REMOVAL OF INTRACANAL MEDICAMENTS – A REVIEW

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ABSTRACT

Although some authors have questioned the benefit of placing inter-appointment intracanal medicaments, calcium hydroxide is still widely and routinely used due to its perceived benefits in disinfecting the root canals, and in rendering the soft tissue debris more susceptible to dissolution by subsequent use of sodium hypochlorite irrigant in the next appointment. After fulfilling its purpose, and prior to root canal obturation, removal of the medicament dressing is mandatory, as its remnants may mechanically block the apical area of the root canal system and also affect the viscosity, working time, integrity, dentin tubule penetration, and adhesion of root canal sealers. The removal of medicaments from the root canal space is challenging, because it should ideally be placed deep and densely, so that its biological effects can be exerted in close proximity to the appropriate tissues.

Keywords: Intracanal Medicaments, Intracanal Irrigants, Ultrasonics, Passive Irrigation, Canal Brush.

INRODUCTION

Most root canals contain viable microorganisms after completion of chemo-mechanical preparation at the end of the first appointment¹. Inter-appointment antimicrobial medication acts to inhibit proliferation and eliminate surviving bacteria, as well as minimize ingress through leaking restorations². Role of intracanal medicaments becomes more relevant in the treatment of pulp necrosis and apical periodontitis¹. The most widely and routinely used intracanal medicament is calcium hydroxide [Ca(OH)₂] because it controls bacteria in the canal environment, renders the necrotic tissue susceptible to solubilizing action of sodium hypochlorite (NaOCl) at the next appointment, achieves a more thorough instrumentation due to longer overall time used for treatment, promotes drying of weeping periapical lesions, enables apexification, treats root resorption, and has good biocompatibility¹,².

Types

The various intracanal medicaments used in endodontics are¹,²

1. Calcium hydroxide;
2. Chlorhexidine digluconate;
3. Triple-antibiotic paste
   (Metronidazole+Ciprofloxacin+Minocycline);
4. Corticosteroid-antibiotic paste: Ledermix;
5. Phenolic compounds: phenol, para-monochlorophenol, thymol, cresol;
6. Formocresol (Formaldehyde);
7. Halogens: chloramine-T, IKI (Iodine-Potassium-Iodide);
8. Bioactive glass;
Newer irrigants like Propolis has also been used as intracanal medicament³.

NEED FOR REMOVAL OF INTRACANAL MEDICAMENTS

Before root canal obturation, the medicament that has been applied to the root canal should be removed. Medicament residue on canal walls hinders sealer penetration into dentinal tubules⁴, and leads to unfavourable interaction between sealer and medicament⁵. Ca(OH)₂ reduces canal permeability by interacting with dentin, thus promoting formation of calcium-carbonate particles and interfering with sealing ability of endodontic cement⁶. Ca(OH)₂ has been proven to interact with the commonly used zinc oxide eugenol (ZnOE) containing sealer. The sealer layer in contact with Ca(OH)₂ exhibits gradual reduction in viscosity, with resultant resistance to placement of gutta-percha cone and inability of placement up to working length within root canals. Clinically, this effect is manifested as rapid setting reaction and reduced flow. Additionally, the set sealer will be poorly cohesive and granular. The reason for this is the preferential interaction of Ca(OH)₂ with eugenol leading to formation of calcium-eugenolate, with unreacted residual eugenol. Spectroscopy has shown this to be a disorganized layer. Presence of such remnants in critical (apical) areas affects clinical performance of the sealer⁵,⁶.
Porkaew et al. has reported that teeth dressed with Ca(OH)\(_2\) paste and then obturated, have significantly less leakage than unmedicated controls. This finding was explained on the possibility of residual Ca(OH)\(_2\) being incorporated into the sealer during obturation, which may lead to decreased sealer permeability. Additionally, Ca(OH)\(_2\) is transported or mechanically forced into the dentinal tubules, thus blocking them and reducing dentinal permeability.

Kim et al. has contradicted this theory reasoning that reduced dentin permeability is unrelated to improved apical seal because leakage occurs at three interfaces, namely, between the sealer and dentin, within the sealer itself, and between the sealer and gutta-percha cone. Additionally, calcium-eugenolate is more soluble, less sealing, and leads to greater film thickness.

