was not hindered 6 months after experimental periodontal surgical injury in dogs (Holland et al. 1998).

Although calcium hydroxide has been the material choice for apexification, recent interest has centred on mineral trioxide aggregate (MTA). MTA has a pH of 12.5 after setting (similar to calcium hydroxide) and has antibacterial properties (Torabinejad et al. 1995). Studies show MTA has a greater consistency than calcium hydroxide in inducing induced hard tissue formation when it was used for the repair of perforations in roots, furcations and apexification (Lee et al. 1993; Pitt Ford et al. 1995; Arens & Torabinejad 1996; Shabahang & Torabinejad 2000).

Calcium hydroxide apexification remains the most commonly used technique for treatment of necrotic teeth with immature apices. However, apical healing takes at least 3-4 months and often requires multiple appointments. Patient compliance problems and the quality of the temporary seal might result in failure or prolonged treatments (Rafter 2005). Single-visit apexification has been suggested. The rationale is to establish an apical stop which enables the root canal to be filled immediately (Morse et al. 1990). Although MTA has been shown to be superior to calcium hydroxide in apexification, prospective clinical trials and long term studies are required to comparing the techniques.

**PHENOL AND PHENOL-DERIVATIVES**

Phenol and phenol-derivative compounds have bactericidal activity (Menezes et al. 2004). They disrupt bacterial cytoplasmic membranes, denature proteins and inactivate enzymes. They also liberate chlorine, a strong oxidizing agent that inactivates enzymes with sulphydryl groups (Siqueira & de Uzeda 1996). Various formulations of chlorine, phenol and camphor have been used for root canal sterilization. However, because of their toxicity, small amounts have been used, and they have been employed only in the pulp chamber. The assumption had been that the vapours would kill bacteria throughout the root canal system. Spangberg et al (1979) demonstrated that the vapours of camphorated para-monochlorophenol (CMCP) could not kill bacteria. Furthermore,
Messer and Chen (1984) showed that almost 95% of the CMCP from a cotton pellet placed inside the pulp chamber was lost within 24 hours. The duration of the intracanal medication was short, due to a rapid inactivation process that occurs a few hours after its exposure to tissue or fluids. CMCP applied alone has shown lower antibacterial activity to calcium hydroxide (Stevens & Grossman 1983; Orstavik & Haapasalo 1990; Menezes et al. 2004).

**Chlorhexidine**
Chlorhexidine is active against a wide range of Gram-positive and Gram-negative microorganisms as well as yeast, fungi, facultative anaerobes and aerobic microorganisms (Fardal & Turnbull 1986; Cervone et al. 1990; Lindskog et al. 1998). Its efficacy is based on the interaction between the positive charge of the chlorhexidine molecule and negatively charged phosphate groups on the bacterial cell wall. This increases the permeability of the cell wall, which allows the chlorhexidine molecule to penetrate into the bacteria with intracellular toxic effects (Leonardo et al. 1999). In endodontics, chlorhexidine had been proposed both as an irrigant and an intracanal medicament (Delany et al. 1982; Ohara et al. 1993; Siqueira & de Uzeda 1997; Ferraz et al. 2001). Used as an intracanal medicament in a sustained-release device, it was composed of a crosslinked protein with chlorhexidine gluconate embedded as the active agent (Friedman & Steinberg 1990; Heling et al. 1992a; Heling et al. 1992b).

Chlorhexidine gluconate was found to be an effective antimicrobial agent when used as an irrigation solution and when used as an intercanal antimicrobial dressing, further reducing remaining bacteria within root canal systems (Delany et al. 1982; Gomes et al. 2001; Gomes et al. 2003b). In in vitro studies chlorhexidine also proved better in eliminating bacteria from dentinal tubules than calcium hydroxide, and prevented secondary infection (Heling et al. 1992a; Heling et al. 1992b; Menezes et al 2004) reported similar findings.

