JOURNAL OF ENDODONTICS
Printed in U.S.A.
VOL. 26, NO. 12, DECEMBER 2000

Reduction of Intracanal Bacteria Using Nickel-Titanium Rotary Instrumentation and Various Medications

George B. Shuping, DDS, MS, Dag Ørstavik, DDS, PhD, Asgeir Sigurdsson, DDS, MS, and Martin Trope, DMD

The purpose of this study was to evaluate the extent of bacterial reduction with nickel-titanium rotary instrumentation and 1.25% NaOCl irrigation. Also, the additional antibacterial effect of calcium hydroxide for >1 wk was tested. Forty-two subjects with radiographic and clinical signs of chronic apical periodontitis were recruited. The canals were sampled before treatment, during and after instrumentation, and after treatment with calcium hydroxide and the samples incubated anaerobically for 7 days at 37°C. The bacteria from each sample were quantified and the log values were used for calculations and comparisons. The initial sample confirmed infection of the canals. There was a significantly greater pattern of reduction of bacteria when NaOCl was used as an irrigant, compared with sterile saline ($p < 0.05$). After instrumentation with NaOCl irrigation, 61.9% of canals were rendered bacteria-free. The placement of calcium hydroxide for at least 1 wk rendered 92.5% of the canals bacteria free. This was a significant reduction, compared with NaOCl irrigation alone ($p = 0.0001$). The results of this study indicate that NaOCl irrigation with rotary instrumentation is an important step in the reduction of canal bacteria during endodontic treatment. However this method could not consistently render canals bacteria-free. The addition of calcium hydroxide intracanal medication should be used to more predictably attain this goal.

The disease process of primary interest to the endodontist is apical periodontitis. Research in the past three decades has established the importance of bacteria in the pathogenesis of apical periodontitis (1, 2). Because bacteria cause apical periodontitis, reduction or elimination of bacteria seems a logical aim for successful endodontic treatment. In fact the literature supports this concept. Teeth without radiolucencies (and presumably uninfected) have a higher endodontic success rate than teeth with radiolucencies at the time of the endodontic treatment (3, 4). Also teeth that are obturated after a negative culture has been obtained have generally a better prognosis than those obturated after a positive culture (5, 6). A study by Sjögren et al. (6) evaluated healing results after one-step treatment of teeth with negative or positive cultures after instrumentation. Ninety-four percent of the teeth obturated after a negative culture succeeded, whereas only 68% of the canals obturated after a positive culture were successful.

Therefore it seems from the above studies that optimal clinical success will be obtained if a tooth is obturated when the canal is uninfected or has bacteria that are at levels that are undetectable with current culturing techniques. Because culturing is as yet only effective as a research tool, the clinician should expect optimal success when treating a vital tooth or when treating an infected tooth with a technique or protocol that has been shown experimentally to result in consistent negative cultures.

Byström et al. (7–10) performed a series of studies to evaluate the antibacteriological effects of the individual steps in the endodontic procedure. Only after instrumentation with NaOCl and EDTA irrigation and a dressing of calcium hydroxide were they able to attain a predictable negative culture (10). The 5-yr follow-up examination of these teeth with negative cultures resulted in a 95% success rate, which confirms the prognostic benefit of a bacteria-free canal before obturation (11).

This classic series of studies was performed with stainless-steel files with a filing or reaming motion.

Recently new instruments and instrumentation techniques have been suggested. Nickel-titanium (NiTi) endodontic hand instruments were introduced in 1988, and soon after NiTi rotary instrumentation became popularized. The superelastic property of NiTi, coupled with advanced file design, allowed safe and effective instrumentation using handpiece-driven files operated at slow speeds in a crown to apex direction. NiTi instrumentation has been proven effective for maintaining the original canal shape (12). It is our intention to evaluate the antibacteriological effectiveness of this technique in a series of studies similar to the series performed by Byström et al. (7–10).

In our first study the bacterial reduction of infected canals with NiTi rotary instrumentation alone was evaluated (13). Rotary instrumentation was performed on infected canals with saline as the

irrigant. Although instrumentation was effective in reducing the number of bacteria after the first visit, the technique could not predictably render canals free of bacteria.

The purpose of the present study was to evaluate the extent of further bacterial reduction using 0.04 NiTi rotary instrumentation with 1.25% NaOCl irrigation (compared with saline irrigation). Also, the effect of the addition of calcium hydroxide for >1 wk after the NaOCl irrigation was tested.

