ABSTRACT

The efficacy of the sodium hypochlorite (NaOCl) and chlorhexidine (CHX) on *Enterococcus faecalis* was evaluated by systematic review and meta-analysis. The search strategies included search in electronic biomedical journal databases (MEDLINE, EMBASE, CENTRAL) and handsearching records, using different matches of keywords for NaOCl, CHX and *Enterococcus faecalis*. From 41 in vivo studies, 5 studies met the inclusion criteria. In a sample containing 159 teeth, *E. faecalis* was detected initially in 16 (10%) teeth by polymerase chain reaction (PCR) and 42 (26.4%) teeth by microbial culture techniques. After root canal disinfection, this species was observed in 11 (6.9%) teeth by PCR and 12 (7.5%) teeth by culture. Risk differences of included studies were combined as generic inverse variance data type (Review Manager Version 5.0 – Cochrane Collaboration, http://www.cc-ims.net, accessed 15 May 2008), taking into account the separate tracking of positive and negative cultures/PCR. The level of statistical significance was set at p<0.05. In conclusion, NaOCl or CHX showed low ability to eliminate *E. faecalis* when evaluated by either PCR or culture techniques.

Key words: *E. faecalis*. Sodium hypochlorite. Chlorhexidine. Irrigating solutions. Systematic review.

INTRODUCTION

The pathogenicity of endodontic microorganisms responsible for stimulating apical periodontitis creates the need for finding effective antimicrobial medicaments. Sodium hypochlorite (NaOCl) and chlorhexidine (CHX) are the most frequently widely studied and employed antimicrobial agents for treatment of root canal infection. These medicaments present chemical characteristics that are particularly responsible for their distinct results when compared. These variations occur probably due to differences in methodology, biological indicators, concentrations, exposure time, the potential for different anatomical and treatment differences between patients.

The contemporary literature contains numerous reports on the antimicrobial efficacy of NaOCl and CHX in several experimental models - infected human teeth in vivo, infected human teeth ex vivo, infected dog’s teeth in vivo, infected bovine teeth ex vivo, biofilm model in membrane filters, direct contact and agar diffusion test. *E. faecalis* is an extensively evaluated biological indicator. Some factors can explain the concern with this pathogen in endodontic infections. Its high prevalence in cases with post-treatment disease associated with virulence factors (aggregation substance, enterococcal surface proteins (Esp), gelatinase, cytolsin toxin, extracellular superoxide production, capsular polysaccharides, antibiotic resistance determinant) can facilitate the adherence of host cells and extracellular matrix, tissue invasions, immunomodulation effect and cause toxin-mediated damage.

Actual thinking has recommended the implementation of evidence-based dentistry, which valorizes studies involving the systematic review or meta-analysis. Systematic reviews use a strict methodological approach to search, select, evaluate, and analyze original data from primary sources. Good scientific evidence is mandatory to elaborate clinical decisions, yet few systematic reviews or meta-analysis have been developed in Endodontics.
Torabinejad and Babjri\textsuperscript{24} reported that the American Dental Association has adopted the concept of evidence-based healthcare, which requires the judicious integration of systematic assessments of clinically relevant scientific evidence.

Previous studies using \textit{in vitro} experimental models have confirmed the antimicrobial efficacy of NaOCl and CHX against \textit{E. faecalis}\textsuperscript{6,23}, while others using different study designs have not found same results\textsuperscript{4,5,7,16-18,29,30}. Relevant clinical questions based on evidence regarding the resistance of \textit{E. faecalis} to NaOCl or CHX should be further discussed. Therefore, the aim of this study was to review findings on the antibacterial efficacy of NaOCl or CHX against \textit{E. faecalis} in endodontic infection using systematic review and meta-analysis.

**MATERIALS AND METHODS**

**Literature Review**

This study was designed using an analysis of longitudinal studies from a quantitative systematic review. Prospective studies were selected towards the efficacy of NaOCl and CHX against \textit{E. faecalis} identified in endodontic infections before and after root canal preparation. English-language articles were retrieved from electronic biomedical journal databases and handsearching records.

The following databases were searched on January 2nd, 2007: MEDLINE (without filter, from 1966 to January 2nd, 2007), EMBASE (without filter, from 1980 to January 2nd, 2007), Cochrane Oral Health Group Trials Register and Cochrane Central Register of Controlled Trials (CENTRAL). For the electronic search strategy, the following terms were used as keywords in several combinations: 1. \textit{faecalis} and sodium hypochlorite OR, 2. \textit{faecalis} and chlorhexidine OR, 3. \textit{faecalis} and root canal infections OR, 4. \textit{faecalis} and endodontics infections OR, 5. \textit{faecalis} and root canal irrigants OR, 6. \textit{faecalis} and irrigating solution OR, 7. \textit{faecalis} and endodontics irrigants OR, 8. \textit{faecalis} and intracanal irrigants.

