IAOMT ACCREDITATION--
Checklist for Completing Unit 9:
Root Canals

INTRODUCTION TO UNIT 9

- ☐ Take the Unit 9 Pre-test.
  Click here to go to pages 3-4.

- ☐ Read the "*Root Canal Cover-up* Conceals Numerous Side Effects" book review by Meinig. Click here to go to pages 5-7.

REQUIRED (MANDATORY) CONTENT OF UNIT 9

- ☐ Read the "Status Report on Endodontic Therapy" by the IAOMT.
  Click here to go to page 8.

- ☐ Read the "Root Canal Dangers: DNA Studies Confirm Dr. Weston Price's Century-old Findings" article by Huggins.
  Click here to go to pages 9-17.

- ☐ Read the "Strategies for Biocompatible Endodontics" article by Koral. Click here to go to pages 18-31.

- ☐ Read the "In Vitro Enzymatic Inhibition Associated with Asymptomatic Root Canal Treated Teeth: Results from a Sample of 25 Extracted Root Fragments" research by Nunnally.
  Click here to go to pages 32-36.

- ☐ Listen to the "Regenerative Endodontics and Controversy over Root Canals" IAOMT Podcast at https://youtu.be/a-Gvw7e9Dsw.
  Click here to go to page 37.

- ☐ Read "The Root Canal and Breast-Cancer Connection" article by Panahpour. Click here to go to pages 38-39.

Continued on next page…

☐ Read the "The Impact of Endodontically Treated Teeth on Systemic Diseases" by Lechner and von Baehr.
Click here to go to pages 40-46.

TEST FOR UNIT 9

☐ Take the Post-Test for Unit 9 at https://www.cvent.com/d/2vq54j.
Click here to go to page 47.

☐ If you are interested in learning more about any of the topics in this unit, explore the readings in the OPTIONAL Unit 9 PDF file. *Note that these are not required materials.*

☐ Continue on to Unit 10!
Click here to go to https://iaomt.org/accreditation-materials/.

Record of Unit 9 Updates:
10/23/20: Regenerative Endodontics and Controversy over Root Canals IAOMT Podcast (added new research and multimedia item); "The Impact of Endodontically Treated Teeth on Systemic Diseases" by Lechner and von Baehr (added new research); Unit 9 Test (revised all test questions to incorporate new materials)

PRE-TEST FOR UNIT 9 TO BE TAKEN BEFORE STUDYING ROOT CANALS

This is a pre-test, and the results are for your records only. You are not expected to know the answers since you have not studied this material yet. The pre-test is simply designed to assist you in recognizing some of the important information that will be presented in this unit. There is no time limit for this test. Choose the option that BEST answers each question.

1. Scientific inquiry ranging from the historic research of Weston Price to ongoing contemporary studies demonstrates that _____ can persist in root canals and dentinal tubules after apparently successful endodontic treatment. Their passage into the blood has been scientifically demonstrated, as has the passage of their highly toxic waste products of anaerobic metabolism, such as sulfides and polyamines.

A. bacteria
B. viruses
C. fungi
D. A & B
E. all of the above

2. A technique/Techniques to project germ-killing disinfection into microscopic spaces of a tooth root is/are _____.

A. inter-appointment treatment dressing
B. ozone therapy
C. laser therapy
D. final filling with calcium oxide
E. all of the above

3. Dr. Weston Price identified as many as seventy-five separate accessory canals in a single central incisor.

A. True
B. False

4. Infected teeth have been linked to _____.

A. cancer and heart disease
B. brain and lung abscesses
C. disorders of the eyes, sinuses, and digestive tract
D. A & B
E. all of the above

5. Sterilizing and disinfecting the tubules of teeth is commonly recognized as the standard way to treat infected teeth.

A. True
B. False

Answers: 1. E; 2. E; 3. A; 4. E; 5. B

Book Review

Root Canal Cover-Up Conceals Numerous Side Effects

The Roger Wyburn-Mason and Jack M. Blount Foundation for the Eradication of Rheumatoid Disease
AKA The Arthritis Trust of America®,
7376 Walker Road, Fairview, TN 37062

George Meinig, D.D.S.

Since the discovery of penicillin and antibiotics, root canal specialists and some physicians have come to believe infections resulting from tooth extractions, root canal work, tonsilectomies, and adnoidectomies no longer cause diseases in other parts of the body. They incorrectly claim that long-standing focal infections are a thing of the past. Most disturbing is their failure to accept the existence of the bacteria that become trapped inside the dentin tubules which make up 90 percent of the structure of teeth. Added to that fact is the inability of antibiotics and other medicaments to be able to get at and kill these organisms.

Extensive research studies in which 5000 animals took part, clearly demonstrate how these bacteria, or their toxins, escape into the circulation of the tooth's surrounding bony socket, and how these organisms are responsible for a high percentage of the chronic and degenerative disease conditions that are so epidemic in America today.

Confusing the issue is the fact that twenty-five percent of individuals who have root canal fillings (or tooth extractions) are free from trouble for extnded periods of time. These are individuals who have excellent health and exceptionally good immune systems.

This groups' freedom from side effects unfortunately has led many root canal specialists to believe their treatment of infected teeth is always successful and can cause no harm.

On the other side are the 75 percent whose immune systems have been compromised by illnesses, accidents, poor nutrition, stress, etc. This group develop a variety of conditions which end up in their going from doctor to doctor, in desperate attempts to find the cause of their problems. A high percentage of these cases are due to the bacteria coming from their root canal filled teeth, or from tooth extractions, or other foci of infection.

Once confronted with root canals, or teeth extractions, being a possible source of their illnesses, these patients often recall their health problems seemed to start right after the root canal treatment was undertaken, teeth extracted. When these infected gums are removed, many find their illnesses disappear.

To visualize what happens, picture the bacteria trapped in the dentin tubules; see them mutate and become more virulent and their toxins more toxic. In their escape into the blood circulation of the tooth's socket, these bacteria, like cancer cells, metastasize to other parts of the body. As they migrate, they infect the heart, kidneys, joints, nervous system, brain, eyes -- and can endanger pregnant women and in fact may infect any organ, gland or other tissue.

The Root Canal Cover-up book was compiled and written by George E. Meinig, D.D.S., F.A.C.D., one of the 19 founding members that organized the American Association of Endodontists and a former Twentieth Century Fox Studio dentist.

His book provides the public and health professionals with their first real look at the serious illnesses that can arise as a result of root canal therapy. This 7 X 10, soft cover 237 page third edition (the first and second edition sold out in record time) is available through this foundation.

The World's Greatest Medical Discovery

If you heard there was a source of disease which caused literally hundreds of different illnesses,wouldn't you think that would be one of the world's greatest medical discoveries?

What will be your reaction when you learn this phenomenal work has been covered up and buried for over 70 years? Be prepared for a series of shocks. Just such a wide assortment of diseases were found and proven to come from focal infections present in infected teeth, jaws and tonsils. While these degenerative diseases could come from almost any oral infection, a high percentage come from bacteria that remain locked in root canal filled teeth. No doubt your first reaction to these words will be -- what kind of crazy man is this Dr. George to make such statements!

Stay with me for a few moments. It will be to your advantage to learn what this unfortunate cover-up is all about. It will be helpful for you to know that I was one of the 19 dentists who started the Root Canal Association now known as the American Association of Endodontists (AAE). My love affair with trying to save teeth led to graduate studies about root canal therapy from Professor Edgar Coolidge, foremost root canal researcher and teacher of the subject in the world. He was my first mentor in the field of dentistry.

It was also my good fortune to be one of the six members of his study and teaching group. Keep in mind at that time, very few dentists did root canal therapy. In fact some dental schools didn't even teach the subject.

To spread the word, Dr. Coolidge arranged for our study group to be guest speakers at numerous dental meetings. Those efforts, and those of the AAE, has resulted in some 20 million root canals now being treated each year. In my general, holistic practice of 47 years -- I did several thousand.

Four years ago I learned there had been a 25 year research program which covered all phases of root canal treatment. This was no small program; 5,000 animals were used and it was directed by Dental Research Specialist, Weston A. Price, D.D.S., M.S. The last ten years was conducted under the auspices of the American Dental Association and its Research Institute. That Research Institute was

governed by 60 of the nation's leading medical and dental scientists.

All of those thousands of studies and experiments were documented in two large volumes containing 1,174 pages and in more than 25 articles which can be found in the dental and medical literature.

A vast array of discoveries were forthcoming from that extensive and meticulous research which found many root canal therapy common beliefs of dentists and endodontists to be false. The most startling one clearly and emphatically demonstrated with 5,000 animal studies, that root canal filled teeth always remain infected no matter how good they look or how good they feel.

You can readily see after 47 years of practice, upon learning about all of the conclusive evidence of this discovery why I was in more of a shock than you. How in the world could it be that these vital and important revelations have been kept from the entire dental profession for over 70 years? During the last four years I have probably talked to two or three thousand dentists and have found only one who knew about Dr. Price's great discoveries.

While I knew from Dr. Coolidge's teaching that infections could be present in the lateral canals of teeth even if they appeared normal on x-ray pictures, I had no knowledge that the infection problem was so immense.

Let me get right to the heart of the problem. To do so requires that you have a little knowledge about the anatomy of a tooth. The crown of a tooth, I am sure you know, is covered by a little less than 1/4 inch of enamel. The root with 1/8 of an inch of cementum. All of the rest of the tooth (over 90 percent of it) is composed of what is called dentin.

Though the dentin is almost as hard as enamel, it is composed of tiny tubules measuring 1.5 microns, which is smaller in size than the thickness of a sheet of paper. In the normal, healthy tooth, these tubules are filled with a liquid which contains nutrients.

Running throug the center of the tooth is the root canal. Everyone knows it contains a nerve. Many are not aware that it also contains an artery, vein, and other tissue. As the blood flows through the artery every day and night, it drops nutrients into the fluid in each of those dentin tubules -- the same way blood vessels drop nutrients into each cell of the body. The nutrients present in those tubules travel to all parts of the tooth. That is the real hidden secret about what keeps teeth alive and healthy.

When we get a small cavity in a tooth which is just breaking through the enamel into the dentin, the bacteria that are part of the decay process get into the tubules in the vicinity of the decay area. Dentists in cleaning out the decay quite readily stop the process.

The problem arises when the person doesn't go to their dentist regularly and that tiny cavity becomes a deep one. Once the decay gets so deep that it penetrates into the root canal itself, the bacteria present in the decayed tooth substance enter the canal and quickly travel it down to the end and then out of the apex of the root into the surrounding bone. Along the way, they spy those dentin tubules and their nutrient food content.

They find those tubules are excellent new home sites. Herein lies the problem. Dentists, in doing root canal treatment, feel they adequately kill the bacteria that are present, but are unaware that the medications they use cannot penetrate into those tiny tubules far enough to kill them. Most dentists are entirely unaware of the bacteria in the tubules, and the fact that hundreds of experiments showed not a single one of over 100 commonly used disinfectants could penetrate those tubules.

When we confront dentists with these facts they often will say, "So what? When we place the root canal filling, the organisms will die off." Here again their opinion is incorrect as they are unaware that these bacteria are polymorphic, which means they can mutate and change form and are able to actually live under the most severe, adverse conditions. [See *Cell-Wall Deficient Forms*, http://www.arthritistrust.org.]