MATERIALS AND METHODS

Subject Recruitment and Qualification

Approval for this project was obtained from the University of North Carolina School of Dentistry Committee on Investigation Involving Human Subjects. Patients presenting to the University of North Carolina School of Dentistry endodontic clinic for evaluation and treatment of apical periodontitis were considered for this study. The primary investigator (G.B.S.) conducted all clinical and sampling procedures. The study and associated risks were explained to the patient and consent was obtained.

Only mandibular first and second premolars and mandibular first and second molars were included in the study. The premolars had to have one canal to qualify. Only the mesiobuccal root of the first and second molars was sampled and included in the study.

The other tooth requirements included:

- A radiographic periapical radiolucent lesion
- A negative response to thermal sensitivity testing or electric pulp testing
- Enough crown structure for adequate isolation
- No history of previous endodontic treatment on the tooth.

Treatment Group Assignment

Qualified subjects were accepted into the study in a nonrandom consecutive sample and treated with NiTi rotary files (*ProFile*® .04 Tapers™ *Series 29*™, Tulsa Dental Products, Tulsa, OK). The teeth were copiously irrigated with 1.25% NaOCl between files.

Bacterial Sampling

The patient was anesthetized and the tooth was isolated with a rubber dam. The tooth and adjacent rubber dam were disinfected with tincture of iodine. Caries removal and endodontic access were achieved with sterile high-speed carbide burs. Gates-Glidden drills (Dentsply Maillefer N.A., Tulsa, OK) #2 and #3 were used for coronal flaring, followed by sterile saline irrigation of the pulp chamber only. Cavit® (ESPE, Norristown, PA) was used as a physical barrier to cover the orifices of other canals and thereby isolate the mesiobuccal canal during instrumentation and sampling of molars. A size ISO 90 gutta-percha master cone was burnished into the orifice of the test canal to serve as a temporary seal during disinfection of the chamber. The tooth and rubber dam were again disinfected with tincture of iodine. The chamber was then flooded for 1 min with 1.25% NaOCl and then neutralized with 5% sodium thiosulfate solution and sterile saline irrigation. The gutta-percha point was then removed and a size 15 or 20 stainless-steel K-file was used to determine working length and minimally disrupt the canal contents for initial bacterial sampling. A description of the five samples taken in the study (S1 to S5) is found in Table 1. The initial sample (S1) was taken with "fine–fine" sterile paper points (Mynol®, Block Drug Corp., Jersey City, NJ) placed as close to working length as possible. The points were allowed to saturate and were then transferred to a vial containing 1 ml of reduced transport fluid. Teeth were filed with the NiTi rotary instruments to working length beginning with the #2 NiTi rotary file and progressing to the appropriate, predetermined final file size. If a file would not go to length, the next size larger file was used in the coronal half as recommended by the manufacturer to facilitate apical progression of smaller files. The final file size differed based on tooth type and canal curvature as shown in Table 2. All rotary instrumentation was performed at 333 rpm using a Micro Mega® MM324 air motor with a model MM10TE contra angle (1:6 reduction) attachment (Tulsa Dental Products, Tulsa, OK) and copious 1.25% NaOCl irrigation.

TABLE 1. Description of microbiological samples taken for each tooth

S1:	Initial, preinstrumentation sample
S2:	Sample after initial instrumentation
S3:	Intermediate sample during instrumentation
S4:	Sample after final instrumentation
S5:	Postdressing sample

TABLE 2. NiTi rotary file size corresponding to sample and tooth type: *ProFile*® *29 Series*™ NiTi Rotary Files

Tooth Type	S2	S3	S4
Curved molar	#4	#5	#6
Straight molar	#5	#6	#7
Curved premolar	#5	#6	#7
Straight premolar	#6	#7	#8