A systematic review was conducted according to the guidelines of the Cochrane Collaboration, which recommend the search for the largest possible number of articles. Handsearching was conducted by the review of the reference lists of the eligible clinical trials and the review of author’s personal databases of trial reports in an attempt to identify any other relevant studies.

**Inclusion and Exclusion Criteria**

The selected articles were identified from titles and abstracts by two independent reviewers, considering the tabulated inclusion and exclusion criteria. The inclusion criteria were studies in humans, studies related to the efficacy of NaOCl or CHX against \textit{E. faecalis}, nonsurgical root canal treatment performed during the study, subjects with a noncontributory medical history, microbiological samples collected before and after root canal preparation, English-language articles. The exclusion criteria were \textit{in vitro} and animal studies, studies related to the efficacy of intracanal irrigants and medications other than NaOCl or CHX, studies without collection of microbiological samples before or immediately after root canal preparation, non-English-language articles, studies abstract only or no abstract, literature reviews, studies involving primary teeth, case reports, studies related only to microbial identification or studies involving microorganisms other than \textit{E. faecalis}.

Full-text reprints were obtained from all relevant and potentially relevant studies, which seemed to meet the inclusion criteria and from those that had insufficient data in the title and abstract to make a clear decision.

**Meta-Analysis**

The design of this meta-analysis was based on the guidelines of the Cochrane Collaboration and on the methodology of previous study\textsuperscript{21}. Chi-square test was used to analyze the differences between the studies. The essential analysis of antibacterial efficacy was risk difference (difference in the ratio of positive bacterial identification

![Table 1: Studies included related to the efficacy of the NaOCl and CHX against \textit{E. faecalis}](Table1.png)

<table>
<thead>
<tr>
<th>Studies (ref.)</th>
<th>n</th>
<th>IET</th>
<th>Baseline infection types</th>
<th>\textit{E. faecalis} before RCP</th>
<th>Irritants</th>
<th>\textit{E. faecalis} after RCP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PCR</td>
<td>Culture</td>
<td>NaOCl</td>
</tr>
<tr>
<td>Willian, et al.\textsuperscript{29}</td>
<td>29</td>
<td>&gt;5 years</td>
<td>primary (n=15)</td>
<td>2 (13.3%)</td>
<td>1 (6.6%)</td>
<td>1% NaOCl</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>secondary (n=14)</td>
<td>6 (42.8%)</td>
<td>2 (14.2%)</td>
<td></td>
</tr>
<tr>
<td>Zerella, et al.\textsuperscript{30}</td>
<td>40</td>
<td>-</td>
<td>secondary</td>
<td>8 (20%)</td>
<td>-</td>
<td>1% NaOCl</td>
</tr>
<tr>
<td>Ferrari, et al.\textsuperscript{7}</td>
<td>25</td>
<td>-</td>
<td>primary</td>
<td>-</td>
<td>4 (16%)</td>
<td>0.5% NaOCl + Endo PTC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peciuleni, et al.\textsuperscript{17}</td>
<td>40</td>
<td>5-10 years</td>
<td>secondary</td>
<td>-</td>
<td>21 (52.5%)</td>
<td>2.5% NaOCl</td>
</tr>
<tr>
<td>Peciuleni, et al.\textsuperscript{18}</td>
<td>25</td>
<td>-</td>
<td>secondary</td>
<td>-</td>
<td>14 (56%)</td>
<td>2.5% NaOCl</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>159</td>
<td>-</td>
<td>-</td>
<td>16 (10%)</td>
<td>42 (28.4%)</td>
<td>-</td>
</tr>
</tbody>
</table>

(n - number of samples, IET- initial endodontic treatment, RCP – root canal preparation)
obtained by PCR of culture techniques between pre- and post-disinfection). Risk differences of included studies were combined as generic inverse variance data type (Review Manager Version 5.0 – Cochrane Collaboration, http://www.cc-ims.net, accessed 15 May 2008), taking into account the separate tracking of positive and negative cultures/PCR. The level of statistical significance was set at p<0.05.