It appears that *E. faecalis* is susceptible to chlorhexidine (Gomes et al. 2003b). A prolonged application of chlorhexidine proved advantageous, particularly when used in retreatment cases (Komorowski et al. 2000; Gomes et al. 2003a; Siren et al. 2004). Komorowski et al 2000 in an in vitro study reported that the root dentine after treatment with chlorhexidine could inhibit reinfections of the canal subsequent to treatment. It is harder to eliminate bacteria in biofilms than in planktonic suspension *in vitro* if the antibacterial agents did not possess any organic tissue dissolving properties (Abdullah et al. 2005). Thus, the strategies were to treat biofilm infection in root canals with mechanical instrumentation, and dissolution of the matrix polymers using irrigation and intracanal medicaments. These procedures might enhance the antibacterial effects by using sodium hypochlorite, iodine or chlorhexidine.

**Iodine Potassium Iodide (IKI)**
IKI is effective against a variety of microorganisms found in root canals, and a 2 % solution had a lower toxicity to tissue culture cells than other intracanal medicaments other than calcium hydroxide (Spångberg et al. 1973; Orstavik & Haapasalo 1990). Iodine is a strong oxidizing agent. It reacts with free sulfhydryl groups of bacterial enzymes, resulting in disulfide linkages (Siren et al. 2004). The disadvantage of iodine is an allergic reactions in some patients. Safavi et al (1990) reported that IKI eliminated *Streptococcus faecium* from infected dentinal tubules in 10 minutes. In contrast, calcium hydroxide took 24 hours. Orstavik and Haapasalo (1990) revealed that IKI was able to penetrate the dentinal tubules to eliminate *S. sanguis* at a depth greater than 1000 µm within 5 minutes. A clinical study by Peciuliene et al (2001) investigated the ability of single appointment chemomechanical preparation followed by 5 minutes irrigation with IKI to eliminate yeasts, enteric Gram-negative rods and *Enterococcus* species from the root canals of previously root filled teeth with chronic apical periodontitis. Initial microbial sampling showed growth from 82.5% of the teeth with *E. faecalis* present in 64% of the culture positive teeth; only 1 sample (2.5%) yielded growth following the final flush with IKI. The study by Baker et al (2004) used calcium hydroxide and IKI as intracanal medicaments and filled the lumen of the bovine incisor roots for the 24 hour period. They found IKI was capable of eliminating *E. faecalis* when used as a 24 hour medicament. More importantly, IKI had a very high probability of eliminating *E. faecalis* when the contact time was as short as 15 minutes, which corresponds to the clinical contact time of an endodontic irrigant. In contrast, Safavi et al (1985) found a significantly lower rate of reinfection due to intervisit microleakages in teeth.
whose canals were filled with calcium hydroxide compared to those having a cotton pellet soaked with IKI placed in the pulp chamber.

**CONCLUSION**

Currently the recommendation is for teeth with infected root canals to be treated in multiple visits, with placement of an intracanal medicament such as calcium hydroxide to attempt to eradicate all pathogens (Trope et al. 1999). Unfortunately multiple visits entail considerable additional time and expense for both patient and dentist. Unrestored and temporary filled teeth are subject to culture reversals – reinfection due to intervisit microleakages (Sundqvist 1992). Ideally, an agent to culture reversals – reinfection due to intervisit time and expense for both patient and dentist.

During root canal retreatment of previous endodontic failure cases, calcium hydroxide is not effective against the dominant species (E. faecalis), which may re-colonise the root canal system rapidly between appointments.

Various medicaments are available and the choices of usage should be based on the therapeutic properties and the toxicity potential of the material. Although IKI and chlorhexidine have shown greater antibacterial effect than calcium hydroxide, further clinical investigation is required.

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Intracanal Medicaments Revisited


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Intracanal Medicaments Revisited


Intracanal Medicaments Revisited

Radiology and Endodontics 96, 96-101.


INTRODUCTION
Primary aetiological agents of necrotic pulps and apical periodontitis are bacteria and their by-products (Kakehashi et al. 1965). Hence, the primary objectives of endodontics are debridement of the pulpal space, the development of a coronal and apical seal and total obliteration of the root canal system.

The main cause of failure of root canal treatment is persistence of micro organisms after therapy (Molander et al. 1998; Sundqvist et al. 1998) and the effect they have on the periapical tissues.

CRITERIA FOR OBURATION
Sjogren et al (1990), found that after 5 years 94% of cases exhibiting negative cultures at the time of obturation were completely successful. In contrast, only 68% of the cases filled with positive cultures were successful after 5 years (Sjogren et al. 1990). The results of this study imply that there was some leakage of bacteria or their by-products through the apical foramen and that the root filling of gutta-percha did not provide an ideal seal.