Tip Diameter
#4 0.216 mm #6 0.360 mm #8 0.600 mm
#5 0.279 mm #7 0.465 mm

Samples were also taken after instrumentation with the final three files (S2, S3, and S4) according to the pumping maximal removal (PMR) method described by Möller (14). This was modified using reduced transport fluid (RTF) as the sampling and transport medium. Before taking the S2, S3, and S4 samples, the canals were irrigated with 2 ml of 5% sodium thiosulfate to neutralize the NaOCl. The canals were then irrigated with 2 ml of sterile saline. The irrigant was flushed using a 28 gauge Endo-needle irrigation tip (Beutlich Pharmaceuticals LP, Waukengan, IL) and then dried with sterile paper points. Approximately 0.02 ml of RTF was introduced into the canal with a sterile tuberculin syringe. A sterile K-file one size larger than the corresponding size of the NiTi rotary instrument was placed in the canal to length and pumped five times with minimal reaming motion to disrupt the canal contents. Samples were taken by absorbing the RTF with sterile paper points until a dry point emerged. Points were transferred directly to the RTF vials labeled for the sample. Bacteriological samples were then immediately transferred to the microbiology lab. Calcium hydroxide was placed into the canal with a Lentulo® spiral filler (Caulk, Milford, DE), and the orifice was then sealed with Cavit. All other canals were then instrumented, irrigated with 1.25% NaOCl, dried and filled with calcium hydroxide; a temporary filling was placed until treatment was completed at a subsequent appointment. After at least 1 wk of calcium hydroxide therapy, the patient was anesthetized and the tooth was

TABLE 3. Log_{10} mean values and standard deviation at each sample

	S1	SD	S2	SD	S3	SD	S4	SD	S5	SD
NaOCl	5.51	1.61	4.03	1.32	2.57	1.85	1.27	1.71	0.21	0.74
Saline	4.60	1.84	3.02	1.99	2.59	1.92	2.22	2.16	—	—
Controls	0.62	—	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NaOCl study: n = 42 S4, 40 S5; saline study: n = 22.

isolated with a rubber dam. The tooth was reaccessed with the strict aseptic protocol previously described. Calcium hydroxide was removed with minimal reaming motion of a corresponding size K-file and sterile saline irrigation. Then 0.5% citric acid was introduced to neutralize the calcium hydroxide. The canal was irrigated again with sterile saline and dried. RTF was introduced and the final sample (S5) was taken as previously described. Root canal therapy was completed at this appointment if the patient was asymptomatic. If symptoms persisted, the tooth was reinstrumented and repacked with calcium hydroxide.

Five additional teeth diagnosed with irreversible pulpitis and no radiographic signs of an apical lesion were treated identically to the test group. These served as a negative control to detect sample contamination potential.

The laboratory procedures were performed at the University of North Carolina Dental Microbiology Laboratory. RTF vials with samples were agitated 30 s on a vortex with a setting of four before aliquot disbursement. Sample dilutions of 10, 100, and 1000-fold were prepared under anaerobic conditions using sterile glassware. Petri dishes with anaerobic sheep blood agar were inoculated with 0.25 ml of undiluted sample, as well as each of the three dilutions. Plates were incubated at 37°C for 7 days in an anaerobic glove box containing 5% hydrogen, 10% nitrogen, and 85% CO_2. After incubation the principal investigator, using a Nikon 69229 stereoscope at 10× magnification, obtained the colony-forming unit (CFU) count. The number of CFUs per sample was calculated using the formula:

$$(\#\text{CFU} \times 4) \times 10^{[y]+1} \times 1\text{ ml RTF/per sample vial}) = \#\text{CFU/sample},$$

where y = dilution factor used in countable specimen (i.e. a 10-fold dilution, or 10^{-1}, $y = [-1]$ or 1).

Statistical Analysis

A $\log_{10}$ transformation of each CFU count was performed to normalize the data before statistical evaluation due to the high range of bacterial numbers. Repeated-measures analysis of variance was used to detect significance in reduction of bacteria from initial sample to final instrumentation and then to 1 wk of calcium hydroxide dressing. A paired t-test was used to determine significance in pattern of reduction between this study and the Dalton et al. (13) saline study. The level of significance was set at 0.05 for all analyses.

RESULTS

Forty-two test subjects and five negative control subjects qualified and were accepted into the study. The $\log_{10}$ mean values and standard deviation for this study (including negative controls) and the Dalton et al. (13) saline study are presented in Table 3. The $\log_{10}$ value means and the relation to instrumentation are depicted in the graph in Fig. 1.

