Irrigation in endodontics
This evidence summary aims to locate and summarise evidence on which endodontic irrigants are most effective. It does not include detailed descriptions of the studies cited nor does it include information that was not presented in the literature.

The Curious about website encourages dental professionals to raise issues where a review of the available evidence would provide a useful resource for other dental professionals. Where there is a lack of evidence, the topic is considered for research and an award is made available.

These activities are sponsored by the Shirley Glasstone Hughes Fund, a restricted fund within the BDA Trust Fund.
Key findings

- There is currently insufficient reliable evidence showing the superiority of one irrigant over another.

Review question

This evidence summary was prepared in response to the following question: Which endodontic irrigants are most effective?

The case for action

Why, when and how are irrigants used?

Irrigants are used during endodontic treatment to flush out inflamed and necrotic tissue, microbes/biofilms and other debris from the root-canal space. Irrigation of the root canal compliments mechanical debridement and is important for tissue healing; the success rate of endodontic treatment is higher if the root canal is free from bacteria at obturation. An ideal irrigant should have all, or most of, the characteristics listed below and have both low toxicity so as not to harm periradicular and gingival tissues and little potential to cause an anaphylactic reaction or weaken tooth structure:

- Washing action to help remove debris
- Reduce instrument friction during preparation
- Facilitate dentin removal
- Dissolve inorganic (smear layer) and organic matter (pulp and bacteria)
- Penetrate to canal periphery
- Broad antimicrobial spectrum
- Ability to inactivate endotoxin.

What irrigants can be used?

A large number of substances have been used as root canal irrigants, including acids (citric and phosphoric), chelating agents (EDTA), proteolytic enzymes, alkaline solutions (sodium hypochlorite, sodium hydroxide, urea and potassium hydroxide), oxidative agents (hydrogen peroxide and Gly-Oxide), local anaesthetic solutions and normal saline. Some of those most often used are described below.

Sodium Hypochlorite

Sodium hypochlorite is the most commonly used root canal irrigant. It is antimicrobial and effectively dissolves pulpal remnants, collagen, necrotic and vital organic tissue. However it has an unpleasant taste, is toxic and, when used in isolation, is unable to remove the smear layer. As complete cleaning of the root-canal system requires dissolution of organic and inorganic material, other substances, such as EDTA, must be used to complete the removal of the smear layer and dentin debris.

Chlorhexidine digluconate

Chlorhexidine digluconate has antimicrobial activity but no tissue dissolving capability. However it is biocompatible and does not possess some of the undesired characteristics of sodium hypochlorite for example the bad smell.

Ethylenediaminetetraacetic acid

Ethylenediaminetetraacetic acid (EDTA) can effectively dissolve inorganic material, including hydroxyapatite, thought it appears to have little or no effect on organic tissue and no antibacterial activity. It is able to remove the smear layer, is biocompatible, able to condition dentine and has some positive effect on the root canal seal. However like previously mentioned irrigants it cannot be extruded safely.

Mixture tetracycline citric acid and detergent (MTAD)

Mixture tetracycline citric acid and detergent (MTAD) is a mixture of doxycycline, citric acid and detergent (tween 80). MTAD has antimicrobial efficacy, removes the smear layer, is able to dissolve pulpal tissue, is biocompatible, has some dentine conditioning properties, a positive effect on the root canal seal, and does not adversely affect the physical properties of the tooth. However there is the possibility that resistance could develop.

Hydrogen peroxide

Hydrogen peroxide physically removes debris as well as through effervescence. It is anti-microbial but does not dissolve necrotic intra-canal tissue and exhibits toxicity to the surrounding tissue.
What happens when it goes wrong?
Published guidelines for endodontic treatment recommend that a rubber dam be used to isolate a tooth during root canal treatment to prevent, amongst other occurrences, irrigants escaping into the oral cavity. (11)

Irrigants can cause incidents, for example, through careless injection, extrusion, infusion, swallowing, spillage or allergy. (12,13) Accidental extrusion of sodium hypochlorite into the surrounding tissues, though rare, can lead to severe and devastating complications; contact with vital tissues can cause chemical burns and tissue necrosis, neurological complications and upper airway obstruction. (12) Complications can require hospital admission, operative intervention under general anaesthesia and even admission to intensive care. (9,12,14) Ingestion can cause irritation of the mouth and throat and burns, corrosion and damage to the digestive tract. (15-17) Accidental spillage of sodium hypochlorite is probably the most common incident (13) with the damage caused dependent on where the spillage has occurred clothes, the skin, the eye etc. The saponification effects of sodium hypochlorite spillage into the eye can result in loss of the organ. (13) An allergic reaction is rare but can result in pain, swelling, breathing difficulties and hospitalisation. (19)

Hazards of other irrigants include:
- Chlorhexine is a known allergen (20,21)
- EDTA can cause eye irritation (22)
- MTAD can cause eye, skin and/or gastrointestinal irritation (23)
- Hydrogen peroxide can cause facial nerve and tissue damage (10) and facial emphysema. (24)

The evidence
There is currently insufficient reliable evidence showing the superiority of one irrigant over another. (25-27) The strength and reliability of the evidence is variable and has been summarised below according to publication type: systematic review and randomised controlled trials (RCTs).