RESULTS

The search retrieved 229 related articles, being 6 literature reviews, 39 articles related to in vivo studies (27 in humans and 12 in animals), and 189 related to in vitro studies. From the 39 in vivo studies, 5 met the inclusion criteria. In these 5 papers, from a total of 159 teeth with primary or secondary endodontic infections, E. faecalis was initially detected in 16 (10%) teeth by PCR and 42 (26.4%) teeth by culture. After disinfection (effect of root canal enlargement associated with the action of chemical irrigants), E. faecalis was identified in 11 (6.9%) teeth by PCR and 12 (7.5%) teeth by culture techniques. No longitudinal studies in humans investigating the efficacy of NaOCl and CHX against E. faecalis from endodontic infections were found (Table 1).

The outcomes of the 5 selected studies are shown in Tables 2 and 3. The analysis was made between pre- and post-disinfection of the same root canals. The 5 5 studies were heterogeneous (Test of Homogeneity Chochran), considering samples evaluated by culture technique ($\chi^2 =45.85$, df=4, p<0.00001) and PCR ($\chi^2 =1.65$, df=1, p=0.20). Thus, NaOCl or CHX showed low ability to eliminate E. faecalis when evaluated by either culture or PCR techniques.

DISCUSSION

The success of endodontic treatment is closely associated to the control of endodontic microbiota. Several chemical irrigants have been suggested for use in the treatment of infected root canal. 

Studies with similar results have been reported when NaOCl and CHX were compared and irrigation with NaOCl or EDTA. Microbes were isolated from 14 of those 20 culture positive teeth, usually where the intracanal medicaments can reach, NaOCl and CHX may present efficacy against E. faecalis. However, when bacteria are lodged within the dentinal tubules or in deep layers, E. faecalis can be more resistant to the antibacterial action of NaOCl and CHX.

The first aspect to be considered is related to the bacteria location. If bacteria are located only on the root canal surface, where the intracanal medicaments can reach, NaOCl and CHX may present efficacy against E. faecalis. However, when bacteria are lodged within the dentinal tubules or in deep layers, E. faecalis can be more resistant to the antibacterial action of NaOCl and CHX.

Five studies met the inclusion criteria established for the present investigation. Peciuliene, et al. observed E. faecalis in 25 asymptomatic teeth with secondary infection. Avoiding contamination, microbiological samples were collected from the canals before and after preparation and irrigation with NaOCl and EDTA. E. faecalis was isolated from 14 of those 20 culture positive teeth, usually in pure culture or as a major component of the flora. Second samples taken after preparation revealed growth in 7 of the 20 teeth. Five of the 7 cases were E. faecalis in pure culture. Isolation of E. faecalis was not related to the use of any specific root filling material in the original root filling. Peciuliene, et al. determined the occurrence and role of yeasts, enteric Gram-negative rods and Enterococcus species in root-filled teeth with chronic apical periodontitis. After collection of the first microbiological sample, the root canals were prepared to a size 40 file using 2.5% NaOCl and 17% EDTA as irrigating solutions. Microbes were isolated from
in Sample 1 than cultivation, but the difference was not statistically significant. At collection times in Samples 2 and 3, qPCR identified more *E. faecalis* infections in refractory lesions than cultivation (Table 1).

Based on the meta-analysis results, in the selected 5 studies\(^{8-13}\), from a total of 159 teeth with endodontic infections, *E. faecalis* was detected initially in 16 (10%) teeth by PCR and 42 (26.4%) teeth by microbial culture techniques. Immediately after root canal preparation using 0.5% to 2.5% NaOCl, it was possibly to identify *E. faecalis* in 11 teeth (6.9%) by PCR and in 12 teeth (7.5%) by culture. No longitudinal studies in humans investigating the efficacy of NaOCl and CHX against *E. faecalis* from endodontic infections were found.

The difficulty in comparing the studies retrieved in the present search is due to differences on the methodological design of each investigation: standardization of the limit of preparation, choice of the preparation technique, standardization of tooth type and sample size, time of the initial endodontic treatment in cases of secondary infection, quality control of the chemical irrigants and variation in their concentration, criteria for the detection of the periapical lesion etc, in addition to other important data that were not mentioned in these studies (Table 1).

The selection of endodontic irrigants that aggregate the largest possible number of ideal properties was a major point in the present study. There was a concern in this systematic review\(^{20}\) regarding to the process of making clinical decisions in the control of microorganisms in endodontic infections.

**CONCLUSION**

In summary, the disinfection of the root canal system produced by emptying, enlargement and action of NaOCl reduces the remaining endodontic microbiota, which optimizes the efficacy of the intracanal dressing and favors the achievement of a higher level of success of the endodontic treatment.

**REFERENCES**