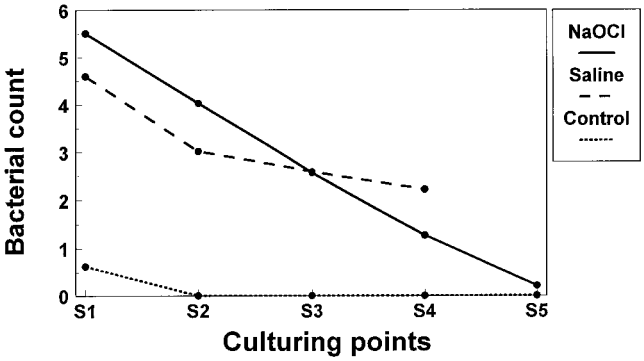

FIG 1. Bacterial reduction: $\log_{10}$ mean values. Bacterial counts for each group at the different culturing points.

Bacteria were initially present in 41 of the 42 test teeth.

The mean $\log_{10}$ value was 5.51 ± 1.61 (S1). The mean $\log_{10}$ value for S2 was reduced to 4.03 ± 1.32. It was further reduced at S3 to 2.57 ± 1.85. The mean $\log_{10}$ value at S4 was 1.27 ± 1.71.

Of the 42 teeth sampled at S4, 26 (61.9%) were bacteria-free at the S4 evaluation. There was a statistically significant decrease in bacterial numbers from S1 to S4 ($p = 0.0001$). The average number of days of calcium hydroxide therapy was 25.1 days, with a range of 7 to 203 days. Only 4 cases were dressed in calcium hydroxide for >50 days. This was because of compliance on the part of the patient, not study design. All cases were completed in two visits. Of the 40 teeth sampled at S5, 37 (92.5%) were free of bacteria. The three that cultured bacteria also contained bacteria at S4. At the S5 sample the mean $\log_{10}$ value was 0.21 ± 0.74. There was a statistically significant decrease in bacterial numbers between S4 and S5 ($p = 0.0001$).

Four of the five negative controls showed no bacterial growth in any of the five samples. One subject produced bacterial growth in the initial sample with a CFU count of 1200. The other four samples of this subject were negative.

Results Compared with the Dalton et al. (14) Saline Study (Table 3, Fig. 1)

The S1 mean $\log_{10}$ value of the Dalton et al. study was 4.60 ± 1.84. The S2 mean $\log_{10}$ value was 3.02 ± 1.99. The S3 mean $\log_{10}$ value was 2.59 ± 1.92. At this progression point the bacterial numbers of the present study were similar to the numbers of the Dalton saline study as depicted in Fig. 1. Only after S3 were bacterial numbers reduced in the NaOCl study, compared with the saline study. The S4 mean $\log_{10}$ value of the Dalton et al. saline study was 2.22 ± 2.16. The paired t-test used to detect differences in $\log_{10}$ value means showed a statistically significant decrease in the pattern of reduction between S1 to S4 of this study when compared with the Dalton et al. saline study ($p < 0.05$).

DISCUSSION

A strong correlation between the presence of bacteria in a root canal and apical periodontitis was confirmed in this study. Of the test subjects in this study with clinical and radiographic signs of apical periodontitis, 41 of 42 (98%) harbored cultivable bacteria in the initial sample. This is similar to findings in other studies (2, 13, 15).

Five vital teeth diagnosed with irreversible pulpitis and a normal periapex were treated and sampled as negative controls. These teeth were confirmed vital through diagnostic tests. Four of the five teeth sampled negative to bacteria. One sample tested positive at very low numbers in the initial sampling, but was negative in all other samples. This negative control group supports the effectiveness of the sampling technique and the fact that vital teeth are essentially free of bacteria.

The sampling technique used in this study was the PMR method with RTF. This technique is ideal for the clinical setting because of the stability of the samples and the high recovery rate of bacteria. The sampling procedure involves placing RTF into the canal, pumping a sterile file that is one size larger than the master apical file in the canal, and then removing the fluid with sterile paper points. Möller (14) compared six sampling techniques and found that a statistically significant ($p < 0.001$) higher number of positive samples with the PMR method using sampling fluid and vigorous pumping action.

Because 1 of the 42 initial samples tested negative to bacteria in the initial sample, all statistics were recalculated after exclusion of that one sample. The results still showed statistically significant differences when the case was included. Therefore the original results from all teeth are presented in this paper.