It is not practical to use culture techniques routinely. The root canal is considered to be ready for filling when the canal is shaped to an optimum size, cleaned with appropriate irrigants and medicaments. and can be dried (Bystrom & Sundqvist 1981).

MATERIALS USED IN OBURATION
Historically, materials used for root canal obturation have been legion, running the gamut from feathers to orangewood sticks to precious metals (Ingle et al. 2002).

Most materials have been shown to be inadequate and are rejected as impractical or biologically unacceptable.
Grossman grouped acceptable materials into plastics, solids, cements and pastes. He also enumerated requirements for an ideal root canal filling material. These apply equally to metals, plastics and cements:
1. It should be easily introduced into a root canal.
2. It should seal the canal laterally as well as apically.
3. It should not shrink after being inserted.
4. It should be bacteriostatic or at least not encourage bacterial growth.
5. It should be impervious to moisture.
6. It should be radiopaque.
7. It should not stain tooth structure.
8. It should not irritate periradicular tissue.
9. It should be sterile or easily and quickly sterilized immediately before insertion.
10. It should be removed easily from the root canal if necessary (Grossman 1982b).

Gutta-percha (GP) is by far the most universally used solid-core root canal filling material and may be classified as a plastic.

GUTTA-PERCHA (GP)
Gutta-percha has been used for root canal fillings for over 100 years. It is a form of rubber obtained from a number of tropical trees. In its pure form it is hard, brittle and less elastic than natural rubber. It is mixed with various other materials to produce a blend, which can be used effectively within the root canal.

 Constituents added to GP include zinc oxide and various waxes, colouring agents, antioxidants and metal salts. The proportions vary from brand to brand, thus causing considerable variation in the stiffness, brittleness and tensile strength of commercially available points (Friedman et al. 1977).

Gutta-percha has many advantages. It is:
1. Inert.
2. Dimensionally stable.
4. Antibacterial.
5. Non- staining to dentine.
New Root Canal Filling Materials

6. Radiopaque.
7. Compactable.
8. Softened by heat.
10. Removable from the canal easily when necessary.

It has some disadvantages. These are:
1. It lacks rigidity.
2. It does not adhere to dentine.
3. It can be stretched.

Despite these disadvantages, GP is the most widely used material for root canal obturation. The biggest drawback is that it does not adhere to dentine. This leads to movement of bacteria between the canal walls and GP in absence of an adequate coronal seal (Torabinejad et al. 1990), leading to failure of root canal treatment.

**MEDICATED GUTTA-PERCHA POINTS**

In order to overcome some of the problems of GP various additions have been made. New innovations include GP points impregnated with chlorhexidine (CHX) (Activ points, Roeko, Langenau, Germany) and metronidazole. Calcium hydroxide containing gutta-percha points are also available commercially (Roeko calcium hydroxide).

**GUTTA-PERCHA POINTS WITH CALCIUM HYDROXIDE**

Root canal infections are caused by a polymicrobial flora that includes facultative and obligate anaerobic bacteria (Sundqvist 1994). Although mechanical instrumentation and the use of irrigants like sodium hypochlorite removes the bulk of the bacteria, some bacteria can persist in dentinal tubules and in the smear layer. Thus, intracanal disinfectants like calcium hydroxide are used between appointments, to eliminate bacteria prior to sealing the canal (Sjogren et al. 1991).

Calcium hydroxide pastes have been shown to be appropriate for elimination of bacteria because they exhibit a bactericidal activity. In addition, the constant release of hydroxyl ions inactivates bacterial lipopolysaccharide, thereby reducing the local inflammatory response. It promotes dissolution of remnant necrotic tissue and produces an alkalisising osteogenic environment in the surrounding tissues (Podbielski et al. 2000).