Undaunted, your dentist will now say, "What difference does it make? The germs can't escape because the root canal filling blocks them out" That too is untrue, as the bacteria can readily escape from the lateral, accessory root canals present in all teeth. Not only that, the toxins formed by bacteria can escape right through the cementum of the tooth. In another series of intelligent experiments, Dr. Price showed that the hard cementum outer covering of the roots was actually a semi-permeable membrane. That means liquid substances like bacteria toxins could travel right through the cementum and escape into the periodontal membrane which holds the tooth in its bony socket. It is that membrane which attaches the tooth to the jaw bone and keeps teeth from falling out.

The peridontal membrane is a hard fibrous tissue but it has a blood supply and the bacteria and their toxins now infect it. From there, the organisms and their toxins have easy access into the surrounding jaw bone and its blood supply. It is similar to cells breaking away from a cancer lesion and metastasizing and setting up a new cancer some other place in the body. These bacteria from teeth and their toxins also metastasize via the blood stream. In their travels when they find a gland, organ or body tissue that appears attractive, they make it their new home and promptly set up a new infection. This eventually results in a degenerative disease.

Now that you know the source of the problem, let me tell you about how a rabbit revealed the actual devastation that occurs.

Dr. Price had treated a root canal infection for a patient who subsequently developed a severe case of arthritis in her hands and legs. He was well aware that physicians in trying to discover the cause of a disease would isolate the bacteria, grow them in culture, and then inject the organism into animals to see if they could reproduce the disease and subsequently find a cure.

At that particular moment, Dr. Price did not know just where the infection was in the tooth, but in thinking how doctors were discovering the causes of diseases, he thought of a similar way that might lead to an answer. After a little trouble he convinced the patient to let him remove the tooth. He washed and bathed it in a disinfectant. He then made a small buttonhole incision in the skin of the back of a rabbit, inserted the extracted root canal tooth, placed a couple of stitches so it wouldn't fall out, and returned the animal to its spacious cage and waited developments.

It didn't take long. In just two days the rabbit's limbs had developed the same arthritic swelling as that of the patient and in ten days it died from the infection coming from that tooth.

Now, Dr. Price immediately thought of all those patients he had who were suffering from heart, kidney, liver, joint disease, eye problems, etc., etc., and he wondered if their root canals were the source of their degenerative health problems. Those who had root canals he suggested their removal and he implanted them under the skin of an animal.

Wht happened was surprising and unexpected. In the vast majority of cases the animal developed the same disease as the patient and most passed away in from two or three days to a week or two from the infections present in the root canal treated teeth. Different kinds of animals were used: Rats, Guinea pigs, dogs and monkeys, but it didn't matter, the same results occurred. They usually used rabbits as they seemed to react a bit more promptly and proved the better choice for such studies.

Early on in his studies Dr. Price made some reports of his research in articles which appeared in medical and dental journals. A number of dentists came to him voicing the opinion that any animal would likely get sick and die with an extracted tooth in its

body. Dr. Price admitted he didn't know the answer to that question but he said let's find out. What he did was to have a group of dentists secure 100 healthy teeth. These were removed for orthodontic pruposes, or impacted teeth, none of them had any tooth decay or gum trouble. He placed each single tooth under the skin of a different animal.

Well, not a single one of those 100 animals got sick or died. All lived their normal life span with the tooth under its skin. In a few, their immune systems were strong enough to expel the tooth out through the skin and in a few the tooth dissolved away. They even did bacteriologic studies of the tissue around the imbedded teeth and always found them to be sterile.

It is always a surprise to learn that Dr. Price's work was buried for over 70 years. Of course, there is the obvious objection of dentists not wanting to lose this part of their income. Actually there were a half dozen or more reasons why his work was covered up and buried. That will have to wait for another time because of space limitations.

I can assure you, hardly a dentist in the country has ever heard about this 25 year extensive and meticulous research program. The Endodontic Association says they teach about Dr. Price in dental schools, but it is strange I never find any dentists who have ever heard about it.

The AAE isn't very happy with me exposing this cover-up and they claim the focal infection theory was proven false years ago, but so many investigators have proven the accuracy of the theory, that it is unbelievable they stick to that old claim that helped bury Dr. Price's work. That story too will need to wait for another day.

I had hoped by now they would set up research to investigate the bacteria in the dentin tubules as these infections prove to be so devastating. The AAE has numbers of research projects but they have not as yet faced this critical issue.

Editor's Comments

If you have a root canal or been told you need one, your best approach is to learn all you can about this subject. See *Root Canal Cover-Up*, http://www.arthritistrust.org. It is written in lay language and covers the major issues covered in Dr. Price's two volumes of 1,174 pages of documentation. Even if you don't have a root canal treated or extracted tooth it is worthwhile to learn about what is taking place in so many people and how these degenerative diseases can be prevented.

An extracted tooth can cause the same problems as does the infected root canal. The executive director of this foundation found that he had sustained a 50 year long, hidden, unknown infection in upper and lower gums from having had teeth extracted 50 years ago via the Veteran's Administration.

Also a word of caution: as with the problems of mercury poisoning from mercury amalgam fillings in teeth (another sad story to be told), it's not easy to find a" biological dentist" trained in its safe removal. Removing mercury amalgams in the wrong manner can result in more harm than the mercury fillings to be replaced.

A specially trained and knowledgeable dentist (biological dentist) can use non-invasive means to determine the source of root canal or tooth extraction infection, after which surgery may be required accompanied by proper sterilization techniques. Even then, follow-up checks may be required. The Price-Pottenger Nutrition Foundation, PO Box 2614, Las Mesa, CA 91943-2614; (619) 462-7600 may help you find your nearest biological dentist. Sad to say, as critical and important as a biological dentist is to achieving wellness, it's been the editor's experience that they are usually few and far from our home stations.

IAOMT
International Academy of Oral Medicine and Toxicology

Status Report on Endodontic Therapy

(Revised March 2001)

The International Academy of Oral Medicine and Toxicology (I.A.O.M.T.) encourages the dental profession to carefully consider the potential impact on systemic health of endodontic therapy.

Scientific inquiry ranging from the historic research of Weston Price to ongoing contemporary studies demonstrates that microorganisms (bacteria, fungi, viruses) can persist in root canals and dentinal tubules after apparently successful endodontic treatment. The passage of these microorganisms into the blood has been scientifically demonstrated, as has the passage of their highly toxic waste products of anaerobic metabolism, such as sulfides and polyamines.

Furthermore, there are many cytotoxic chemicals used in endodontics, such as formaldehyde, eugenol, camphorated paramonochlorophenol, and other phenols. These have also been shown to diffuse into the general circulation.

However, the extent of the potential health risk from these influences has not been investigated scientifically, and criteria for evaluating the risk to individual patients have not been established.

Clinical criteria used to determine the success or failure of endodontic treatment have been shown to be contradictory and inconsistent, especially when compared to pathological examination. Improved methods are needed to evaluate both the clinical success of endodontic treatment, and the level of bacterial toxicity emanating from the treated root.

The I.A.O.M.T. has encouraged the use of calcium oxide root filling materials when the doctor and patient choose endodontic therapy, because they have been shown to be non-cytotoxic, penetrate the dentinal tubules, and raise the pH of the treated root. However, the evidence that alkaline calcium materials, especially calcium hydroxide, can truly disinfect dentin remains equivocal. More work needs to be done to evaluate whether this or any other technique can eliminate the potential for systemic health effects of endodontic therapy.

Therefore, the I.A.O.M.T. cannot take the position that all non-vital teeth must be extracted. On the other hand, it is clear that non-vital teeth – with or without endodontic therapy – can present a systemic health risk to some patients. Each patient must be evaluated on an individual basis, considering the medical status and other factors.

The I.A.O.M.T. encourages the dental, medical, and scientific communities to address this area with vigor. Efforts must be made to provide valid methods of determining the systemic health risk from non-vital teeth and provide techniques of endodontic therapy that eliminate, or at least reduce, the risk.

Root Canal Dangers

Hal Huggins, DDS, MS June 25, 2010

DNA Studies Confirm Dr. Weston Price's Century-Old Findings

Toxic dental materials have created much havoc in the dental profession, as well as in patient health, for nearly two centuries. Dental mercury fillings, nickel crowns (especially in children, called "chrome crowns"), root canals and cavitations have been the target of concern for a long time.

Dental mercury was first exposed as a health-compromising product in 1840. The dental profession finally overcame the perception that putting toxic mercury in the mouth might be detrimental to human health; organized dentistry still considers the current fillings containing 50 percent mercury as "state of the art."

The toxicity of root canals was disclosed by Mayo's Clinic and Dr. Weston Price jointly back in about 1910. Close to a century ago. Price's textbook on root canals, published in 1922, upset the dental associations at that time, and still does today. The American Dental Association (ADA), denies his findings and claims that they have proven root canals to be safe; however, no published data from the ADA is available to confirm this statement. Statements, but no actual research.

My attention was drawn to the increase in autoimmune disease after the high-copper amalgams of 1975 were initiated as "state of the art" fillings, which ADA claimed released no mercury. On the contrary, studies from Europe[1] found that the high-copper amalgams released fifty times more mercury than previous amalgam!

In watching these changes regarding the onset of autoimmune disease, I noticed a blip in the statistics—an increase in amyotrophic lateral sclerosis (ALS or Lou Gehrig's disease) in 1976 (See Figure 1).

Note in Figure 2 that the actual number of cases of multiple sclerosis increased tremendously, from an average of 8800 per year during the period 1970 to 1975, to an increase of up to 123,000 in one year. That year being 1976, the birth date of high-copper amalgams.

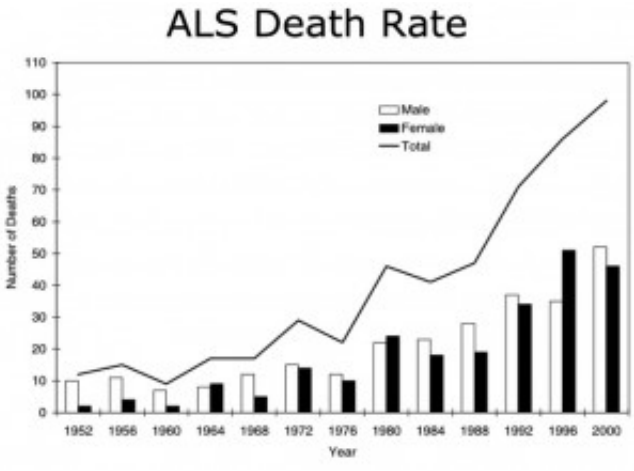


Figure 1

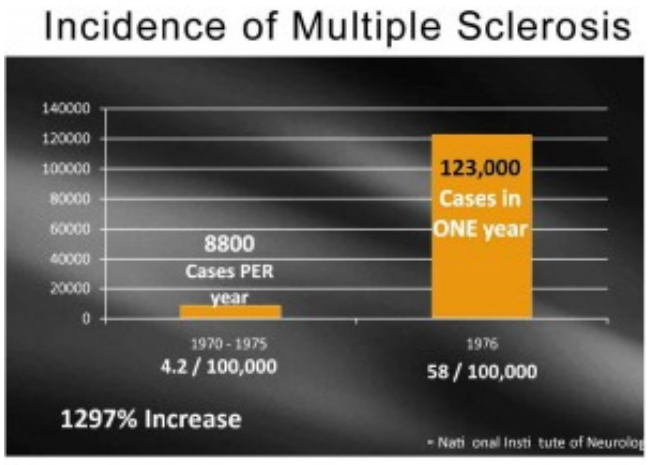


Figure 2

ROOT CANAL HAZARD

Is mercury the only dental hazard that can create conditions favorable to autoimmune diseases? No. There are bacteria in root canals that favor destruction of the nervous system and many other systems, resulting in the creation of autoimmune reactions.