The average CFU count in the initial samples of this study are comparable with other studies (13, 15, 16). The S2 and S3 samples taken during instrumentation showed a continual decrease in bacterial numbers in the canals. Of interest was the S3 sample. This sample is the point where the bacterial numbers from this study were decreased below the numbers of the Dalton saline study. The graph indicates that a difference in pattern of reduction is not seen until after the second sample, and the bacterial numbers are nearly equal at the S3 sample. This shows that NaOCl requires a certain size of canal to become beneficial in bacterial reduction. A larger canal would allow better access for the NaOCl irrigant to reach the apical region and disinfect the bacterial contents. If the canal is not instrumented to an appropriate size, the whole purpose of using an antibacterial irrigant may be negated.

There was a statistically significant decrease in bacterial numbers from S1 to S4 ($p = 0.0001$) with NaOCl irrigation and a significant decrease in the pattern of reduction between S1 to S4 when compared with the Dalton et al. saline study ($p < 0.05$) (14). This verifies other studies in showing that NaOCl is an effective antibacterial irrigant. (8, 16, 17).

Of the 42 teeth in the final instrumentation sample (S4) of this study, 26 (61.9%) were bacteria-free. This is comparable with the results of Sjögren et al. (6), who showed elimination of bacteria in 60.0% of the samples. The Dalton et al. (13) study, using sterile saline as an irrigant, showed elimination of bacteria in only 28% of the teeth. This again shows the effectiveness of NaOCl as an irrigant and the advantage over sterile saline.

As previously described, an increase in file size is important in the reduction of bacteria. This is shown in Fig. 1. The bacterial numbers continue to decrease with progressive filing to larger size files. There is a statistically significant reduction between the initial (S1) sample and the final instrumentation (S4) sample ($p = 0.0001$). From an instrumentation aspect, Byström and Sundqvist (7) showed that hand instrumentation of infected canals with sterile saline irrigation decreased bacterial numbers by 10^2 to 10^3. Ørstavik et al. (16) reported a 10-fold decrease in bacterial numbers with extensive reaming. Matsumiya and Kitamura (17) histologically observed canals of infected teeth that were instrumented. They showed that as canals were instrumented to larger sizes, the number of bacteria decreased. This is an important aspect of bacterial reduction.

Although 61.9% of the samples in this study were negative to bacterial growth after instrumentation and NaOCl irrigation, nearly 40% still contained viable bacteria. Therefore obturation of these canals without further antibacterial means would not afford the best chance of endodontic success.

In this study, 40 of the 42 patients returned for final treatment with a calcium hydroxide dressing and the canals were sampled (S5). The percentage of negative cultures increased from 61.9% to 92.5%. Whereas a negative culture might not ensure a bacteria-free canal and the possibility for bacterial regrowth exists, obturation of the canal after a negative culture has been shown to result in an extremely high success rate. Sjögren et al. (6) demonstrated that teeth that had persistent infection at the time of obturation had a success rate of 68%, whereas teeth that sampled negative to bacteria had a success rate of 94%. The addition of at least 1 wk of calcium hydroxide significantly increases the number of negative cultures and may increase the success rate in the treatment of teeth with apical periodontitis.

Citric acid (0.5%) was used to neutralize the calcium hydroxide before the S5 sample. This use was recommended and first described by Möller (14). Citric acid is easily buffered by live bacteria and should have no antibacterial effects to influence the results.

The increase in size of NiTi rotary files, use of NaOCl irrigant, and use of calcium hydroxide as an intracanal medication have been shown in this study to significantly reduce or eliminate bacteria from infected canals. NiTi rotary instrumentation has been claimed to be superior in every way. These files do increase efficiency in instrumentation and have the advantage of flexibility. However, in this bacteriological study, the results indicate that the ability of these instruments to fully eliminate bacteria with the addition of NaOCl is no better than previous means using conventional instruments. An intracanal medication, such as calcium hydroxide, is still needed to render canals bacteria-free. One reason that these files are not as effective as expected may be that the taper of the files and relatively narrow tips favors cutting of the dentin coronal to the file tip so that in fact the apical part of the canal is hardly touched. The addition of files used specifically to enlarge the apical third may be shown to clean the canals better. A study to evaluate the antibacterial effects of larger file sizes is a logical next step in the clinical assessment of our endodontic technique. Our goal is to find a technique that consistently renders canals negative to experimental bacteriological culturing. This would conceivably enable us to complete endodontic therapy of teeth with apical periodontitis in one visit with a high long-term success rate.