The use of impregnated GP points is a convenient way of inserting calcium hydroxide into the instrumented canal. Some studies have demonstrated the applicability and efficacy of these points in comparison to calcium hydroxide paste (Holland et al. 1996). However, the study by Podbielski and colleagues to compare the efficacy of different types of gutta-percha points consisting of a variety of medicaments (ZnO, CHX, Calcium hydroxide, iodine-polyvinyl pyrrolidine and combinations thereof) on a wide spectrum of endodontic pathogens showed that none possessed an inhibitory activity strong or broad enough to sterilize root canals contaminated with a moderately high number of single pathogens or a mixture of common endodontic pathogens. The authors reiterated the importance of careful mechanical removal of contaminated material and abundant intermittent irrigation for the reduction of bacterial numbers.

Economides and colleagues (1999) designed an in-vitro study to compare the alkalisising potential of calcium hydroxide GP points to chemically pure calcium hydroxide mixed with distilled water and Reogan rapid, a non setting preparation of calcium hydroxide. This study found that the GP points with calcium hydroxide showed a significantly lower alkalisising potential than the other two. The authors suggested that GP matrix probably binds the hydroxyl ions and blocks their release at the site of application (Economides et al. 1999).

Two subsequent studies also show similar results (Azabal-Arroyo et al. 2002; Ho et al. 2003).

**CHLORHEXIDINE-IMPREGNATED GUTTA-PERCHA POINTS**

Infections of untreated root canals with necrotic pulps and apical periodontitis are typically polymicrobial, with approximately equal proportions of Gram-positive and Gram-negative anaerobic bacteria (Sundqvist 1976). However in retreatment cases, the microbial flora is characterised as monoinfections of predominantly Gram-positive micro-organisms, with approximately equal proportions of facultative and obligate anaerobes (Molander et al. 1998; Hancock et al. 2001). *Enterococcus faecalis*, a facultative Gram-positive coccus, is the most frequently isolated species and may sometimes be the only isolate (Molander et al. 1998; Sundqvist et al. 1998; Hancock et al. 2001).
Several studies have shown that *E. faecalis* is relatively resistant to calcium hydroxide (Byström *et al.* 1985; Haapasalo & Orstavik 1987). Chlorhexidine, a cationic biguanide with the ability to adsorb onto dentine (Parsons *et al.* 1980) is considered a broad-spectrum antimicrobial agent. It acts by adsorbing onto the bacterial cell wall and causing intracellular component leakage. There is some evidence suggesting the efficacy of chlorhexidine as an irrigant (Delaney *et al.* 1982; Jeansonne & White 1994) and an intracanal medicament because of its ability to disinfect dentinal tubules against *E. faecalis* (Heling *et al.* 1992; Vahdaty *et al.* 1993).

In order to take advantage of this antibacterial property of chlorhexidine, a new formulation of a chlorhexidine-impregnated gutta-percha point, ‘Activ point’ (Roeko, Langenau, Germany), has recently been marketed. According to the manufacturer, ‘activ points’ contains gutta-percha matrix embedded with 5% chlorhexidine diacetate.

Several studies have been undertaken to investigate the antimicrobial activity of ‘activ points’ (Podbielski *et al.* 2000; Lui *et al.* 2004).

All of these studies concluded that ‘Activ points’ did not possess an inhibitory activity strong enough to completely eliminate a moderately large number of *E. faecalis* organisms from infected human dentinal tubules.

An in-vitro study conducted by Szep *et al* in 2002 to test the cellular toxicity of medicated and non-medicated GP points found that chlorhexidine-impregnated GP were the most cytotoxic, as compared to calcium hydroxide impregnated GP points and non-medicated GP points (Szep *et al.* 2003).

**GUTTA-PERCHA POINTS IMPREGNATED WITH METRONIDAZOLE**

According to an abstract of a study conducted at Dentistry school of Shandong University in China (Wang *et al.* 2003), controlled-release delivery gutta-percha points (CDGMC) containing metronidazole compounds were prepared and placed in routinely prepared extracted teeth. The non-drug CDGMC was used as the control. The absorbency of the drugs in normal saline (37 degrees C, ph 7.4) was determined. The percentage of release and cumulated release of the drugs were calculated according to the concentrations of drugs in medium.

The authors concluded that the CDGMC could continuously release effective drug concentrations for more than 10 days. (This article is in Chinese; only the abstract is available in English. Hence, the details available are quite sketchy).