What is the common denominator? The formation of a hapten (see page 46). A hapten is a small molecule that can elicit an immune response only when attached to a large carrier such as a protein; the carrier may be one that also does not elicit an immune response by itself. In general, only large molecules, infectious agents, or insoluble foreign matter can elicit an immune response in the body.

Healthy cells have a code imprinted on them. It is called the Major Histo-compatibility Complex (MHC). This is your personal code called “self.” Your body considers other code or alteration of this code to be “non-self.” The immune system is trained to kill and eliminate any “non-self” invaders.

If an atom of mercury attaches to a normal healthy cell, a hapten is formed and the immune system immediately identifies that cell as “nonself.” The immune system then proceeds to kill the contaminated cell. If mercury attaches to a nerve cell, the result is a neurological disease, such as multiple sclerosis, Lou Gehrig’s disease, seizures or lupus. If mercury attaches to a binding site on a hormone, that endocrine function is altered. Mercury can attach to almost any cell in the body and create autoimmune diseases in those tissues.

Lately, it has become evident that toxins from anaerobic bacteria have the same ability to create non-self autoimmune diseases by interfering with the MHC. This is the project that Dr. Price began to study a century ago. Resistance from organized dentistry was the same then as it is today. Price wondered why dentistry was considered a “health” profession.

Price was concerned about the pathological bacteria found in nearly all root canal teeth of that time. He was able to transfer diseases harbored by humans from their extracted root canal teeth into rabbits by inserting a fragment of a root canal root under the skin in the belly area of a test rabbit. He found that root canal fragments from a person who had suffered a heart attack, when implanted into a rabbit, would cause a heart attack in the rabbit within a few weeks. Transference of heart disease could be accomplished 100 percent of the time. Some diseases transferred only 88 percent of the time, but the handwriting was on the wall.

Dr. Price discovered that root canals had within them bacteria capable of producing many diseases. They had no place in the body. Which is more important? The life of the tooth or the life of the patient? This is still the primary argument facing us today.

ROOT CANALS AND NEUROLOGICAL DISEASE

Considering the difficulty of culturing anaerobic bacteria, it was hard to identify them with 1920s technology. Most of the bacteria reported by organized dentistry at that time were aerobes of unknown significance. Today, with DNA analysis available, anaerobic bacteria (the dangerous kind) can be identified whether dead or alive by the presence of their tell tale DNA signatures.

Let’s go back to the graphs of ALS up through the year 2000. Note an increase in 1976 and another increase in slope in 1991. In 1990, the dental association “suggested” that dentists perform thirty million root canals per year by the year 2000. Dentists accomplished that goal by 1999. As I understand it, the bar has now been raised to sixty million per year.

The unexplained increase in MS (8800 to 123,000) coincided with the advent of high copper amalgams. The increase in ALS in the same year is suggestive of the same cause. ALS also increased in 1991 as more root canals were performed. Statistical coincidence?

The goal of dentistry is to save teeth. Root canals allow dentists to maintain many teeth for years instead of extracting them. But is this goal appropriate considering the biological expense exposed with DNA research? What is more important? To save the life of the tooth or that of the patient?

HAVENS FOR BACTERIA

Dr. Price, while head of research for the now-defunct National Dental Association, took one thousand extracted teeth and reamed them out as dentists normally do, prior to filling the canals with wax. Price sterilized the canals with forty different chemicals far too toxic to be used in a live human situation; he wanted to see whether the canals could be permanently sterilized. After forty-eight hours, each tooth was broken apart, and cultured for the presence of bacteria. Nine hundred ninety out of one thousand cultured toxic bacteria just two days after treatment with chemicals designed to make the tooth sterile. Where did these bacteria come from?

An overview of the structure of a tooth (see Figure 4) shows the outer layer, known as enamel, the second layer, known as dentin, and the inner portion, known as the pulp chamber, where the nerve lives. On the outside of the tooth is what is called the periodontal ligament. Teeth are not attached directly to bone. Fibers come out of the tooth and intertwine with fibers coming out of the bone, and they unite to form what is called the periodontal ligament.

The second layer of the tooth, the dentin, is not really solid but composed of tiny dentinal tubules. In a front tooth, if all these tubules were attached end to end, they would reach over three miles.[3] Note that the tubules have adequate space to house many thousands of bacteria (see Figure 5). This is where the bacteria were hiding in the thousand teeth Price tested. From the dentin tubules, bacteria can migrate either into the pulp chamber, where space is left as the gutta percha—a natural form of rubber used to fill the space inside the cleaned-out root—shrinks upon cooling, rebounding from the force applied to push the wax down the canal, and losing the liquid portion (see Figure 6), or into the periodontal ligament where a plentiful supply of food awaits them.

A tooth has one to four major canals. This fact is taught in dental school, but never mentioned are the additional “accessory canals.” Price identified as many as seventy-five separate accessory canals in a single central incisor (the front tooth). Figure 7 shows one of these canals filled with necrotic (dead) tissue.

There is no way that any dental procedure can reach into these accessory canals and clean out the dead tissue. This necrotic tissue creates a home for multiple bacterial infections outside the tooth in the periodontal ligament. With added food supply from this area, the anaerobic bacteria can multiply and their toxins can contribute to the onset of disease (see Figure 8).

Of course, the root apex (terminal end) is the primary area of concentration of infection. Even though this may be the last area to show infection, dentistry generally considers a tooth sterile unless areas of bone resorption show up on X-ray. Upon cooling and shrinking of the gutta percha, space is left at the apex in which bacteria can thrive, where neither white blood cells of the immune system, nor antibiotics can reach them.

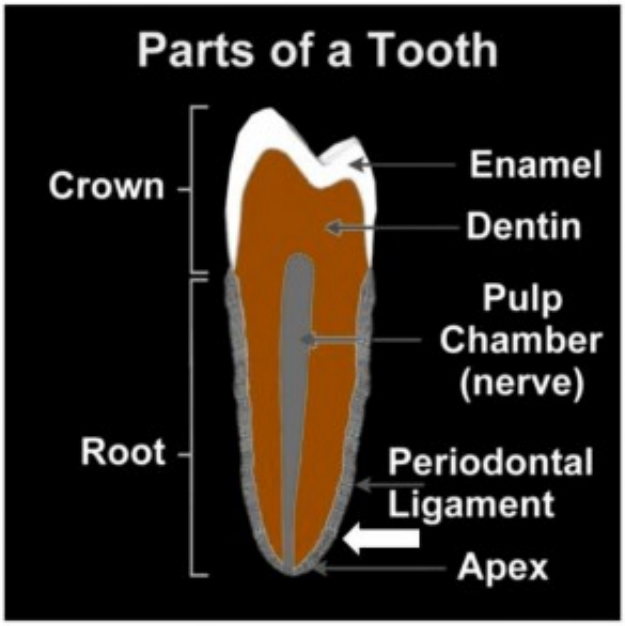


Figure 4

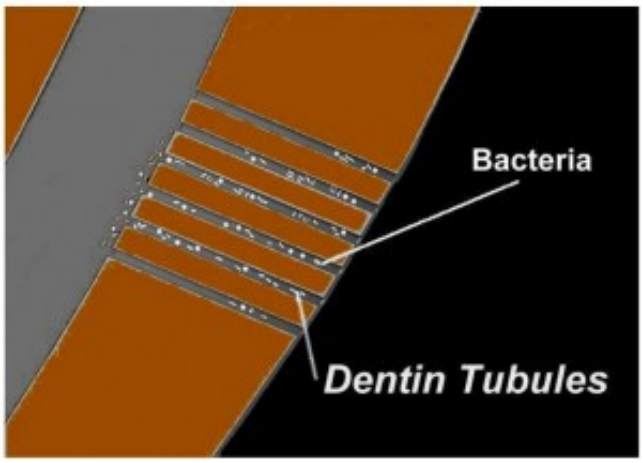


Figure 5

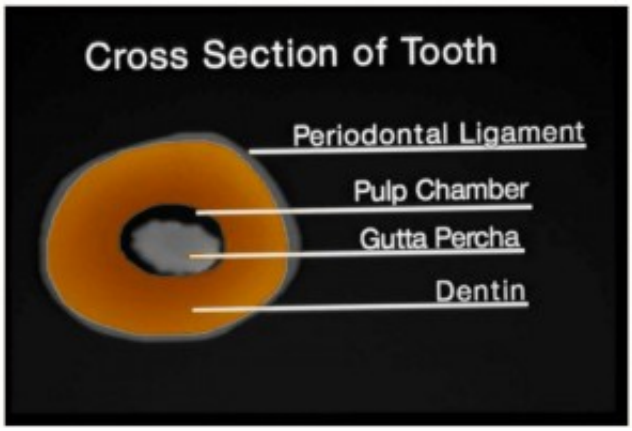


Figure 6

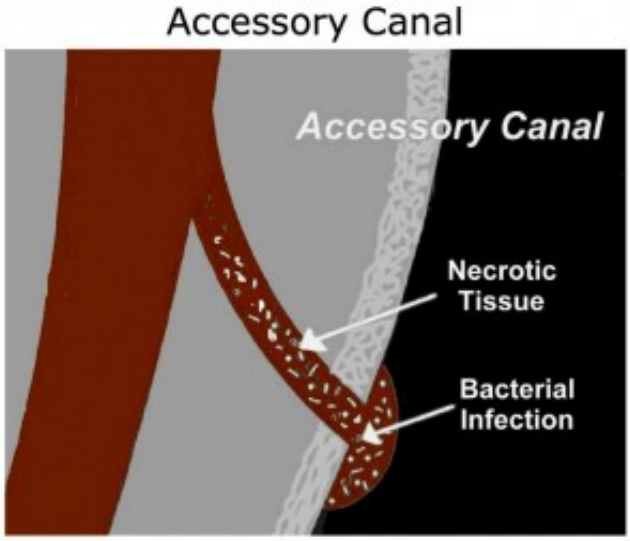


Figure 7

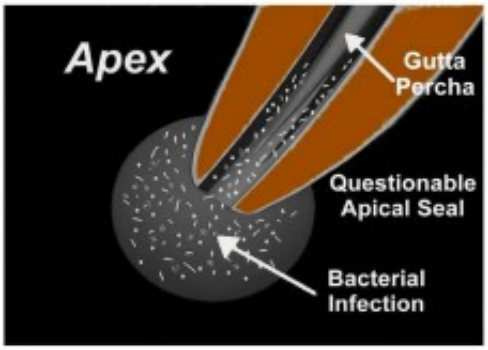
Figure 8

TOXIC MICROORGANISMS

Our first DNA studies examined bacteria retrieved from crushed root tips. We can identify eighty-three different anaerobic bacterial species with DNA testing. Root canals contain fifty-three different species out of these eighty-three samples. Some are more dangerous than others, and some occur frequently, some occasionally. Selecting those that occur more than 5 percent of the time, we found:

Capnocytophaga ochracea
Fusobacterium nucleatum

Gemella morbillorum
Leptotrichia buccalis
Porphyromonas gingivalis



Of what significance are these? Four affect the heart, three the nerves, two the kidneys, two the brain and one the sinus cavities. Shouldn't we question the wisdom of supplying a haven for these microbes so close to our brain and circulatory system? Does this information validate the claims of "sterile" root canals?