Systematic review (25)
The studies included in this review evaluated a range of irrigants, their strengths, combinations, and methods and duration of administration but did not provide sufficient data to enable fair and reasonable comparisons for any one single irrigant (or irrigant combination) against another for a specific outcome for example pain. The results, where available, are presented below under their outcome measure. No adverse effects were reported for any irrigant investigated. Only irrigant combinations where evidence was reported and only outcomes for which evidence was located are included.

(a) Pain and inflammation
Compared (one trial): sodium hypochlorite (5.25%); sodium hypochlorite (5.25%) combined with hydrogen peroxide (3%); and normal saline.
There was no evidence to suggest that either irrigant combination resulted in a difference in moderate to severe pain at follow up (two to 14 days).

Compared (one trial): sodium hypochlorite (5%); and sodium hypochlorite (5%) with ‘proteolytic enzyme’
There was no evidence that either irrigant affected the moderate to severe pain that persisted after day two. Swelling was reported in both groups of study participants (non-significant) but there was no evidence of swelling beyond day three. Pain on the day of the procedure was reported for both groups with the results being non-significant.

(b) Bacterial growth following the procedure and until 72 hours at follow-up
Compared (two trials): sodium hypochlorite and chlorhexidine
There was insufficient evidence to conclude a difference between the two irrigants in reducing positive bacterial growth.

Compared (one trial): sodium hypochlorite (1%); sodium hypochlorite (2.5%); and sodium hypochlorite (5%)
Sodium hypochlorite (5%) reduced the proportion of patient samples with positive culture when compared to sodium hypochlorite (1%).

Compared (one trial): sodium hypochlorite (1%) with additional irrigation using chlorhexidine (2%) or using normal saline
There was no significant difference in bacterial growth following the use of either irrigant.

Compared (one trial): sodium hypochlorite (1.3%) with MTAD; and normal saline
Live bacteria were present in all samples but counts decreased after sodium hypochlorite (1.3%) with MTAD was used.

Compared: chlorhexidine (0.2%) and normal saline
Bacterial growth occurred in both groups (65% in the chlorhexidine group and 89% in the saline group).

Randomised controlled trials (26,27)
Neither of the RCTs demonstrated any difference in the irrigants that were examined (excluding saline) so do not alter the conclusion reached by the systematic review. (26) Results from individual comparisons are given below.
Compared: sodium hypochlorite (5.25%); and chlorhexidine gel (2%) with saline (0.9%)²⁶
There were no significant differences between the two irrigants in terms of postoperative pain; no patient reported severe pain and pain decreased over time. At the worst point (24 hours after the treatment) two of the 63 patients in each group (3%) experienced moderate pain.

Compared: sodium hypochlorite (2.5%); chlorhexidine (0.2%); Neem Extract; alternate use of sodium hypochlorite (2.5%) and ELE; chlorhexidine (0.2%) and ELE; and saline (0.9%) as a control²⁷
There were no significant differences between the antimicrobial efficacy of sodium hypochlorite, chlorhexidine and ELE. Maximum tissue clearance and reduction in microbial loads was found with a combination of sodium hypochlorite and ELE. ELE has demonstrable anti-microbial efficacy and combining the extract with sodium hypochlorite has a synergistic antimicrobial effect.

Methods

Search strategy
A systematic review of literature published up to July 2012 was located. It examined the available data on the effects of irrigants used in the non-surgical root canal treatment of mature permanent teeth.²⁵ As a consequence, only relevant studies published since the systematic review were sought (2012 – 2014) and the search strategy, including search strings, was followed as closely as was possible. Four of the five search strategies used in the identified review were repeated (as below). The EMBASE database was not searched. Clinical trial registers (WHO, ISRCTN registry and The U.S. National Institutes of Health Ongoing Trials) were also searched.