In summary there was a statistically significant difference in bacterial reduction between the initial sample and the progressive filing to final instrumentation with 0.04 NiTi rotary files and NaOCl irrigation. Instrumentation with NaOCl irrigation was superior in bacterial reduction to instrumentation with sterile saline and resulted in 61.9% of canals becoming free of bacteria. An increase in file size was shown to be important in allowing the NaOCl to be an effective antibacterial irrigant. The addition of calcium hydroxide as an intracanal medication for at least 1 wk produced 92.5% of canals void of bacteria. There was a statistically significant decrease in bacterial numbers between the final instrumentation samples and the samples taken after calcium hydroxide therapy.

Drs. Shuping, Sigurdsson, and Trope are affiliated with the Department of Endodontics, School of Dentistry, University of North Carolina, Chapel Hill, NC. Dr. Ørstavik is affiliated with the Scandinavian Institute of Dental Materials, Haslum, Norway.

Address requests for reprints to Dr. Martin Trope, Department of Endodontics, School of Dentistry, University of North Carolina, Chapel Hill, NC 27599.

References

1. Kakehashi S, Stanley H, Fitzgerald R. The effect of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol 1965;20:340–9.
2. Bergenholtz G. Micro-organisms from necrotic pulp of traumatized teeth. Odontol Revy 1974;25:347–58.
3. Kerekes K, Tronstad L. Long-term results of endodontic treatment performed with a standardized technique. J Endodon 1979;5:83–90.
4. Sjögren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endodon 1990;16:498–504.
5. Engström B, Hard AF, Segerstad L, Ramström G, Frostell G. Correlation of positive cultures with the prognosis for root canal treatment. Odontol Revy 1964;15:257–70.
6. Sjögren U, Figdor D, Persson S, Sundqvist G. Influence of infection at the time of root filling on the outcome of endodontic treatment of teeth with apical periodontitis. Int Endod J 1997;30:297–306.
7. Byström A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res 1981;89:321–8.
8. Byström A, Sundqvist G. Bacteriologic evaluation of the effect 0.5 percent sodium hypochlorite in endodontic therapy. Oral Surg Oral Med Oral Pathol 1983;55:307–12.
9. Byström A, Sundqvist G. The antibacterial action of sodium hypochlorite and EDTA in 60 cases of endodontic therapy. Int Endod J 1985;18:35–40.
10. Byström A, Claesson R, Sundqvist G. The antibacterial effect of camphorated paramonochlorophenol, camphorated phenol and calcium hydroxide in the treatment of infected root canals. Endod Dent Traumatol 1985;1: 170–5.
11. Byström A, Happonen R, Sjögren U, Sundqvist G. Healing of periapical lesions of pulpless teeth after endodontic treatment with controlled asepsis. Endod Dent Traumatol 1987;3:58–63.
12. Pettiette M, Metzger Z, Phillips C, Trope M. Endodontic complications of root canal therapy performed by dental students with stainless steel K-files and NiTi hand files. J Endodon 1999;25:230–4.
13. Dalton BC, Ørstavik D, Phillips C, Pettiette M, Trope M. Bacterial reduction with nickel-titanium rotary instrumentation. J Endodon 1998;24: 763–7.
14. Möller AJ. Microbiological examination of root canals and periapical tissues of human teeth: methodological studies. Goteborg: Akadamiforlaget, 1966.
15. Sundqvist G. Bacteriological studies of necrotic dental pulps. Umea University Odontological Dissertations No. 7. University of Umea, Sweden, 1976.
16. Ørstavik D, Kerekes K, Molven O. Effects of extensive apical reaming and calcium hydroxide dressing on bacterial infection during treatment of apical periodontitis: a pilot study. Int Endod J 1991;24:1–7.
17. Matsumiya S, Kitamura M. Histo-pathological and histo-bacteriological studies of the relationship between the condition of sterilization of the interior of the root canal and the healing process of periapical tissues in experimentally infected root canal treatment. Bull Tokyo Dent Coll 1960;1:1–19.

You Might Be Interested

The urge to do *something* when suffering the miseries of a respiratory infection is almost overwhelming. Emotion often overrules reason, and even though we know that most causative agents are viral and thus antibiotics are ineffective, we often pop a course of pills rationalizing about "preventing secondary bacterial infection." A recent review of the only nine studies published between 1966 and 1995 on the effectiveness of antibiotics on acute bronchitis found that they were of absolutely no value (J Gen Intern Med 11:557).

Oh, for a cure for the common cold!

William Cornelius