Dentists claim they can "sterilize" the tooth before forcing the gutta percha wax down into the canal. Perhaps they can sterilize a column of air in the center of the tooth, but is that really where the problem is? Bacteria wandering out of the dentinal tubules is what Price was finding, and what we were finding in the crushed tooth samples. But does the problem end there? Hardly.

Just out of curiosity, we tested blood samples adjacent to the removed teeth and analyzed them for the presence of anaerobic bacteria. Approximately 400 percent more bacteria were found in the blood surrounding the root canal tooth than were in the tooth itself. It seems that the tooth is the incubator. The periodontal ligament supplies more food, therefore higher concentration of bacteria.

But the winner in pathological growth was in the bone surrounding the dead tooth. Looking at bacterial needs, there is a smorgasbord of bacterial nutrients present in the bone. This explains the tremendous increase in bacterial concentration in the blood surrounding the root canal tooth. Try sterilizing that volume of bone.

Apparently, the immune system doesn't care for dead substances, and just the presence of dead tissue will cause the system to launch an attack. Infection, plus the autoimmune rejection reaction, causes more bacteria to collect around the dead tissue. Every time a person with a root canal bites down, these bacteria are flushed into the blood stream, and they start looking for a new home. Chemotaxis, or the chemical attraction of a specific bacteria for a specific tissue, assists the anaerobes in finding new quarters in the heart, nervous system, kidney, brain, etc., where they will perform their primary damage.

Many of the bacteria in the surrounding bone are present in far more than 50 percent of the samples tested. Streptococcus mutans was found in 92 percent of the blood samples. It can cause pneumonia, sinusitis, otitis media, meningitis and tooth decay.

Streptococcus mitis was found 92 percent of the time. This microbe attacks the heart and red blood cells. It is a rather hearty bug, for it went to the moon (hiding in a camera) on an unmanned expedition, stayed there over two years in an environment without atmosphere, exposed to temperatures of 250 degrees Fahrenheit during the day, minus 250 in the shadow. Upon returning to Earth with the astronauts of Apollo 12, over two years later, this microbe was still alive.[10] In humans, S. mitis binds to platelets and is involved in the pathogenesis of infective endocarditis. Want this guy living in your dead root canal tooth?

Of the top eight bacteria in the blood adjacent to root canal teeth, five affect the heart, five the nervous system, two the kidney, two the liver, and one attacks the brain sinus, where they kill red blood cells Of these, P*revotella intermedia* (present in 76 percent of the samples) attacks heart, kidney and sinus; *Strep intermedius* (present in 69 percent of the samples) attacks heart, nerves, lungs, liver and brain.

DNA examination of extracted root canals has shown bacterial contamination in 100 percent of the samples

tested. This is quite the opposite of official claims that root canals are 97 percent successful. Do they need a new definition of success?

CAVITATIONS

Cavitations are the next big problem that result from dental procedures. Cavitations are areas of unhealed bone left over after a tooth extraction (see Figure 9).

Dentists are generally taught to remove a tooth and leave the periodontal ligament in the socket, a procedure which would be like delivering a baby and leaving the placenta in the uterus.

These socket areas with the ligament left in place rarely heal. After tooth removal, a cap of about 2 millimeters (one sixteenth of an inch) covers the extraction site, leaving a hole the size of the root of the tooth behind. In records of five thousand surgical debridements (cleaning) of cavitations, only two were found to be healed.[14] When the periodontal ligament is left in the bone, the body senses that the tooth is still there, and the order for healing is canceled. These holes are lined with many of the same bacteria found in root canal sockets, but actually more different species. Whereas root canal teeth contain up to fifty-three different species of bacteria, cavitations yield up to eighty-two of the eighty-three we test for.

Of the five most frequently present bacteria found in cavitations, three affect the heart, two the nervous system and one the kidneys and lungs. They are as follows:

Streptococcus mutans (occurrence 63 percent of the samples), affects the nervous system, can cause pneumonia, sinusitis, otitis media and meningitis. It has also been blamed for causing dental decay in teeth, but this may be more the result of the fluid flow pulling bacteria into the tooth than actual active invasion by the bacteria.[2]

Porphyromonas gingivalis (occurring in 51 percent of the samples), damages the kidney, alters integrity of endothelial lining of blood vessels, and induces foam cells from macrophages, contributing to atherogenesis. It contains proteases that lyse red blood cells and extract nutrients (primarily iron) from the red blood cells. This action is called porin forming, which can destroy red blood cells rapidly. (By the way, *P. gingivalis* can both up and down regulate about five hundred different proteins critical to maintaining our normal biochemical actions.)

Candida albicans (present in 44 percent of the samples), in its yeast form is beneficial in the process of demethylation of methyl-mercury as well as its ability to destroy pathogenic bacteria in the intestinal tract. When converted into the fungal form by a shift in pH in the digestive system, candida can penetrate the intestinal wall, leaving microscopic holes that allow toxins, undigested food particles, bacteria and other yeasts to enter the blood stream. This condition is sometimes referred to as Leaky Gut Syndrome, which can lead to environmental intolerances.

Prevotella intermedia (occurrence rate of 44 percent) has as its primary concern coronary heart disease (CHD). *P. intermedia* invades human coronary artery endothelial cells and smooth muscle cells. It is generally located in atheromatous plaques. Cellular invasion of cardiac muscle is central to the infective process.[11]

ANTIBIOTICS

So, if all these diseases of “unknown etiology,” that is, of unknown origin, are the result of bacterial invasion, why not just flood the body with antibiotics? They kill bacteria, don’t they? Ever hear of someone who was sick,

was given antibiotics, and then got even worse? Most of us have heard the story. Perhaps the following information explains what happens in these cases, and why antibiotics cannot be used in infections of this nature.

Most antibiotics are “bactericidal”—think suicidal, or homicidal. Antibiotics kill. But this is not the same type of killing that John Wayne was noted for. When he fired at the bad guy, the bad guy fell over dead. Was then presumed to be buried. But when bactericidal antibiotics kill a bacterium, the bacterium explodes (see Figure 10).

The fragments are not eliminated immediately, for each piece is a lipopolysaccharide called endotoxin.[12] By way of contrast, exotoxins are the toxic chemicals that are released by pathogenic bacteria, and endotoxins are toxic entities (fragments of the original bacteria) that are the result of the bacterial explosion caused by the antibiotic. Endotoxins present a huge challenge to the immune system, for now, instead of facing one bacterium, it has to process and eliminate perhaps one hundred endotoxins. With dozens of bacteria to confront from each single root canal or cavitation, no one antibiotic can kill all of them, and if there were one, the resulting dead bacterial corpses would overwhelm the body and produce either greater disease or death.

Broad spectrum antibiotics cannot be used for this reason. Sometimes even one capsule of antibiotic produces more problems than the immune system can tolerate. Plus, of course, it takes only two or three capsules to completely sterilize the gut of its four or more pounds of friendly bacteria.[13] Antibiotics are far more powerful and potentially devastating than I ever thought they were. Antibiotics should be used with ultra caution, not routinely given for ten days or so after oral surgery, “just in case.”

There are other ways to get these microbes under control, and several are being tested at this time. It is advantageous to have intravenous vitamin C and occasionally a non-killing antibiotic is added to this solution. This combination does reduce the challenge to the immune system, but, overall, root canals represent the rock-and-hard-place situation.

Leave the root canal or cavitation in the body, and there is the potential of creating an unwanted autoimmune or degenerative disease that could be life threatening. Toxins and bacteria can both leak from these contamination sites wreaking havoc with a person’s cardiovascular, endocrine, nervous and immune systems. The public needs to be informed, so they can make educated choices in the trade-off between toxic convenience and health.

Removing the offending tooth presents problems that must be confronted, or other problems can be induced —problems not as dangerous as the continuous bacterial spill, but ones that need to be avoided if possible. In order to allow the immune system to focus on healing, all other offending dental materials should be removed (mercury, copper, implants, tattoos and nickel crowns) so that the immune system can deal with the bacterial challenge instead of the bacteria plus toxic metals. Nutrition should be calculated from the aspect of the blood chemistries commensurate with one’s ancestral diet and in line with the dietary principles formulated by Dr. Price. Recovery from a root canal is complicated, but your patient’s life is worth salvaging.

These studies in DNA analysis of bacteria in root canals and cavitations confirm the fact that Dr. Weston Price, despite being one century ahead of his colleagues, was absolutely correct in determining that bacteria-laden root canals have no place in the body of people interested in their health. This toxic waste spill can be stopped, but not with the assistance of dental associations, which continue to insist that the procedure of root canals is perfectly safe. The recent increase in suggested quota up to sixty million root canals per year is not in the best interest of their patients, nor can that action do anything but increase health costs for the innocent patient.

Price was right. Root canals are not worth the price.

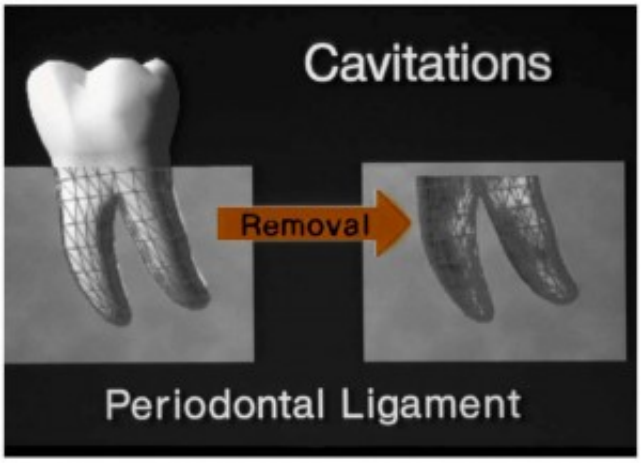


Figure 9

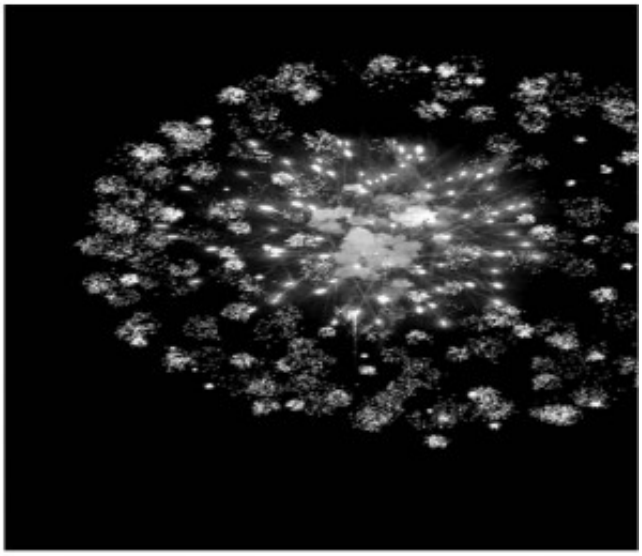


Figure 10

SIDEBARS

HAPTENS

A hapten is a small molecule that can elicit an immune response only when attached to a large carrier such as a protein or toxic metal such as mercury; the carrier may be one that also does not elicit an immune response by itself. In general, only large molecules, infectious agents, or insoluble foreign matter can elicit an immune response in the body. Once the body has generated antibodies to a hapten-carrier adduct, the small-molecule hapten may also be able to bind to the antibody, but it will usually not initiate an immune response; usually only the hapten-carrier adduct can do this.