Although an apical plug with Ca(OH)\(_2\) has been advocated for its prolonged antimicrobial activity after filling of the canal space, it is preferable to remove it as it might enhance apical leakage, because Ca(OH)\(_2\) is believed to be diluted in contact with tissue fluids.

Barbizam et al. reported lower bond strength values between Epiphany™ sealer (a resin-based sealer) and dentin after use of Ca(OH)\(_2\) medicament, suggesting that Ca(OH)\(_2\) residues left in the canal space could have interfered with sealer adhesion to root dentin. Renovato et al. has suggested that Ca(OH)\(_2\), being of basic character, promotes neutralization of acid monomers within the sealer, reducing its ability to hybridize dentine. These changes led to a decrease in the area of contact between sealer and dentine during obturation, thus affecting bond strength.

**FACTORS AFFECTING REMOVAL EFFICIENCY OF MEDICAMENTS**

**1. Variations in root canal morphology:** Various anatomical complexities of the root canal system pose challenges to cleaning and shaping. Removal of Ca(OH)\(_2\) residues from irregular canal walls is difficult. In straight root canals, it was shown that recapitulation with master apical file (MAP) in combination with irrigation resulted in improved removal of Ca(OH)\(_2\) when compared to irrigant alone.

**2. Irrigating solution used:** NaOCl is ineffective in removing Ca(OH)\(_2\) as it lacks chelating ability; it merely removes superficial debris. Chelators like EDTA neutralizes Ca(OH)\(_2\) residues, but these residues must then be flushed out with NaOCl, or a neutral agent like saline.

**3. Medicament formulation (physical state, concentration, excipients used):** Physical state of the medicament may affect its removal. Calle et al. found the removal of Temp Canal to be very difficult due to its hardness.

According to Lambriniadis et al., Ca(OH)\(_2\) content or concentration has no influence on its removal efficiency from root canal walls. But the vehicle used to mix Ca(OH)\(_2\) paste is important for complete retrieval: Methyl cellulosate vehicle resists removal from root canals when retrieved with 17% EDTA. This was probably due to interactions between methylcellulose and EDTA.

Nandini et al. found that particulate form of Ca(OH)\(_2\) in distilled water was easily removed, but Metapex (oily vehicle: silicone oil) resists dissolution in water and hence was retained in the canal. Both EDTA and citric acid chelators efficiently removed Ca(OH)\(_2\) powder in distilled water. Also, citric acid performed better compared to EDTA in removal of Metapex because EDTA chelates calcium ions in water, but citric acid can penetrate silicone oil better than EDTA. Ca(OH)\(_2\) combined with an oily vehicle is difficult to remove and leaves residues on canal walls.

**4. Factors pertaining to chelating agents:**

**a) Application time:** There is no clear-cut recommendation as to duration of application of chelating agents. Generally, each canal is rinsed for atleast 1 min. Prolonged exposure to strong chelators like EDTA may weaken root dentin, as dentin hardness and elastic modulus are functions of dentin mineral content.

Chelating activity of EDTA is observed at 1-4 min, reducing beyond 5 min. But Teixeira et al. reported that EDTA has similar chelation efficiency at 1, 3 and 5 min.

For citric acid, there is a trend of saturation of demineralizing ability after 60s. da Silva et al. reported good results in terms of smear layer removal when applied to root canals for 30s. Citric acid has a time-dependent action; beyond 15 min, chelation is not observed.

Etidronic acid (1-hydroxyethylidene-1,1-biphosphonate/HEBP) is a relatively slow chelator. De-deus et al. found that complete smear layer removal was achieved only after 300s of etching.

**b) pH and concentration of solution:** EDTA is more effective at neutral pH than alkaline pH. EDTA has a self-limiting action; this is explained on its ability for complex formation and protonation: EDTA has special affinity for chelation in the ratio 1:1, and its action ceases once EDTA molecules are used up.

Protonation, manifested as decreased pH, leads to a fall in demineralizing power of EDTA over time. According to Sousa et al., pH of citric acid is more important than concentration for chelating ability. It is not an effective chelator at neutral pH. Sterrett et al. reported that this phenomenon may be due to balance between decrease in pH and increase in viscosity of the solution caused by increase in constituent concentration. At high concentrations, citrate monopolizes such a large portion of the solvent that the amount of solvent available for Ca\(^{2+}\) diffusion is dramatically reduced.