**RESILON**

Recently, a new product has been introduced to the endodontic marketplace for obturation of root canals. Resilon (Pentron corp., Wallingford, CT, USA) is a thermoplastic, synthetic polymer substitute shown to seal significantly better than GP. This obturation system is also available as Real Seal (Sybron Endo, Orange CA, USA). It consists of a core obturation material and a sealer. The core material is available as master cones in all ISO sizes and accessory cones in all sizes, similar to GP. In addition, it is available as pellets, which can be used for the backfill in warm thermoplasticised techniques.

At present this obturation system is available under 3 brand names, namely, Resilon, Real Seal and Epiphany. They have all received regulatory clearance from the FDA in the USA.

**Chemical composition**

Resilon is a thermoplastic synthetic resin material based on the polymers of polyester and contains a hydrophilic difunctional methacrylate resin, bioactive glass and radio opaque fillers, bismuth oxychloride and barium sulphate. The overall filler content is 65%.

The sealer contains UDMA, PEGDMA, EBPADMA and Bis-GMA resins, silane treated barium borosilicate glasses, barium sulphate, silica, calcium hydroxide, bismuth oxychloride with amines, peroxide, photo initiator, stabilizers and pigment and is available as a two paste system. Overall filler content is 70% by weight.

The primer is a self etch primer, which contains a sulfonic acid terminated functional monomer, HEMA, water and polymerisation initiator.

**Handling characteristics**

In virtually all its handling characteristics, Resilon
New Root Canal Filling Materials

is similar to GP. It can be used with all present forms of endodontic obturation (vertical compaction of warm GP, cold lateral condensation, lateral/vertical combinations) and there is virtually no learning curve to its use. This allows the clinician to use this new technology with only two added steps; clearing the smear layer and placing the self etch primer. Resilon cones are very flexible and pellets are available for the Obtura gun (Spartan Obtura, Fenton, MO).

Technique
Mounce and Glassman (Mounce & Glassman 2004) described the following technique for the use of Real Seal in Oral Health, July 2004:

Canal preparation
Canal preparation protocol is followed as with GP. No alterations are required to facilitate the use of this material.

Smear layer removal
Smear layer is the layer of organic and inorganic debris that is created along the walls of canals during instrumentation. Use of 17% EDTA and sodium hypochlorite in an alternating sequence is recommended throughout the entire instrumentation protocol. After the instrumentation is completed, 17% EDTA may be used as a final canal rinse. As an alternative, the authors recommend the use of Smear Clear (Sybron Endo, Orange, CA, USA) as a final rinse. This product contains surfactants that enhance wetting of the canal walls and provides optimal smear layer removal. However, neither sodium hypochlorite nor absolute alcohol should be used as a final rinse after smear layer is removed, because sodium hypochlorite will disrupt the sealer bond and absolute alcohol will act as a drying agent. The walls do not need to be fully dry as the sealer is hydrophilic.

Chivian advises the use of 0.12% chlorhexidine gluconate as the final rinse (Chivian 2004).

Primer application
Canals are dried with paper points. Self etch primer is introduced into the coronal third of the canal with a brush or paper point. The primer should be dispersed evenly on the canal walls.

Mixing of the resin sealer
The two components of the sealer may be either hand mixed on a paper pad using a spatula or in mixing tips provided with the dual syringe, which mixes the two components as they are expressed. Sealer is placed in canal with a master cone or lentulo spiral kept 3 mm from the apex and rotating no faster than 300RPM.

Obturation
The canal is filled with Resilon core material using the preferred technique. When the core filling is completed, the coronal surface is light cured for 40 seconds to create an immediate coronal seal. The deeper resin sealer then polymerises by chemical curing during the following 30 to 60 minutes.

Post space preparation
If required, post space preparation may be done at the same appointment after the canals are first filled to the level of the orifices. If any lateral/accessory canals and/or dentinal tubules have not been sealed during the down pack, perhaps they may be sealed during the back fill. If post space needs to be prepared after the material has set and the monoblock created, a small amount of chloroform can be used to dissolve the material.

Properties
The most important property of Resilon is that it is a synthetic, polymer based composite material. The resin sealer attaches to it as well as to the bonding agent used to penetrate into the dentinal tubules, forming a “monoblock” composed of filling material, resin sealant, bonding agent and dentine. This monoblock does not occur when GP is used as the core material because the sealer, even if resin based, does not bind to GP and tends to pull away from the GP on setting (Teixeira et al. 2004a).