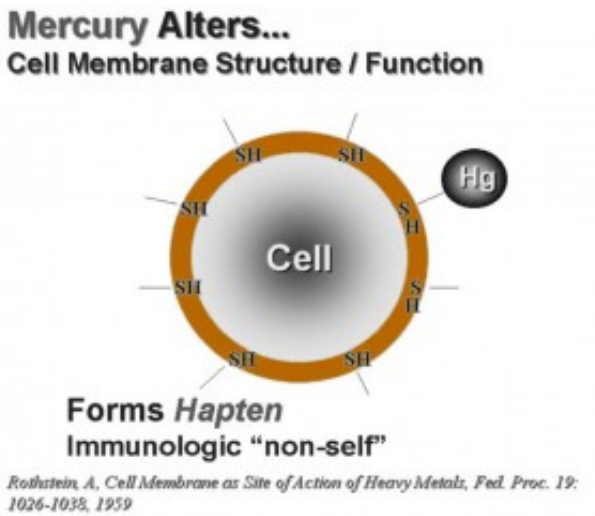


Figure 3

BACTERIA LURKING IN ROOT CANALS

Let's look at five major bacterial species lurking in root canals more closely, keeping in mind that these are only five of the fifty-three that are routinely found in root canal teeth.

Capnocytophaga ochracea: Found in brain abscesses associated with dental source of infection. Causes human disease in the central nervous system. Also related to septicemia and meningitis.[4]

Fusobacterium nucleatum: Produces toxins that inhibit fibroblast cell division and wound healing processes.

Causes infection in the heart, joints, liver and spleen.[5,6]

Gemella morbillorum: Linked to acute invasive endocarditis, septic arthritis and meningitis.[7]

Leptotrichia buccalis: Reduces the number of neutrophils (a critically important white blood cell), thus lowering immune competence.[8]

Porphyromonas gingivalis: Destroys red blood cells by drilling holes (porins) in them, causing the cell to "bleed to death." Low red cell counts that do not recover after dental revision are frequently responding to the porin activity of this microbe. *P. gingivalis* also alters the integrity of the endothelial lining of blood vessels, which leads to inflammation and bleeding in the inner lining of blood vessels. This is the key step in formation of atherogenesis that leads to heart attacks. *P. gingivalis* can change friendly bacteria into pathogens.[9]

REFERENCES

1. Brune, D, Metal release from dental biomaterials, *Biomaterials*, Vol. 7, May 1986.

2. Steinman, RR, Leonora, J, Relationship of fluid transport through the dentin to the incidence of dental caries. *J Dental Research*, Vol. 50, No. 6, Nov-Dec 1971.

3. Price, WA, *Dental Infections, Oral and Systemic*, Vol. I, Penton Pub Co. Ohio, USA, 1923.

4. *J. Clin Microbiology* Vol. 45, No. 2 p. 645-647.

5. Apoptic cell death in PMNs, *J. Infection and Immunology* Vol. 68, No. 4, April 2000, p. 1893-1898.

6. *Can Family Physician* Vol. 53, No.9 Sept. 2007 p. 1451-1453.

7. *J. Med Microbiology* Vol. 56 2007 p. 1689-1691.

8. *Anaerobe* Vol. II Issue 6 Dec 2005 p. 350-353.

9. JSTOR: *Clinical infectious diseases* Vol. 25 Sept 1997 p. 5284-5286.

10. Science.nasa.gov/science-news/science-at-has a Sept. 1, 1998

11. *Archives of Internal Medicine* Vol. 166 No. 5 Mar 13, 2006, PP 554-559.

12. *Todar's Online Textbook of Bacteriology*, Kenneth Todar, PhD 2008.

13. *Journal of Nutrition* Vol. 130 p.4105-4145 – PubMed.

14. Personal communication, Dr. Blanche Grube.

This article appeared in *Wise Traditions in Food, Farming and the Healing Arts*, the quarterly magazine of the Weston A. Price Foundation, Summer 2010.

Strategies for Biocompatible Endodontics

And a technique manual for using calcium oxide to fill root canals

We Still Need Root Canal Treatment

Despite the fact that there are serious objections to the use of root canal treatment in dentistry, due to the persistence of microbes in the dentinal tubules, the inaccessible microscopic spaces in a root, the fact remains that it is an ingrained part of our professional culture. It was easy to convert to mercury–free restorative dentistry once good alternatives became available, but the only alternative to endodontics is extraction, and our patients have been trained by the greater society to expect to keep their teeth. Even highly aware and health conscious patients can become subject to the conundrum of whether to lose a tooth or keep it at the price of a root canal treatment.

A discussion of the problem of long term toxicity emanating from root treated teeth is presented in the video, "Rooted," by Dr. Robert Gammal. Also see the book, Root Canal Coverup, by Dr. George Meinig, available on Amazon and other online sources.

A perfect example of the current state of confusion among health conscious consumers trying to do the right thing for themselves is illustrated in figure 1. This patient entered the care of a "holistic" dentist, who convinced him that root canal treated teeth were unhealthy. Therefore, tooth #12 (24) with its old root treatment, had to go. The tooth was extracted, the extraction site handled according to the latest anti-NICO protocol, and a porcelain fused to gold bridge was placed. He later moved to another city and sought another holistic dentist, because his bridge was bothering him. When the new dentist took a radiograph, it was apparent that tooth #13 (25) had now developed a periapical radiolucency, and needed a root canal treatment, or the new bridge would have to go too. The patient replied, "Forget it, I just paid $3000 for that bridge!" OK, let's do the root canal treatment, says the dentist. "Uh-uh, root canals are no good for you," responded the patient, and he went away untreated, only to return a year later with a serious, painful abscess.

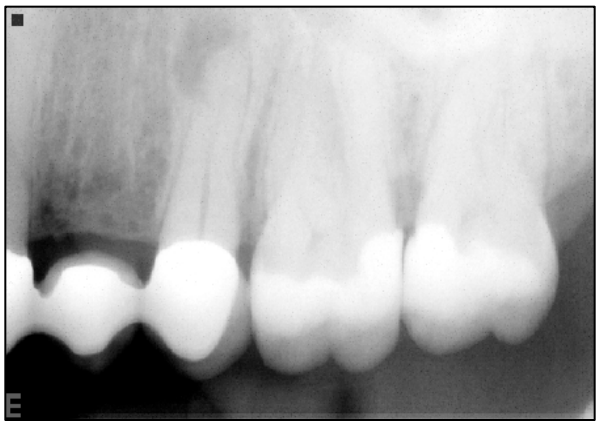


Figure 1

The possible responses a dentist can make when faced with non–vital teeth ranges from the typical, uncritical trust and dependence on root canal treatment, all the way to the "100 percenter's" total rejection of it. Unfortunately, our determination to avoid the possible toxicity of root-treated teeth clashes with the complexity of clinical situations, and the science, while suggestive, is limited. We don't know how to tell which tooth in which patient will present a toxic challenge that exceeds that person's physiological ability to deal with it.

We still need endodontics. No dentist can prevent the consequences of a patient's caries history and the restorative dentistry that follows, as the example above illustrates. In some cases, it will be acceptable to extract a tooth that would otherwise be a root canal candidate. In many other cases, it will not be acceptable to the patient to lose the tooth, and we must be prepared to treat the root canal.

Can there be an endodontic technique that minimizes the toxicity that develops in a root treated tooth? Can there be a middle ground between uncritical trust of root canal treatment and extracting everything? Can there be a treatment for the root canal and the dentin tubules as well? The IAOMT has some strategies to add to the discussion, methods that may improve the outcome. It takes a bit of knowledge and technique. Not enough information is available to allow us to be certain whether these methods can alleviate the problem of long term toxicity in root canals, but we offer these options for your consideration.

Everything to Kill Microbes

The standard technique in endodontic therapy is to clean, shape, disinfect and fill the main channel root canals, with no attempt made to reach into and disinfect the microscopic spaces. It's well established that canal irrigants and disinfectants penetrate only the first 100 microns of the dentinal tubules.[1] This approach has been very successful at getting rid of overt pain and infection, but inevitably leaves bacteria living in the dentinal tubules and other inaccessible places. Their metabolic waste products, anaerobic toxins which can be very potent, leach slowly out of the tooth into the body. If we are to continue to treat root canals, we must accept a new responsibility. Disinfecting the tubules must become the standard.

There actually are a variety of techniques that are well supported in the literature that are known to project germ-killing disinfection into those microscopic spaces of a root. Some that we can consider are the inter-appointment treatment dressing, ozone therapy, laser therapy, and final filling with calcium oxide (Endocal-10). Can there ever be perfect disinfection? Certainly not, because there is no regeneration of the pulp, with its blood supply, fluid flow, and immune potency. It will always be an asymptotic

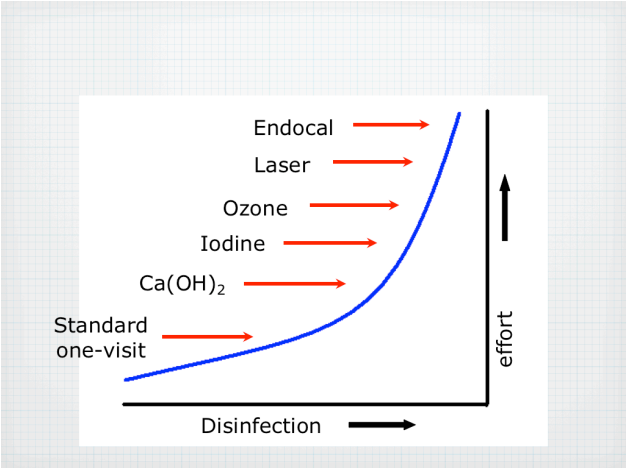


Figure 2-

process, one in which, with more effort, by adding disinfecting procedures, we can approach, but never really reach the goal. (figure 2) Somewhere on the graph of effort vs. disinfection is a vertical line that represents the patient's threshold for tolerating a non-vital tooth. It may vary with each patient; it may vary with each tooth. What we are truly lacking is a verifiable method for evaluating that threshold, and keeping track of it over time.

Treatment dressings between appointments are a classic method for disinfecting the roots of non-vital cases, and the agents used are quite diffusive, typically able to penetrate dentin tubules. Toxic phenols have been used traditionally, although they can be detected systemically within minutes of their application in a tooth.[2] Calcium hydroxide, a relatively efficient disinfectant, is far more biocompatible, and known to diffuse through dentin as well. The effectiveness of calcium hydroxide is greatly enhanced when it is mixed with chlorhexidine or iodine.[3] Iodine, of course, has the advantage of being not only biocompatible, but nutritional, in addition to its germ-killing properties. An easy treatment dressing can be made by mixing dry calcium hydroxide powder (SultanHealthcare.com) with either povidone iodine, or I-KI solution. There is no hard and fast rule about how long to leave it in the tooth between appointments.