**c) Volume of solution:** It has been recommended that 5-10 mL of the chelator irrigant be used for each canal.

**d) Reaction by-products:** Citric acid decalcifies the dentin, leading to precipitation of calcium-citrate crystals, which appear as debris under scanning electron microscope (S.E.M.). NaOCl oxidizes EDTA leading to formation of intermediate by-products (gloxilic acid, ethylenediaminetetraacetic acid). The significance of these reaction products remains unknown, but could potentially interfere with S.E.M. analysis in determining the extent of medicament removal.

**e) Apical-third of root canal:** Chelator efficiency decreases significantly from coronal part towards apical. This is because,
towards the apex, tubule density and hence the dentin permeability decreases. Also, apical dentin is often sclerosed, more and non-uniformly mineralized.  

**MEDICAMENT REMOVAL TECHNIQUES**  

**Manual (Figure 1a).**  
Before obturation, Ca(OH)₂ removal is routinely accomplished by either sodium hypochlorite or saline and/or instrumentation in a reaming motion with a small endodontic instrument, or with the master apical file. Irrigants are delivered by the conventional method of syringe irrigation. The most commonly described method is instrumentation along with irrigation by sodium hypochlorite and EDTA, combined with the use of ‘master apical file’ at working length.²⁻⁴ Irrigation is performed to disrupt and loosen the medication are up-and-down filing/oscillation with #15 K-file and #40 H-file. Instrumentation with a file, one size larger than the one used to the working length has also been performed.⁷  

**Machine-assisted (Figure 1b).**  
Different devices have been used for activation of the intracanal solution, so as to improve the mechanical flushing action of the irrigant. The various devices/techniques that have been used for medicament removal are: pressure alternation devices, rotary brush agitation, NiTi rotary instrument, ultrasonic, and sonic irrigation devices, and Er:YAG laser.  

**Chemical [Endodontic irrigants] (Figure 1c).**  
The most frequently used irrigant is sodium hypochlorite. Neutral agents like saline has also been used. Chelating agents which have been assessed for their medicament removal efficiency are EDTA, citric acid, maleic acid, and peracetic acid. Other chelators that have the potential for use in Ca(OH)₂ removal are Etridonic acid (1-hydroxyethylidene-1,1-biphosphonate), Tetracycline-hydrochloride, MTAD & Tetraclean.  

**Combination – Advantages & Drawbacks.**  
**Importance of final irrigant after the use of working solution:** EDTA emulsifies, neutralizes and holds Ca(OH)₂ debris in suspension, but if these residues are not removed, they may interfere with sealing efficiency. Hence the need arises for the mechanical flushing action afforded by NaOCl or saline. EDTA alone or prior to NaOCl irrigation has caused reduction in dentin microhardness. Combination of tetracycline-hydrochloride and NaOCl exhibited less dentin softening in comparison. Use of irrigation in combination with filing has proven to be more efficient in cleaning the root canals than manual filing unassisted by irrigants.  

**Association with wetting agent:** Salgado et al. has shown superior results of Ca(OH)₂ removal by EDTA-T (EDTA + 0.2% sodium lauryl sulphate biological detergent), than by NaOCl. EDTA-C and citric acid irrigants. On the contrary, Zehnder et al. showed that the association of wetting agents with EDTA may be detrimental to its calcium-chelating ability. This finding was supported by De-Deus et al. who reported that EDTA-C (EDTA + Cetavlon) had a weaker effect than EDTA.  

Previous studies done to assess efficiency of various methods of intracanal medicament removal are shown in Table 1. A great majority of these studies have assessed the removal of Ca(OH)₂ and its various formulations. Limited studies have been performed on other intracanal medicaments.  

**CONCLUSION**  
No technique has completely removed medicaments from the root canal walls. It is the appropriate use of mechanical instrumentation combined with the use of chelating agents, followed by final flushing with sodium hypochlorite that enables adequate cleanliness of root canal walls. Agitation of the irrigant solution with mechanical devices seems to improve the removal efficiency of intracanal medicaments.  

**REFERENCES**  


Manual
- Instrumentation with a small endodontic instrument, or with master apical file.
- Use of file, one size larger than the one used to the working length.
- Irrigant delivery: Conventional syringe irrigation.