A recent study by Shipper et al (2004) found that a comparison of bacterial leakage through both GP and Resilon over a 30-day period demonstrated that Resilon showed minimal leakage, compared to GP. They used Streptococcus mutans and Enterococcus faecalis for the study. Two filling techniques were used - lateral and vertical condensation.

In the same study, a scanning electron microscope study was made of the dentin-filling interface of the longitudinal sections for teeth filled with GP as well as Resilon. In the GP specimens, there was a uniform gap between the dentine and the filling of approximately 10 micrometers width. This gap existed mainly between the resin sealer that penetrated the dentine and GP. By comparison, there was no gap between the Resilon material and sealer. High-power scanning electron micrograph
(SEM) of a decalcified specimen showed that the resin tags had penetrated the dentin (Shipper et al. 2004).

A recent study (Tay et al. 2005) reported that the apical seal achieved by Resilon and Epiphany was no superior to that achieved by GP and AHPlus.

Resilon is quite flexible. It handles and feels like GP. It is easy to use with both cold and heated root canal filling techniques.

Resilon has the potential to strengthen roots. A recent in-vitro study found that the resistance to root fracture with Resilon was superior to GP/AH26 sealer (Dentsply Maillefer). In this study the authors used single rooted teeth filled with GP and Resilon and stored them in 100% humidity for 2 weeks prior to subjecting them to forces to determine the point of fracture of the various groups. The difference between the control group (unfilled) and gutta-percha filled group were not significant, but there was a statistically significant difference between Resilon and GP groups. Additionally, not much difference was noted between different filling techniques (lateral and vertical condensation) (Teixeira et al. 2004b). The results however must be interpreted with caution as the results had large standard deviations.

**Removal from canals**

According to the manufacturers, Resilon can be removed from canals quite easily if retreatment is required. It can be dissolved by chloroform.

**Biological properties**

Some basic studies have been done on Resilon to test its toxicity and mutagenicity. Toxikon Corporation (ISO project no 01-442-G1) performed Salmonella typhimurium and Escherichia coli reverse mutation assay, which demonstrated that Resilon is non mutagenic. The sealant was evaluated and scored using the skin sensitisation Kligman maximization test (Magnusson & Kligman 1969) and received a grade I reaction, which is considered not significant (Teixeira et al. 2004a).

In a recent study performed on Beagle dogs (Shipper et al. 2005) an attempt was made to assess and compare in vivo the efficacy of GP and AH26 versus Resilon with Epiphany primer and sealer filled roots in preventing apical periodontitis subsequent to coronal inoculation with oral micro organisms. The results suggested that the Resilon monoblock system was associated with less apical periodontitis, which may be due to its superior resistance to coronal micro leakage.

Resilon is as yet a new material on the endodontic market. There is very little research available on it. Most has been done at the University of North Carolina. More research would be required before conclusively establishing Resilon as superior to GP. However, the initial reports appear to be very encouraging. The studies available to date seem to indicate that it is superior to GP when it comes to creating a seal in the canal.

Its toxicity has been tested. The FDA has approved it for use as a root canal filling material. According to Chivian (2004) a recent survey showed that in the first 8 months since its introduction, 8% of the responding endodontists are using the Resilon Obtrurating system.
New Root Canal Filling Materials

ROOT CANAL SEALERS

Grossman listed 11 requirements and characteristics of a good root canal sealer:

1. It should be tacky when mixed, to provide good adhesion between it and the canal wall when set.
2. It should make a hermetic seal.
3. It should be radiopaque so that it can be visualised on the radiograph.
4. The particles of powder should be very fine so that they can mix easily with the liquid.
5. It should not shrink upon setting.
6. It should not stain tooth structure.
7. It should be bacteriostatic or at least not encourage bacterial growth.
8. It should set slowly.
9. It should be insoluble in tissue fluids.
10. It should be tissue tolerant, that is, non-irritating to tissues.
11. It should be soluble in a common solvent if it is necessary to remove the root canal filling (Grossman 1982a).

