Influence of calcium hydroxide intracanal dressings on the prognosis of teeth with endodontically induced periapical lesions

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Abstract


Aim This prospective clinical study explored the influence of calcium hydroxide as an interappointment dressing on the healing of periapical lesions associated with pulpless teeth that had not been endodontically treated previously. This was achieved by comparing the prognosis after a two-visit root canal treatment with that following a one-visit treatment.

Methodology Seventy-three patients were recruited having one tooth with an endodontically induced lesion. Of these patients, 67 could be re-examined. Calcium hydroxide was placed in the instrumented root canals of 31 teeth for at least one week and the treatment finished at the second visit. Thirty-six teeth were root canal treated at one visit. The criteria for success were the absence of signs and symptoms indicating an acute phase of periapical periodontitis and radiographically a periodontal ligament space of normal width. Methods for event time analysis were used to evaluate and compare the prognosis of both treatment approaches.

Results The probability that complete periapical healing will take place increased continuously with the length of the observation period. In both treatment groups the likelihood that the root canal treatment yields a success within an observation time of five years exceeded 90%. A statistically significant difference between the two treatment groups could not be detected.

Conclusions From a microbiological perspective, one-visit root canal treatment created favourable environmental conditions for periapical repair similar to the two-visit therapy when calcium hydroxide was used as antimicrobial dressing. One-visit root canal treatment is an acceptable alternative to two-visit treatment for pulpless teeth associated with an endodontically induced lesion.

Keywords: calcium hydroxide, one-visit endodontic treatment, periapical lesion, prognosis, root canal treatment.

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Introduction

The development and progression of an endodontically induced apical periodontitis are clearly associated with the presence of microorganisms in the root canal system (Kakehashi et al. 1965, Sundqvist 1976, Möller et al. 1981). Thus, conventional root canal treatment aims primarily at eliminating these bacteria as completely as possible. The root canal is cleaned and shaped, ideally to the apical constriction (Ricucci 1998, Ricucci & Langeland 1998), under sufficient irrigation with a potent solution, e.g. sodium hypochlorite. In addition, an interappointment antimicrobial dressing is generally advocated to prevent recovery and multiplication of microorganisms remaining even after careful instrumentation and debridement of the root canal space (Byström et al. 1985, European...
Society of Endodontology 1994, Sjögren et al. 1997): a popular medicament is calcium hydroxide. Clinically, microbiological samples from initially infected root canals substantiated the potential of calcium hydroxide to eliminate or reduce the total number of cultivable bacteria in the root canal system when the medicament was placed in the root canal for at least one week (Byström et al. 1985, Sjögren et al. 1991).

Due to the inaccuracy of the sampling method itself, however, there is a risk of obtaining false negative bacterial samples. Thus, it can be speculated that in some teeth periapical healing occurred even when bacteria were left in inaccessible areas of the root canal system, e.g. in the dentinal tubules, following complete instrumentation and placement of an antimicrobial medicament. This may be one reason for the recent controversy about the necessity of an antimicrobial intracanal dressing (Byström et al. 1987, Peters et al. 1995, Sjögren et al. 1997, Weiger et al. 1998). It has been reported that calcium hydroxide has the potential to kill bacteria left in inaccessible areas of the root canal system and therefore favours the healing process of periapical lesions (Byström et al. 1985, 1987). Others have recommended for practical reasons that endodontic treatment should be completed in a single visit (one-visit treatment) without any intracanal dressing (Peters et al. 1995). It is argued that bacteria surviving in the root canal system after root canal preparation are entombed by obturating the root canal and perish as a result of lack of substrate (Peters et al. 1995). These microorganisms may no longer interfere with the periapical healing process. Likewise, some root canal sealers and gutta-percha cones elicit in vitro an antibacterial activity that may contribute to the elimination of intracanal microorganisms (Moorer & Genet 1982, Weiger et al. 1993).

The present prospective clinical study was initiated to explore the influence of calcium hydroxide applied as an interappointment intracanal dressing on the healing process of periapical lesions associated with pulpless teeth. For this purpose the prognosis after a two-visit root canal treatment was compared with that following a one-visit treatment.