Ozone therapy has emerged as a very useful all purpose anti-infective therapy.[4] Canals can be irrigated during treatment with ozone saturated water instead of sodium hypochlorite. It is as effective as a disinfectant, without the attendant cytotoxicity. Whether it has the same digestive capacity for organic material is not known. Oxygen-ozone gas can be used to fumigate canals once they have been cleaned and shaped. The ozone, being very highly soluble, will dissolve into the moist tubules. Oxygen-ozone gas can be used to perfuse the peri-radicular bone with a trephine device such as the X-tip, to provide disinfection of the medullary tissues, and promotion of healing. Training in dental ozone therapy is available from an IAOMT affiliate.

Laser therapy is gaining increasing acceptance in dentistry, not least in endodontics. In particular, the Waterlase (Biolase, Irvine, CA) has long, flexible fiber tips that are polished in such a way that the energy is directed out in a radial pattern. When they are placed in the root canal, the laser light shines right into the tubules, which act as wave guides, conducting the pulsed energy through their length. With the right amount of time and the right energy settings, effective disinfection of dentinal tubules can be documented.[5] [6]

The French Paste

Calcium oxide, or quicklime, has been used as a disinfectant since time immemorial. Its use in modern endodontics dates back to France in the mid 1960's and the publication of Pierre Bernard's work, Therapie Ocalexique.[7] Bernard proposed that CaO would diffuse through the hidden, microscopic spaces of the root canal system, providing continuous disinfection throughout the structure of the dentin, and ultimately obturation, by hardening in place; in other words, a treatment for both the root canal and the dentin tubules. His work was promoted and improved upon by Pierre Fohr, and Pierre Morin, who introduced "heavy" CaO, a much denser crystalline form that delivers up to three times as much calcium per volume as the original quicklime formula. The "three Pierres" and others including Cohen-Scali, began an era of interest in ocalexique root canal therapy in Europe, which has waned severely in recent years in the face of technical improvements (and marketing pressure!) from American gutta percha methods. The ocalexique technique was brought to North America by Pierre Donnedieu, DDS, of Montreal in 1979, and promoted by IAOMT member Guy Duquet, DDS.

Commercially, CaO root canal material was manufactured and marketed for a long time by Spad Laboratories in France, under the name "Biocalex 6/9." Biocalex was discontinued in 2001, shortly after Spad was acquired by Dentsply. It is now manufactured by Albuca Laboratories, of Montreal, and sold under the name "Endocal-10."

The first question dentists ask about this alternative technique is, "How long do they last?" There have been no formal clinical outcome studies published on the CaO technique, although an as-yet unpublished prospective follow-up study conducted by some IAOMT members showed clinical success rates that were indistinguishable from the literature on conventional techniques. Those dentists who have stuck with CaO root treatment over the years have experienced great clinical success, at least at the anecdotal level. None of the detractors' dire predictions have come true – roots don't break from expansion of the material, cases don't "wash out" and get reinfected, and there is nothing in our experience to indicate that it is in any way inferior to standard root canal therapy (figure 3).

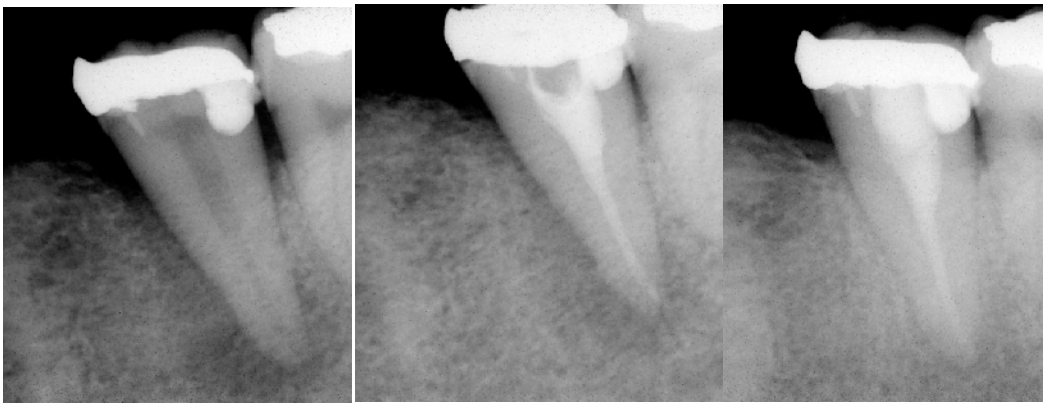


Figure 3 – A combined endo–perio lesion resolves after CaO root canal treatment.

Why Calcium Oxide?

Calcium Oxide as a root canal filling material represents an attempt to merge the well known disinfecting properties of calcium hydroxide with a hard setting, obturating material – in other words to make the calcium hydroxide effect permanent. Dentists have always used lime in the form of calcium hydroxide ($Ca(OH)_2$) as a disinfectant and stimulator of tissue regeneration. It is slightly soluble in water, and dissociates to form a powerfully alkaline solution, at pH 10 –11, which is inhospitable to germs but seems to have a stimulatory effect on dentin and bone cells. Unfortunately, it never sets hard, and does wash away in time from the root canal, leaving the tooth susceptible to reinfection.

Calcium oxide (CaO), on the other hand undergoes two reactions that make it much better suited as a root canal filler. First of all, it reacts with water, to form $Ca(OH)_2$, yielding all its beneficial properties:

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Secondly, it reacts with carbon dioxide ambient in the extracellular environment to form calcium carbonate, also known as limestone:

$$CaO + CO_2 \rightarrow CaCO_3$$

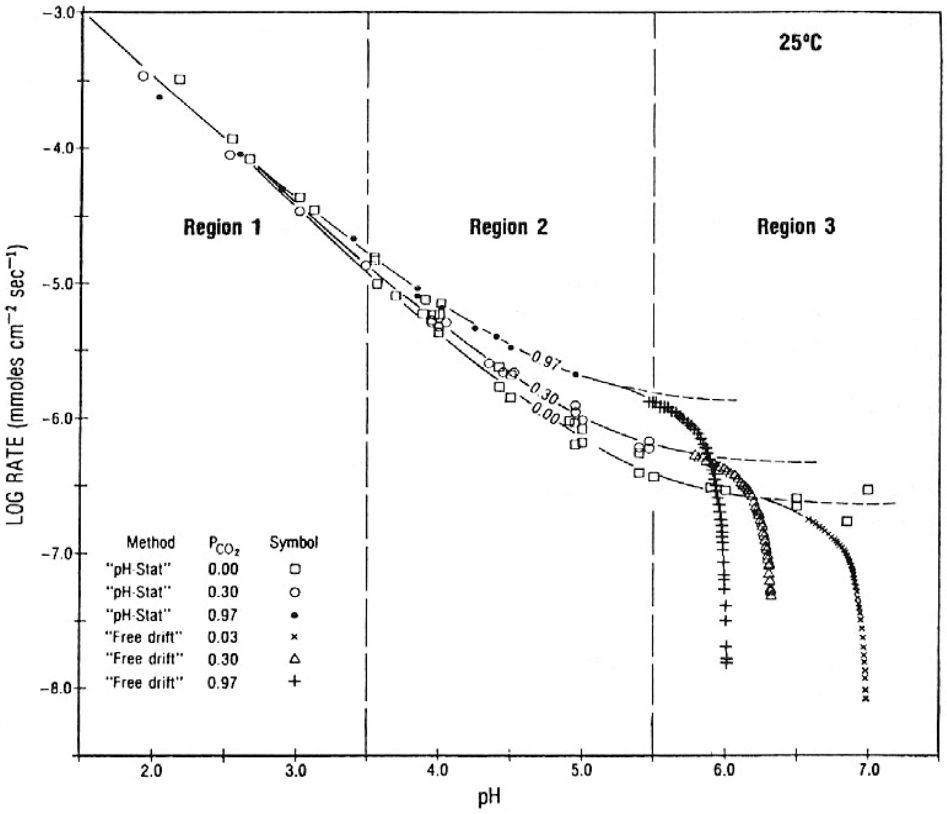


Figure 4 – Solubility curves for $CaCO_3$, depending upon pH and pCO_2, from Plummer, et al, (1978).

Calcium carbonate will form and remain insoluble only as long as the milieu is alkaline (figure 4). In an infected root canal, where the environment is made acidic by bacterial metabolic activity, CaO will generate $Ca(OH)_2$, which then buffers and disinfects. When the infection comes under control and the fluids return to physiological pH, the reaction of CaO turns to generation of calcium carbonate, and the material hardens in place. It's a *self–regulating system*, a material that is both an active disinfectant and an obturator, as required by the surrounding conditions. If the periapical infection reasserts itself and again produces acid, the previously hardened calcium carbonate will re-dissolve, yielding more $Ca(OH)_2$ to fight the infection.

Calcium oxide is strongly hygroscopic – it attracts water, and will expand through a water layer. This gives it the ability to actively diffuse through the microscopic spaces of a tooth, the tiny fins, isthmuses, lateral canals, and dentinal tubules. Minana[8] et. al showed that CaO, placed in the root canal of extracted teeth, can diffuse completely through the dentin and raise the pH at the cemental surface as effectively as $Ca(OH)_2$. Guigand, et. al,[9] [10] demonstrated that calcium from CaO penetrates into dentin tubules further than that from $Ca(OH)_2$, and that CaO dissolves organic matter such as predentin and smear layer more effectively that $Ca(OH)_2$. The hygroscopic nature of CaO has also given rise to one of the most serious objections to its use, namely the fear that pressure developed by hygroscopic expansion will fracture roots. This misapprehension derives from an unfortunate translation from the French, and if the original translator had used the word "penetrating" instead of "expansive," we wouldn't have had to labor under this misunderstanding. In clinical practice, CaO root treatments do not break roots. Treated roots sometimes break, it's a fact of life in endodontics, but clinical experience shows that the CaO treatments do not produce excess fractures.

Calcium oxide root treatment is not always as efficient or convenient a method as the standard gutta percha filling technique. It does not lend itself to single visit endo, because the hardened set of the material has to be checked at a subsequent appointment before restoration can proceed. The setting process is not a two–part chemical reaction, like ZOE or resin–based sealers. It sets by a biologically mediated interaction with its environment. Usually it sets on the first application, but not all the time. We use it despite the inconvenience because it is an attempt to more fully disinfect the treated tooth. If we can get an active disinfection of the dentinal tubules, we are more likely to avoid the kind of long term toxicity that develops in the tubules from anaerobic bacterial waste products. We have confidence that the CaO penetrates the tubules, disinfects them, obturates them, and stays there more effectively than anything else we can use. We hope, subject to future research, that we are really having the effect we desire – treating the dentin tubules and producing a less toxic root canal!

Technique Manual for CaO Root Treatment

1. **Case selection**.
   There do not appear to be any conditions that can be treated endodontically that can't be treated with CaO. The same problems that increase the failure rate of any root canal treatment will compromise CaO treatments as well – broken instruments, incompletely prepared canals, long standing infection, etc. There have been suggestions and claims that because CaO is penetrating and actively disinfecting, it can succeed in reversing infection in cases where the canals are not fully accessible. That may be true, but there's no research to back up the statement.

   Something should be said for evaluating a patient's overall health status, to evaluate the relative risk of root canal treatment for that individual. Should a person with chronic illness, immune system challenges, or other debilities be expected to tolerate root treated teeth? This is currently a matter of art, not science. Whose choice will it ultimately be to keep or lose an affected tooth?