Requirement 10 might be expanded a little to say that an ideal sealer should not provoke an immune response in periradicular tissues and it should be neither mutagenic nor carcinogenic (Ingle et al. 2002).

Commonly used sealers can be divided into four groups based on their constituents (Regan & Gutmann 2004):

1. Zinc oxide-eugenol sealers – Commercial products include Tubliseal (Kerr, Romulus, MI, USA), Pulp canal sealer (Kerr) and Roth sealer (Roth, Chicago, USA).
2. Calcium hydroxide sealers – Sealapex (Kerr), Apexit (Ivoclar-Vivadent, Liechtenstein).
3. Resin sealers – AH26, AHPlus (Dentsply, Konstanz, Germany).

Inevitably, no single material satisfies the requirements of an ideal sealer but several materials function adequately in clinical practice. However, the search is always on for a new material that will improve upon the ones already in use. Some of the new materials being researched are as follows:

GLASS Ionomer CEMENT (GIC) SEALER WITH AN ADDED ANTIMICROBIAL-CONTAINING ZEOLITE (ZUT)

GIC exhibits antimicrobial properties because of fluoride release, low pH values when setting and the presence of cations such as strontium and zinc (Herrera et al. 2001). Recently, an experimental GIC based root canal sealer (ZUT) has been developed at the Faculty of Dentistry, University of Toronto, with an emphasis on enhanced antimicrobial properties.

ZUT consists of a GIC base combined with antimicrobial zeolites. A zeolite is a porous ceramic (aluminosilicate) structure that can enclose a core material, which can be either an alkali earth metal ion or organic molecule (e.g., pharmaceuticals). The proportion of the zeolite in the GIC powder can vary, depending on the desired physical properties of the material and the level of antimicrobial dose required (Patel et al. 2000).

These workers conducted a study to compare the antimicrobial effects of ZUT with Ketac Endo. E. faecalis was used as the test organism. Ketac Endo was reported to suppress E. faecalis effectively 24 hours after preparation, but failed to do so 1 week later. ZUT formulations showed a strong antimicrobial effect that was sustained much longer.

Thom and coworkers (2003) tested the haemolytic and cytotoxic properties of ZUT and compared them to those of the unmodified GIC component, Ketac-Endo and two AH26 (with and without silver) formulations. ZUT showed either better or similar cytotoxicity to standard materials currently applied in endodontic practice (Thom et al. 2003).

ENDOREZ

Recently EndoRez (Ultradent Products, South Jordan, UT, USA) has been introduced to the market. According to the manufacturer, EndoRez is a two part chemical set material containing zinc oxide, barium sulphate, resins and pigments in a matrix of urethane dimethacrylate resin supplied in a mixing and delivery syringe (Zmener & Pameijer 2004).

According to the manufacturer, EndoRez (ER) is biocompatible and has satisfactory sealing properties, hydrophilic characteristics and an
easy delivery system. It has been reported by the manufacturer that EndoRez may be used in slightly moist canals because of its hydrophilic property. As it is not possible to obtain a completely dry surface, this characteristic may be advantageous.

Properties

Biocompatibility
According to studies conducted in-vitro on cell cultures and in rabbits and nonhuman primates, EndoRez proved to be biocompatible when compared to several controls currently in use (ZOE and AHPlus) (Becce & Pameijer 2001). Another study by Louw and coworkers in nonhuman primates also showed it to be biocompatible. This study used histology to study the effects of EndoRez on periradicular tissues (Louw et al. 2001).

In a clinical study conducted by Zmener’s group the performance of ER, used in conjunction with GP was evaluated for up to 24 months in 180 patients. It seemed to be well tolerated by tissues (Zmener & Pameijer 2004).

Sealing properties
Several studies have tried to evaluate the strength of the bond between dentine and ER.

Sevimay and Kalayci (2005) compared the apical sealing ability and adaptation to dentine of ER and AHPlus. AHPlus showed a much lower mean apical leakage value than ER. The difference was statistically significant. SEM examination revealed that ER sealer showed less penetration than AHPlus in the coronal and middle thirds of canal. In the apical third, penetration into dentinal tubules of ER was not observed and the adaptation to dentinal walls was poorer than that of AHPlus (Sevimay & Kalayci 2005).