Materials and methods

Clinical material

Seventy-three patients that had not taken antibiotics four weeks prior to endodontic therapy were recruited for this trial that began in September 1992. In each patient one tooth was selected that radiographically demonstrated a lesion associated with a root and did not respond to the sensitivity test. The probing depth of this tooth was recorded at up to 10 sites to exclude the possibility that a pocket communicated with the lesion.

Radiographs were taken using the paralleling technique, a beam guide, standardized bite blocks and standardized exposure times; films were processed conventionally.

The teeth had not been endodontically treated previously. The lesions detected were located predominantly periapically and in rare cases laterally or interradicularly; regardless of their location they were all called ‘periapical lesions’.

Of the 73 recruited patients, 67 could be re-examined (37 females and 30 males). The mean age was 38 years (range: 11–84 years). Five patients did not respond to our repeated request to attend the recall appointments or refused further examination. One patient deceased prior to the first scheduled recall date. The recall rate related to the number of treated teeth was 92%.

Root canal treatment

Root canal treatment was carried out by two experienced endodontists (RW and RR) according to criteria defined at the outset. If present, caries lesions and leaking restorations were removed. After initially accessing the floor of the coronal pulp chamber the tooth was isolated with rubber dam and disinfected with 1% sodium hypochlorite. Subsequently, the access cavity was completed using a separate set of sterile instruments. If present, the coronal pulp tissue was removed by irrigation with a 1% sodium hypochlorite solution and the most cervical portion of the root canals flared with Gates-Glidden drills from size one through either size three or four for large root canals. The working length was determined radiographically from a coronal reference to a distance 1 mm short of the radiographic apex. The root canals were instrumented with conventional K-type files or flexible files in case of curved root canal configurations under thorough irrigation of 1% sodium hypochlorite. The apical portion of straight root canals was prepared with the standardized technique (‘apical box preparation’) (Tronstad 1991) to an apical size 40 or larger and curved root canals with the step-back technique to an apical size 30 or larger. The root canal walls in the middle portion of the root were filed circumferentially.

When the instrumented root canals were not obturated at the same visit, calcium hydroxide mixed...
with sterile physiological saline to a creamy consistency was repeatedly placed in the root canal with sterile paper points. The calcium hydroxide paste in the root canal was step-by-step condensed with additional dry paper points. No radiograph was taken to control the proper placement of the dressing. The access cavity was sealed with a temporary dressing with a minimum thickness of 3 mm. Calcium hydroxide remained in the root canal system for 7–47 days (mean value: 22 days).

At the second appointment calcium hydroxide was removed by irrigating the root canals with 1% sodium hypochlorite and filing the root canal walls with the master apical file. The root canal was obturated with a master gutta-percha point, laterally condensed gutta-percha points and a calcium hydroxide sealer (Sealapex®, Kerr Corp., Romulus, MI, USA). The pulp chamber was sealed with either a glass ionomer cement or a composite filling which served as a base for the definitive restoration. The thickness of the base varied from 1 mm to 3 mm. A final radiograph was taken to evaluate the quality of the obturation.

Pre- and postoperative findings

At the initial examination and at the recall appointments the following clinical findings were recorded: history of pain indicating symptomatic periapical periodontitis, presence of a swelling, presence of a fistula, tenderness to axial percussion, periodontal probing depths, mobility.

Radiographically, signs of periapical pathosis were recorded. The preoperative size of the periapical lesion was evaluated by averaging its largest diameter and its smallest one which were measured to the nearest 0.5 mm. After obturation of the root canal system the apical extension of the root canal filling related to the radiographic apex associated with the periapical lesion was assessed.

The clinical findings recorded at the last follow-up and the comparison of the preoperative diagnostic radiograph with that of the last follow-up were the basis for evaluating the outcome of the endodontic therapy. The radiographs were judged by both dentists involved in the study (RW and RR) by using a magnifying glass and a light box. The operators did not know whether the tooth belonged to the one-visit or the two-visit group. In case of disagreement, a joint decision was made. The criteria for success or failure were the following:

1. Complete healing (= success):
   - no clinical signs and symptoms and;
   - radiographically a periodontal ligament space of normal width.
2. Incomplete healing:
   - no clinical signs and symptoms and;
   - radiographically a reduction of the lesion in size or an unchanged lesion within a observation time of 4 years.
3. No healing (= failure):
   - clinical signs and symptoms indicating an acute phase of apical periodontitis and/or;
   - radiographically a persisting lesion after a follow-up time of 4–5 years and/or;
   - a new lesion formed at an initially uninvolved root of a multi-rooted tooth.