2. **Informed consent.**
   In the United States, where fully informed consent is the rule, the dentist must inform the patient that the CaO root canal technique is not the prevailing standard, that it is an "alternative" method, and that if the patient prefers, he or she can receive the standard treatment instead, either in your office or by referral.

   Legally, Biocalex and Endocal have section 510(k) "premarket notification" approval from the FDA, allowing them to be sold for use by dentists in the USA. No state dental board has ruled as to whether CaO root treatment is within the standard of care or not. In Canada, the Quebec Order of Dentists has found it to be within the standard of care.

3. **Canal preparation.**
   Because the CaO material is a paste filling, the goal of instrumentation is to allow a Lentulo spiral to reach the apex without binding or obstruction. You need a wide preparation to do this, like the Schilder prep for vertical condensation, or a wide conical prep to the apex. The modern machine driven rotary techniques with NiTi files make this goal so much easier to attain than hand files, it's like night and day. Tulsa ProFiles, Files of Greater Taper, Lightspeed, Twisted Files, are some of the brand names. It's well worth learning how to use one of these systems.

   The location of the apex should be within 1 millimeter of the radiographic apex, or the actual full length measurement if you use an electronic apex locator.

   The earlier French authors preferred very little preparation, to preserve as much tooth

structure as possible. They felt that the ocalexique technique was essentially chemical, not mechanical.

An interesting series of experiments at the University of Texas argues in favor of the wide prep.[11] [12] When the roots of extracted teeth were filled with $Ca(OH)_2$ pastes, such as Pulpdent® or $Ca(OH)_2$ powder suspended in water, the pH of the entire thickness of the dentin, as measured at the cemental surface, was quickly rendered alkaline. But when the roots were filled by condensing gutta percha into a $Ca(OH)_2$ containing sealer, such as Sealapex® (Kerr), thereby reducing the amount of paste left inside the root, there was no such effect, and the root surface pH did not change. This was later repeated using CaO, with the same result.[13] The implication is that if raising the pH is related to disinfection, and you want to alkalinize all the way through the dentin structure of a tooth, you need a bigger reservoir of calcium material. A wide root preparation makes this possible.

4. **Irrigation.**
   There are many opinions on irrigants – for and against hypochlorite, especially. There is no conflict between the CaO root filling technique and any irrigation scheme you like, with one important exception: you must limit the use of EDTA canal irrigants.

   Any EDTA remaining in the canal will sequester the calcium, and poison the calcium-based root filling. It will absolutely prevent CaO from setting. You must rinse it out thoroughly. Rinse with sterile water and dry with paper points two or three times after using EDTA. There is an interesting observation about EDTA made by some IAOMT members. It seems that those who use EDTA for the longest time during instrumentation have the most trouble with CaO failing to set, while those who use it the least report only rare problems with setting. Perhaps it diffuses into the tubules, forming a reservoir that leaches back into the canal later on. On that basis we recommend against using RC Prep® or Glyde® during instrumentation.

5. **Go right to CaO, or use a treatment dressing?**
   There is a debate going on in endodontics right now over the single visit treatment that has been advocated over the last decade. Some authors are advocating a treatment dressing of $Ca(OH)_2$ for a week or two after the instrumentation appointment, especially in non-vital cases, and obturation on a second visit.

   We can use CaO as both a treatment dressing and as an obturant, since it either generates $Ca(OH)_2$ or sets hard as $CaCO_3$, depending upon the surrounding conditions. Instances of weeping or bleeding from the canal apex, that one would normally treat with a $Ca(OH)_2$ dressing, can be equally treated with CaO. But the

evidence is that alkaline calcium by itself is a good but not perfect disinfectant, and there will be instances in which it may be advisable to use a treatment dressing to get an infection under better control.

6. **Filling the canals with CaO.**
   Mix the CaO material (Endocal®) according to manufacturer's directions, to the familiar sour cream consistency. The canals are filled using a Lentulo spiral. In order to prevent trapping of air bubbles, start with a thin, number 1 (or ISO 25) spiral, and load it only to its own diameter. Don't glob the paste on it, to avoid trapping air. Slide it down to the apex and rotate at a medium-slow speed. Keep it there for ten whole seconds, because it will progressively beat any air pockets out of the fill. Withdraw slowly while spinning. Repeat this step in each canal two or three times, and then again with a larger diameter Lentulo. Apply only an amount that will fit within the diameter of the spiral, and let it spin to beat out any trapped air. It is inconvenient to keep repeating this way in, say, the mesio-buccal canals of upper second molars, but the results are worth it in terms of density of the fill. You can appreciate the need for a wide canal prep when you think of a Lentulo spinning all the way to the apex. If it binds, it's broken!

   Temporize with a non–eugenol temporary filling.

   Endocal, like Biocalex before it, is not well suited as a sealer for gutta percha. It is a bit too crunchy to allow a gutta percha point to slide to full length through it. As was noted in section 3, condensing gutta percha into the material reduces the amount of CaO material left in a root, and compromises its ability to alkalinize the dentin. That's contrary to the theory we're working with here. A paste filling of CaO without gutta percha works best.

7. **Check that the CaO filling has hardened.**
   Here is where the use of CaO becomes a lot less efficient than gutta percha. We truly hope that we can one day prove the stuff is worth the trouble of the extra appointments it requires by leaving treated teeth healthier. We shall see.

   Here is a typical routine: When the canal is filled, schedule a 15 or 20 minute appointment for a buildup, prefab post-and-core, or access filling, a week or two later. Re-open the access and probe the canal with a file. If the CaO filling has not set, you will be able to slip right down the canal as you would into a $Ca(OH)_2$ dressing. In that case, rinse it out, reapply new material, and re-appoint the patient for another week or two. If, instead, your file meets resistance, it's set, and you're ready to proceed with the restorative. Sometimes the set is stony hard, while at other times it seems more compacted yet able to be picked out. Most practitioners would leave it at that stage.

Pretty inconvenient, but it is essential to be certain that the CaO root filling has set. "Treatment failures" have generally proven to have soft material in the canals, meaning either that the once–set material has been re-dissolved by acids produced by a recurring infection, or it was never properly set in the first place.

The majority of cases do set hard on the first application, although there are lots of variants. It is not untypical to see two canals in a molar hardened nicely while the third is soft. You may use CaO as a treatment dressing, intending to rinse it out and reapply it one or two days later, only to find that it's already set rock hard. It's all just part of the dynamic nature of CaO root fillings. Think of a CaO filling that hasn't set as the equivalent of a necessary $Ca(OH)_2$ treatment, and you won't feel too frustrated by the phenomenon. It is rare, though, to have a canal filling still fail to harden after three applications. If your treatments begin to experience more frequent failures to harden, get a fresh kit of material, as your old stock may have absorbed too much moisture from the air.

8. **Post preparation.**
   A fully hardened CaO root filling cannot be drilled for the post prep. If you intend to restore the tooth with a post, you must prepare the post space by removing some fresh CaO paste just after you place it. A convenient method is to dip out the paste to the appropriate length with a paper point

9. **Overfills.**
   Some practitioners have reported that overfills cause post–operative pain, though most others have not seen it. Biologically, there is no problem with overfills of this highly biocompatible material, as it resorbs with no consequences. The extra alkalinity may promote better bone healing as well.

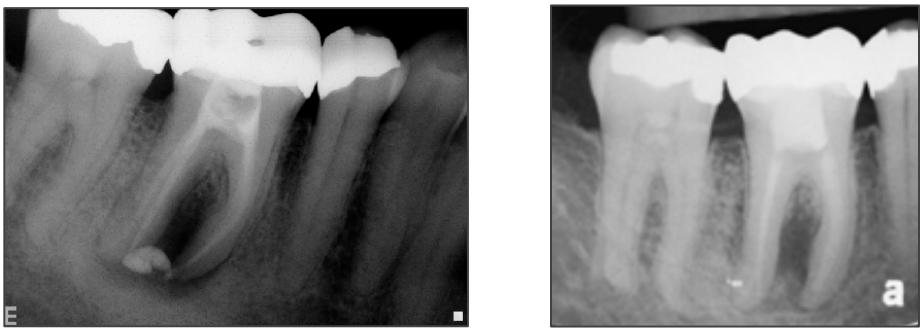


Figure 5 – An overfill resolves with with apical bone regeneration.

10. **Radio-opacity.**

The original Biocalex formulation contained 2/3 calcium oxide and 1/3 zinc oxide. The insoluble ZnO was used as an inactive ingredient, an extender to reduce the degree to which the material would expand into the water layer. Unfortunately, neither of these ingredients is radio-opaque relative to tooth structure, so a completed treatment was nearly invisible on a radiograph – a problem that has made a lot of dentists uncomfortable!

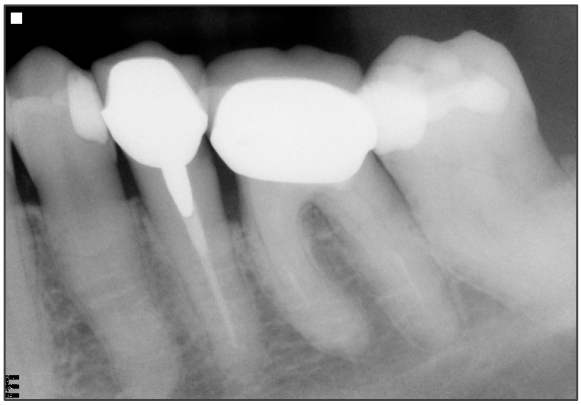


Figure 6 - Tooth #19 (36) successfuly filled with Biocalex, but it is invisible on x-ray.

The original instructions for Biocalex stated that when a root could be instrumented to its full length, an additional ⅓ volume of zinc oxide should be mixed in. Yttrium oxide, Y_2O_3, has physical properties identical to ZnO[14], and a completely benign toxicological profile.[15] It is moderately radio-opaque, enough to make all the difference in the radiograph. By substituting yttrium oxide for the original zinc oxide, the radiolucency problem has been solved. All the clinical examples shown in this article were filled with a CaO/Y_2O_3 formula.

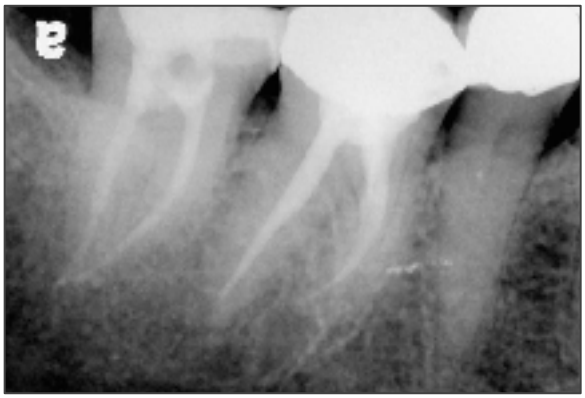


Figure 7 - Tooth # 30 (46) filled with conventional gutta percha, #31 (47) filled with CaO/Y_2O_3 formula for adequate radio-opacity.

We could use barium sulfate to give somewhat more dense radio-opacity, but many high–touch biocompatible practitioners try to stay away from barium. All barium compounds are considered toxic, with the exception of barium sulfate, and that only because of its exceptional insolubility.[16]

Bismuth oxide mixed with CaO makes a very radio-opaque fill, but it turns the tooth totally black!