Machine-assisted
- PRESSURE ALTERNATION DEVICES: EndoVac system; RinsEndo
- ROTARY: NiTi (ProTaper, ProFile) rotary instrument
- ROTARY BRUSH AGITATION: CanalBrush
- ULTRASONIC IRRIGATION: ProUltra® PiezoFlow™; Passive ultrasonic irrigation (PUI)
- SONIC IRRIGATION: Self-Adjusting File (SAF); EndoActivator
- LASER: Er:YAG

Chemical (Irrigants)
- MOST FREQUENTLY USED: Sodium hypochlorite
- NEUTRAL AGENT: Saline
- CHELATORS: EDTA; Citric acid; Maleic acid; Peracetic acid.
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<td>25.</td>
<td>Ahmetoğlu et al.</td>
<td>2013</td>
<td>Removal efficiency</td>
<td>CH (MM-paste)</td>
<td>SAF, PUI, CI</td>
<td>Incomplete removal - all methods; PUI significantly better than SAF &amp; CI.</td>
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<tr>
<td>26.</td>
<td>Faria et al.</td>
<td>2013</td>
<td>Removal efficiency</td>
<td>CH (Calen)</td>
<td>SAF, ProTaper rotary</td>
<td>Incomplete removal - all methods; No difference between SAF &amp; ProTaper.</td>
<td></td>
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<tr>
<td>27.</td>
<td>Maalouf et al.</td>
<td>2013</td>
<td>Removal efficiency of 2 CH preparations.</td>
<td>CH (CH powder + water; Pulpdent)</td>
<td>CI US/ RinsEndo® + saline</td>
<td>Percentage of overall canal surface area.</td>
<td></td>
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<tr>
<td>28.</td>
<td>Yüce et al.</td>
<td>2013</td>
<td>Removal efficiency</td>
<td>CH (Cals-In + saline)</td>
<td>EndoVac, ProUltra®/PiezoFlow™, CI by 30-gauge slot-tipped needle</td>
<td>EndoVac &amp; PiezoFlow - cleanest canals with no statistical difference; CI - insufficient.</td>
<td></td>
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<tr>
<td>29.</td>
<td>Nainan et al.</td>
<td>2013</td>
<td>Removal efficiency of 3 CH preparations using chelators.</td>
<td>CH (CH in distilled water + barium sulfate for radio-opacity; Apexcal; Metapex)</td>
<td>17% EDTA; 7% MA</td>
<td>CH in distilled water &amp; Apexcal (in PEG) were efficiently removed by 17% EDTA &amp; 7% MA. 7% MA removed Metapex (in silicone oil) better than 17% EDTA.</td>
<td></td>
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<tr>
<td>30.</td>
<td>Khaleel et al.</td>
<td>2013</td>
<td>Removal efficiency</td>
<td>CH</td>
<td>Irrigation (2.5% NaOCl + 17% EDTA + 2.5% NaOCl) with no agitation; irrigant agitation by ProTaper; agitation by EndoActivator tip size 25/.04; agitation by US file 25/.02</td>
<td>Percentage of overall canal surface area.</td>
<td>Sonic &amp; US agitation more effective than ProTaper rotary &amp; CI.</td>
</tr>
</tbody>
</table>

**Ultrasonic Irrigation**
- **US** = Ultrasonic
- **SAF** = Self-Adjusting File
- **S.E.M.** = Scanning Electron Microscopy
- **LM** = Light microscopy
- **EDX** = Energy Dispersive X-ray microanalyzer.
- **CH** = Calcium hydroxide
- **EDTA** = Ethylenediaminetetraacetic acid
- **CA** = Citric acid
- **MA** = Maleic acid
- **PAA** = Peracetic acid
- **NaOCl** = Sodium hypochlorite
- **CHX** = Chlorhexidine
- **PEG** = Polyethylene glycol
- **PG** = Propylene glycol
- **PA** = Phosphoric acid
- **CPMC** = Camphorated paramonochlorophenol
- **Antibiotic paste** contains ciprofloxacin & metronidazole.
- **CI** = Conventional Irrigation (syringe)
- **PUI** = Passive Ultrasonic Irrigation
- **US** = Ultrasonic
- **SAF** = Self-Adjusting File
- **S.E.M.** = Scanning Electron Microscopy
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