Multi-rooted teeth associated with at least two periapical lesions were categorized according to the most unfavourable findings.

The time intervals planned for follow-up were 6 months and 1, 2, 3, 4 and 5 years. If the treatment was judged successful within a certain time period, no further controls were envisaged. The last patient entered into the trial 12 months before the study was finished in October 1998.

Statistical analysis

The allocation of the tooth to a treatment modality (one-visit treatment or two-visit treatment) followed the method of ‘minimization’ (Altman 1991) to balance the two groups of teeth with regard to the criterion ‘tooth type’.

In this clinical trial the individual time to complete healing of a periapical lesion following root canal treatment (= favourable event) was of interest. An analysis of event times that also accounts for the observation periods of teeth associated with ‘no healing’ was applied. This approach also considers the individual time span within which the tooth under observation (‘incomplete healing’) is ‘at hope’ although this time is cut off before the event of interest possibly occurs.

The empirical distribution of the event times for both treatment groups were separately calculated on the basis of the Kaplan–Meier method (Kaplan & Meier 1958) and presented as step functions. These give the probabilities that a specific treatment resulted in a success within a certain period of time. The logrank test was applied for the comparison of the two treatment groups.
In addition, the Cox’s proportional hazards model (Cox 1972) served to analyse the simultaneous effect of potential risk factors (= covariates) on the event times. The covariates included were ‘tooth type’ (incisor/canine, premolar or molar), ‘presence of a symptomatic periapical periodontitis’ (yes or no), ‘apical level of the root canal filling’ [0–2 mm short of the radiographic apex, > 2 mm short of the radiographic apex or overextended], ‘type of root canal treatment’ (one-visit or two-visit root canal treatment) and ‘preoperative size of the periapical lesion’ [‘size’ ≤ 2 mm, 2 mm < ‘size’ ≤ 5 mm or ‘size’ > 5 mm]. This approach provides relative risk ratios with the corresponding 95% confidence intervals (CI) for each covariate. P-values lower or equal to 0.05 indicate that the selected covariate exerts a statistically significant effect on the response variable (= event time).

The statistical unit was the patient. The level of statistical significance was set at $\alpha = 0.05$.

**Results**

Thirty-six of the 67 re-examined teeth (RW: 46 teeth, RR: 21 teeth) were subjected to the one-visit root canal treatment, whilst the other 31 teeth were obturated at the second visit after calcium hydroxide was placed in the root canal at the first visit. Fifty-two teeth could be categorized as ‘complete healing’, 11 teeth as ‘incomplete healing’ and four teeth as ‘failure’. The estimated times to complete periapical healing used as basis for calculation ranged from 4 to 58 months. The individual observation times varied between 6 and 37 months for those teeth associated with ‘incomplete healing’.

The number of tooth types and instrumented root canals, the presence of preoperative signs and symptoms, the apical level of the root canal filling and the kind of coronal restoration are given for both treatment groups in Tables 1–5. Figure 1 documents the preoperative sizes of the lesions in the two groups. The teeth lost to follow-up were not considered.

The probability ($P$) that complete healing occurred within a certain time span increased continuously with the length of the observation period (Fig. 2, Table 6). The logrank test did not reveal any statistically significant difference in both treatment groups ($P > 0.05$). In both treatment groups the probability that the root canal treatment yielded a success within
In order to substantiate the results of the logrank test the type of endodontic treatment (one-visit versus two-visit endodontic treatment) was introduced in the Cox’s regression model as a binary covariable along with four additional covariables (‘tooth type’, ‘presence of signs and symptoms’, ‘apical level of the root canal filling’, ‘size of the lesion’) known as potential risk factors. This analysis confirmed that the kind of endodontic treatment did not have any statistical impact on the likelihood that a complete periapical repair would occur ($P > 0.05$) (Table 7). By contrast, the covariable ‘size of the apical lesion’ exerted a significant effect on the healing process ($P < 0.05$). The hazard rate ratio of 2.45 (95% CI: 1.21–4.58) indicates an elevated risk of a failure when a large apical lesion (‘size’ > 5 mm) was present prior to treatment.