Eldeniz and coworkers compared the shear bond strength of Diaket, AHPlus and EndoRez to dentin. EndoRez showed the lowest bond strength to dentine of all three and AHPlus showed the highest (Eldeniz et al. 2005).

Other new resin sealers
Kataoka and colleagues (2000) reported having developed an experimental resin sealer composed of 70wt% vinlylidene fluoride/hexafluoropropylene copolymer, methyl methacrylate, zirconia and tributylborane catalyst. They evaluated the dentine bonding and sealing ability of this new sealer. They found that it showed good adhesion to both dentine and GP as compared to the control group (EWT and Sealapex). This product was given the name Endoresin (Kataoka et al. 2000).

Imai and Komabayashi (2002) reported the development of Endoresin-2, which is a modified version of Endoresin, because of the problem of supply of the fluoropolymer, which was a key component of the first version. They substituted it with polymethylmethacrylate. This team tested the properties of this new material. It was found to have good sealing ability, adhesiveness to dentin, and easy removability (Imai & Komabayashi 2003).

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2006 ANNUAL GENERAL MEETING

FRIDAY 8 SEPTEMBER 2006

NZDA CONFERENCE
Rydges Hotel, Auckland
Kingston Room 2

5:05PM

NOTICE OF MEETING

The New Zealand Society of Endodontics 2006 AGM will be held at Rydges Hotel, Auckland. Election of officers will take place so please forward nominations and any items of General Business to Dr. Mike Jameson, Secretary, 2 Granville Terrace, Belleknowes, Dunedin.
ROOT-END FILLING MATERIALS: RATIONALE AND TISSUE RESPONSE

BUN SAN CHONG & THOMAS R PIT T FORD

Endodontic Topics 2005, 11,114-130

The need for a root-end filling should be decided at the time of surgery, after root-end resection, when there is opportunity to examine the quality of the exposed root canal filling with magnification. If the portion of root apex that is inaccessible to instrumentation and consequently a source of infection is removed, provided the exposed root filling is of a good quality and there are no additional canals or canal extensions, a root-end filling is not necessary.

Currently, there does not appear to be an ‘ideal’ rootend filling material as none fulfils all the desired requirements. Although there is insufficient evidence to specify a single material for root-end filling, the evidence points to ZOE cements, MTA, Diaket and Retroplast as being acceptable.

SURGICAL PREPARATION: ANAESTHESIA & HEMOSTASIS

KENNETH M HARGREAVES & ASMA KHAN

Endodontic Topics 2005, 11, 32-55

Effective intra-operative hemostasis often requires the slow infiltration injection of one to two cartridges of local anaesthetic containing 2% lidocaine with 1 : 50 000 epinephrine and waiting for tissue blanching as a sign of effective vasoconstriction. Excellent surgical skills including careful design of flaps, handling of tissues, positioning of retractors, etc, to reduce trauma to the tissue. Hemostasis in the surgical crypt can be managed by any of several techniques, including resorbable sponges containing epinephrine or direct application of ferric sulfate. A reasonable alternative, particularly for patients at cardiovascular risk, might be the local application of a calcium sulfate paste on the surgical crypt. Good tissue approximation with appropriate suturing techniques combined with 5-10 minutes of wound compression is effective for promoting post-operative hemostasis in otherwise healthy patients.

COMPARATIVE EVALUATION OF ENDODONTIC IRRIGANTS AGAINST ENTEROCOCCUS FAECALIS BIOFILMS

THOMAS R DUNAVANT, JOHN D REGAN, GERALD N GLICKMAN, ERIC S SOLOMON, ALLEN L HONEYMAN

The aim of this study was to compare the efficacy of root canal irrigants against E. faecalis biofilms. Biofilms grown in a flow cell system were submerged in test irrigants for either 1 or 5 minutes. No statistically significant relationship between time and percentage kill was found. The percentage kill of the biofilm bacteria was: 6% NaOCl (>99.99%), 1% NaOCl (99.78%), SmearClear (78.06%), 2% chlorhexidine (60.49%), REDTA (26.99%), and BioPure MTAD (16.08%). Within the parameters of this study, both 1%NaOCl and 6%NaOCl were more efficient in eliminating E. faecalis biofilm than the other solutions tested. J Endod 2006,32, 527-531