- Cochrane Oral Health Group’s Trials Register
- Cochrane Central Register of Controlled Trials (CENTRAL)
- MEDLINE via Ovid
- LILACS via BIREME

Hand searching of the following journals was also undertaken:
- The International Endodontic Journal
- Journal of Endodontics
- Oral Surgery, Oral Pathology, Oral Radiology, and Endodontics
- Dental Traumatology
- Australian Endodontic Journal

Grey literature was searched and a snowballing strategy was employed once publications relating to the questions were located.

Papers were included if they met the following criteria:
- Randomised controlled trial
- Single or multi-rooted permanent teeth with pulpal and/or periapical pathology requiring root canal treatment
- Irrigants investigated either against each other or against inactive irrigant or placebo
- Combinations of irrigants allowed and if used in conjunction with EDTA or similar chelating agents

Results
A systematic review²⁵ covering this topic was located so only subsequent publications were sought. Over 1000 publications were located and following sifting by the author, the full text of 28 publications were obtained. Of these, two RCTs were judged to be relevant (Appendix one).

The systematic review examined irrigants for non-surgical root canal treatment in mature permanent teeth.²⁵ Of the two RCTs, one compared sodium hypochlorite and chlorhexidine gel in terms of postoperative pain;²⁶ the other evaluated the antimicrobial properties of neem extract (ELE) against that of sodium hypochlorite and chlorhexidine.²⁷

The systematic review contained a meta-analysis, covered 11 studies and 851 participants with 879 teeth undergoing root canal treatment. The design of each study was described, at best, as adequate with reported limitations including:
- Variations in the inclusion criteria
- Missing post-procedure questionnaires
- Disordered analysis
- Questionable assessment methods.
Six of the included studies were judged to have an unclear risk of bias; three were high risk and two low risk.

Almeida et al assessed the incidence of postoperative pain. Although a four-point, easily understandable scale was used, it remained difficult to measure objectively a patient’s level of pain; the information provided was subjective. The study was judged to have an unknown risk of bias as it was unclear if participants receiving care were ‘blind’ to treatment allocation and if investigators were ‘blind’ to factors that might provide an indication to the outcome for a patient or factors that may have masked or falsely demonstrated an association between irrigants.[26]

The antimicrobial properties of neem extract as an irrigant during root canal treatment was compared with sodium hypochlorite and chlorhexidine irrigants. The trial, carried out in India, was judged to have an unknown risk of bias as it was unclear if the groups were comparable at baseline. Further information concerning this study was provided by Dr Arindam Dutta.[27]

References


## Appendix one

### Table 1a

<table>
<thead>
<tr>
<th>Study</th>
<th>Included studies</th>
<th>Aim</th>
<th>Outcome measures</th>
<th>Salient findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systematic review(25)</td>
<td>11 RCTs</td>
<td>Assess the effects of irrigants used in the non-surgical root canal</td>
<td><strong>Primary outcomes</strong>: moderate to severe pain; new or worsening signs, symptoms or both of inflammation requiring a revisit.</td>
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<td></td>
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<td>treatment of mature permanent teeth.</td>
<td><strong>Secondary outcomes</strong>: moderate to severe pain; mean change in health-related quality of life, or expressed satisfaction with the procedure; positive bacterial growth culture; change in periapical radiolucency</td>
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<td></td>
<td>Pain experienced immediately after treatment and between appointments did not appear to differ between some of the irrigants or between the different strengths of irrigants. Higher strength sodium hypochlorite solution with chlorhexidine may be more effective than other irrigants at destroying bacteria.</td>
<td>Systematic review included in this evidence summary.</td>
</tr>
</tbody>
</table>

### Table 1b

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Study length</th>
<th>Aim</th>
<th>Outcome measure</th>
<th>Salient findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alemedia(26)</td>
<td>36 single rooted anterior teeth in 36 adult patients (&gt;18 years) at the Manipal College of Dental Sciences, Manipl, India.</td>
<td>72 hours</td>
<td>Compare the anti-microbial efficacy of sodium hypochlorite and chlorhexidine gluconate with an experimental irrigant formulated from the Neem tree.</td>
<td>Microbial load (anaerobic culture and Gram stained smears)</td>
<td>There were no significant differences between the antimicrobial efficacy of sodium hypochlorite, chlorhexidine and experimental neem extract.</td>
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<tr>
<td>Dutta(27)</td>
<td>126 teeth in 126 patients (18 to 59 years) in dental practices in Brazil.</td>
<td>Seven days</td>
<td>To compare 2 irrigation solutions in terms of postoperative pain after single-visit treatment of chronic apical periodontitis with pulp necrosis</td>
<td>Postoperative pain</td>
<td>Postoperative pain after single-visit endodontic was uniformly low, regardless of the irrigant used.</td>
</tr>
</tbody>
</table>

Randomised controlled trials included in this evidence summary.