**Discussion**

Generally, the significance of the results of a prospective clinical trial dealing with the prognosis, for example, of two treatment approaches, depends...
decisively on the recall rate of the patients treated. In
the present study this rate was 92%, higher than in
most other comparable studies (for review see Weiger
et al. 1998). From a statistical point of view, therefore, the so-called bias that might be caused by
those patients lost to follow-up was likely to be
negligible. In contrast to two prospective studies
(Byström et al. 1987, Sjögren et al. 1997) closely
related to the present trial, the clinical material was
not limited a priori to single-rooted teeth.

The root canal treatment was performed to a
standard recommended by the official guidelines of the
European Society of Endodontology (1994). Conse-
quently, the elimination of bacteria from the root canal
system was accomplished by mechanical instrumenta-
tion supported by sodium hypochlorite as the irrigating
solution. When the biomechanical preparation was
combined with calcium hydroxide as antimicrobial
medicament, it was placed in the root canal for at least
7 days. Sjögren et al. (1991) demonstrated that after
this time calcium hydroxide achieved an optimal anti-
bacterial effect under clinical conditions.

The applied criteria for a successful root canal
treatment was based closely on those established by
Strindberg (1956). Accordingly, in the present investiga-
tion 30 out of 36 teeth could be judged as a success
after the one-visit treatment and 22 out of 31 teeth
following the two-visit treatment. Four cases failed
(one-visit treatment: three; two-visit treatment: one).
In multi-rooted teeth no new lesions formed on roots
that were originally free of periapical disease. Radiogra-
phically, seven periapical lesions (one-visit treatment:
three; two-visit treatment: four) out of the 11 cases
categorized as ‘incomplete healing’ clearly decreased in
size within the given observation time, indicating that
healing was expected to occur at a later time. The
probability that a treatment success will show up
within a 4-year observation period was 87% (95% CI:
74–99%) for the one-visit treatment and 84% (95% CI:
67–100%) for the two-visit treatment. Although the
comparison with other studies on the prognosis of root
canal treatment is generally limited due to differences
in methodology and statistical analysis (for review see
Weiger et al. 1998), the numbers corroborated well
with the outcomes of two closely related studies of
Byström et al. (1987) and Sjögren et al. (1997) that
dealt with the regeneration of periapical periodontitis
after initial root canal treatment. Byström et al. (1987)
reported a success rate (that was unadjusted for time)
of 85% (95% CI: 77–93%) after the use of calcium
hydroxide as final intracanal dressing. In a recent
paper (Weiger et al. 1998) an attempt was made to
extract and to analyse the event times from the data
presented by Byström et al. (1987). The estimated
probability that a periapical lesion will completely
resolve within 4 years was stated to be 94% (95% CI:
87–100%). Recently, the role of microbial infection at
the time of root canal filling was related to the
prognosis of the one-visit endodontic treatment
(Sjögren et al. 1997). This clinical and microbiological
investigation substantiated the potential of this
treatment approach. A success rate of 83% (95% CI:
73–93%) after an observation period of 5 years could
be calculated on the basis of the published data. This
was in line with the calculated probability of complete
healing of 93% (95% CI: 82–100%) within the 5-year
observation period.

The logrank-test and the Cox’s regression analysis
revealed that the use of calcium hydroxide as
intracanal dressing did not lead to more favourable
results than the one-visit treatment. The Cox’s analysis
ascertained that the true influence of calcium
hydroxide on periapical repair was not obscured by the
other identified variables that might have an impact on
the healing process. Therefore, an adequate considera-
tion of these factors is mandatory. In this study
population, the size of the periapical lesion was proven
to be a risk factor. That means that a larger periapical
lesion was associated with a lower probability to
resolve within a given period of time than a smaller
lesion. However, it must be considered that the
diameter of a lesion measured by means of the
radiograph only approximates its true dimensions. The
covariable ‘apical extension of the root canal filling’ did
not exert a significant effect on the probability of
periapical healing although some studies have demon-
strated that root canal fillings, being either too short or
overextended, interfere with the periapical healing
process (Strindberg 1956, Sjögren et al. 1990,
Friedman et al. 1995, Pelka et al. 1996). It is most
probable that in the present investigation the number
of inadequate root canal fillings was too small to reveal
a true difference.

As results from a single sample are generally subject
to statistical uncertainty, this imprecision should be
adequately considered. In this respect, the correspond-
ing 95% confidence intervals of the estimated
parameters are an important measure of this
uncertainty. Also, the simulation of a worst-case
situation and a real-case situation are helpful in order
to gain insight into the true treatment effects of
calcium hydroxide as intracanal medicament. This
concerns those teeth associated with ‘incomplete’ healing whose observation times did not reach 4 years, making a definite decision on success or failure impossible. The worst-case situation would assume that all teeth categorized as ‘incomplete healing’ would result in a failure after 4 years. A real case situation would assume that the majority of the lesions that decreased in size radiographically will completely resolve within 4 years, say two out of the three in the group ‘one-visit treatment’ and three out of the four in the group ‘calcium hydroxide’. Under these premises, the Kaplan–Meier statistic and the Cox’s regression analysis were recalculated. The results of these simulations summarized in Table 8 underline that the difference between both treatment modalities remained negligible and proved not to be statistically significant; this confirmed the results of a comparative study on periapical healing in dogs (Allard et al. 1987). As expected, the estimated values for the probability that a periapical periodontitis will completely heal within a certain period of time decreased when taking the worst case situation as given.

An attempt to interpret the present results requires the knowledge and the analysis of potential causes for refractory periapical periodontitis. Generally, it can not be excluded that a persistent intraradicular infection may sustain the periapical inflammatory process despite careful chemomechanical instrumentation of the root canal system and even the use of calcium hydroxide (Byström et al. 1985, Nair et al. 1990). Recently, it was reported that calcium hydroxide with an appropriate vehicle like paramono-chlorophenol/glycerin may be more effective on intracanal bacteria than pure calcium hydroxide (Siqueira & Uzedà 1996, Siqueira & Uzedà 1998). Nevertheless, intracanal microorganisms surviving in the obturated root canal system may interfere with the periapical healing process. In this respect, an important question addresses the immunological role of bacterial cell wall remnants (from dead bacteria) still present in the root canal system and their impact on periapical healing. To our knowledge clinical data that supports their significance are lacking. Furthermore, persistent extraradicular infection, foreign body reaction or the presence of a true cyst (Nair 1998) can impede the regeneration of periapical lesions. Undoubtedly, reinfection via leaking restorations or vertical root fractures may also be a cause for failures (Friedman et al. 1997). Although no additional microbiological and histological data existed in our cases that did not respond to the conservative treatment approaches, it can only be speculated about the causes for the therapy-resistant periapical lesions in both treatment groups.

In conclusion, the promising prognosis of both treatment approaches substantiated the hypothesis that from a microbiological view one-visit root canal treatment with gutta-percha cones and a calcium hydroxide-containing sealer created favourable environmental conditions for periapical healing. Thus, one-visit root canal treatment is an alternative to two-visit treatment with calcium hydroxide as an interappointment dressing for pulpless teeth associated with endodontically induced lesions.

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| Table 8 | Results of the statistical analysis after simulating a real-case situation and a worst-case situation |
|---------|----------------------------------|-----------------|-----------------|
|         | Kaplan–Meier                      | Cox’s regression analysis |
|         | P*years                          | P-values         |                  |
| **Real-case situation** |                          |                  |
| One-visit root canal treatment | 0.94 | [0.83–1.00] |
| Two-visit root canal treatment | 0.89 | [0.71–1.00] |
| **Worst-case situation** |                          |                  |
| One-visit root canal treatment | 0.90 | [0.76–1.00] |
| Two-visit root canal treatment | 0.84 | [0.60–1.00] |

*CI, confidence interval.
References