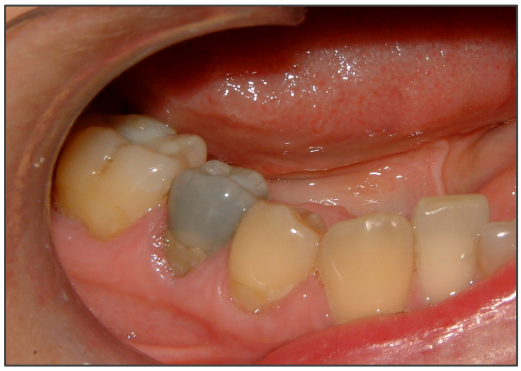


Figure 8 - The bismuth tooth presents certain problems despite excellent radio-opacity.

11. **Retreatment.**

Most cases that are indicated for retreatment will be found to have soft material in the canals, and are easy to retreat. Occasionally there will be a tooth you'll want to retreat in which the fill in the canals is still rock hard. These cases should be considered for apical surgery, or carefully evaluated for fractured roots. But if you definitely want to re-negotiate the canals, soak the access cavity with 17% EDTA solution for a few minutes, and the material will soften up, allowing you to pick through it.

Research opportunities.

Every statement in this article that is not referenced to the scientific literature is backed only by accumulated clinical experience. Every aspect of CaO root canal technique still needs to be tested by experiment, and precious little has been. If the material is hard at the canal orifice, is it necessarily hard all the way to the apex? Do the chemical reactions described above really occur in the root canal? What is the canal filling like a year later, five years later? And most importantly, how disinfected do these teeth remain over time? Are we really reducing the long term accumulation of anaerobic toxins in the dentin tubules?

These questions should be investigated by academic researchers with access to animal subjects, but so far, this subject has not attracted the attention of those folks. The Guigand papers are about the only real science that has been published on the CaO root canal filling. It's a shame – there are clearly opportunities being missed for numerous PhD theses, while we continue to produce clinically acceptable root canal treatments in the field, justifying our work by trading anecdotes.

A video presentation of this material, from the IAOMT meeting in Kansas city, March, 2005, is available from the online store.

[1] Vahdaty A, Pitt Ford TR, Wilson RF. Efficacy of chlorhexidine in disinfecting dentinal tubules in vitro. Endod Dent Traumatol. 1993 Dec;9(6):243-8.

[2] Araki, K, et al. Systemic distribution of formocresol containing 14C formaldehyde after pulpectomy.. JDR 1988; 67(SI): 274, A1291

[3] Siqueira JF Jr, Lopes HP. Mechanisms of antimicrobial activity of calcium hydroxide: a critical review. Int Endod J. 1999 Sep;32(5):361-9.

[4] Lynch, E, ed. Ozone: the revolution in dentistry. Quintessence Publishing, Surrey, UK. 2004

[5] Schoop, U, et al. The use of the erbium, chromium:yttrium-scandium-gallium-garnet laser in endodontic treatment: The results of an in vitro study. JADA July 2007

[6] Gordon, W, et al. The antimicrobial efficacy of the erbium, chromium:yttrium-scandium-gallium-garnet laser with radial emitting tips on root canal dentin walls infected with Enterococcus faecalis. JADA July 2007

[7] Bernard, PD, Therapie Ocalexique, Editions Maloine, Paris, 1967.

[8] Minana M, Carnes DL, Walker WL. pH changes at the surface of root dentin after intracanal dressing with calcium oxide and calcium hydroxide. J Endodon 2001; 27:43-45.

[9] Guigand M, Vulcain JM, Dautel-Morazin A, Bonnaure-Mallet M. An ultrastructural study of root canal walls in contact with endodontic biomaterials. J Endodon 1997; 23:327-330.

[10] Guigand M, Vulcain JM, Dautel-Morazin A, Bonnaure-Mallet M. In vitro study of intradental calcium diffusion induced by two endodontic biomaterials. J Endodon 1997; 23:387-390.

[11] Esberard RM, Carnes DL, del Rio CE. Changes in pH at the dentin surface in roots obturated with calcium hydroxide pastes. J Endodon 1996; 22:402-405.

[12] Esberard RM, Carnes DL, del Rio CE. PH changes at the surface of root dentin when using root canal sealers containing calcium hydroxide. J Endodon 1996; 22:399-401

[13] Minana, op. cit.

[14] Handbook of Chemistry and Physics, 73rd Edition. David R. Lide, editor. CRC Press, Boca Raton, Florida. 1992

[15] Rare Earth Poisindex, Meditext Medical Management, in TOMES System, KM Hurlburt, editor. Micromedex, Inc, Englewood , Colorado. Edition expires February 2001.

[16] Barium Salts Poisindex, Meditext Medical Management, in TOMES System, KM Hurlburt, editor. MICROMEDEX(R) Healthcare Series Vol. 107 expires 2/2001

In Vitro Enzymatic Inhibition Associated with Asymptomatic Root Canal Treated Teeth: Results from a Sample of 25 Extracted Root Fragments

Stuart M. Nunnally, DDS, MS[1]

[1] Nunnally/Freeman Dentistry, 2100 Highway 1431, Marble Falls, Texas, USA 78654 tel: 830-693-3646 email: snunnally@mac.com

Abstract ***Background:*** *For almost a century there has been debate over the toxicity associated with root canal treated teeth.*
Objective: *This study sought to determine the level of enzymatic inhibition associated with asymptomatic root canal treated teeth in which there was no radiographic evidence of pathology.*
Design: *In vitro study.*
Setting: *Private dental office (Marble Falls, Texas, USA).*
Intervention: *A photo-affinity labeling technique performed by Affinity Labeling Technologies (ALT) Bioscience Laboratory was used to determine the level of enzymatic inhibition of the extracted teeth.*
Main outcome measures: *Six commercially available enzymes that are critically important for human life were tested in order to determine their percent inhibition when exposed to root fragments of the 25 extracted root canal treated teeth.*
Results: *The enzymes averaged 65.6% inhibition, which reflected severe toxicity on the scale developed by ALT Bioscience Laboratory. Limitations of this study included the lack of a control group, the inability to ascertain if these in vitro results have significant clinical relevance, the inability to correlate these in vitro findings to a patient's clinical health status, possible contamination of the root fragments with mercury or other substances, and the absence of culturing the root fragments.*
Conclusion: *Root canal therapy has proved to be an effective way of treating and retaining endodontically diseased teeth, but does not render the teeth sterile. These preliminary results suggest that root canal treated teeth inhibit the action of critically important enzymes that generate cellular adenosine triphosphate.*

Introduction

For almost 100 years there has been debate regarding toxicity associated with teeth that have undergone root canal therapy. Weston Price, D.D.S., M.S., F.A.C.D., Director of the Research Institute of the National Dental Association, published an exhaustive 1,044 page, two-volume treatise in 1923, which correlated numerous systemic illnesses with diseased teeth, including teeth that had undergone root canal therapy. His testing methods involved isolating bacteria from infected teeth, injecting these bacterial cultures into experimental animals, and then observing the systemic effects on the experimental animals. He found that many sys-

temic illnesses were precipitated by diseased teeth, including teeth which had undergone root canal therapy.[1,2]

Recent research is consistent with Price's findings and has revealed that teeth which have undergone root canal therapy continue to harbor bacteria, viruses, and fungi.[3-11] Unpublished research by Nunnally has revealed via deoxyribonucleic acid analysis that endodontically treated teeth play host to numerous species of anaerobic bacteria. The toxicities associated with endodontically treated teeth do not remain silently tucked away within the structure of the dead tooth.

This study sought to determine the level of enzymatic inhibition associated with root canal treated teeth which: (1) had undergone root canal therapy as confirmed by radiographs; (2) had no radiographic evidence of disease; and (3) produced no symptoms, i.e., teeth were asymptomatic with respect to chewing pressure or thermal sensitivities and were indistinguishable by the patient from any of the patient's other non-root canal treated teeth.

Methods

During a three year period, 87 root canal treated teeth were extracted on consecutive patients who requested removal of their asymptomatic root canal treated teeth. After root canal therapy, all of these patients noted declines in their overall health and had been informed by their health care providers of the possible systemic health risks associated with root canal treated teeth. Only extracted root canal treated teeth were accepted into the study.

Radiographs of the 87 extracted teeth were evaluated by Nunnally and independently evaluated by three independent dentist evaluators who were asked to critically examine each radiograph. Radiographs of the teeth prior to endodontic treatment were not evaluated. Only teeth which radiographically had been completely obturated to within 0.5 millimeters of the apex, had no extrusion of the root canal filling material, and which showed no signs of disease were admitted into the study.

Of the 87 original teeth, 25 were unanimously approved by Nunnally and three independent dentist evaluators for inclusion in this study. Of the 25 teeth, 15 had been treated by endodontists, six had been treated by general dentists and in the remaining four teeth, the patients were unable to recall who performed the root canal therapy. The included teeth consisted of twelve molars, eight bicuspids, three canines, and two incisors. All 25 teeth appeared radiographically and clinically to have been filled with gutta percha, but no attempt was made to determine which endodontic sealer had been used.

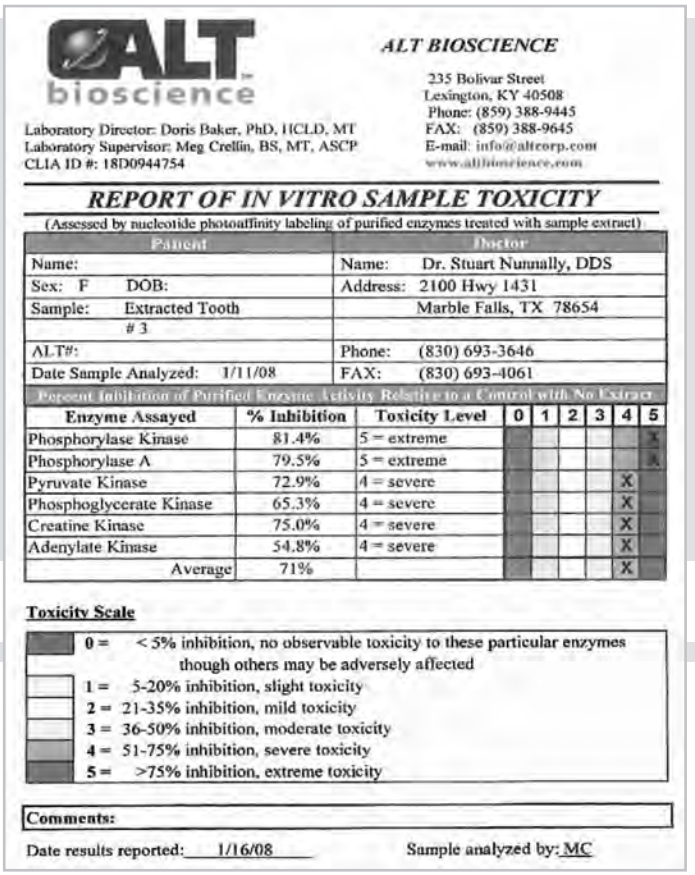
The extracted teeth were placed into sterile biopsy bottles and submitted to Affinity Labeling Technologies (ALT) laboratory for in vitro toxicity testing. Root fragments were analyzed from the 25 extracted teeth containing restorative materials, such as mercury fillings, metallic, ceramic, or metalloceramic crowns. The individual root fragments were carefully selected to minimize the impact of contamination or leaching from the restorative materials. The ALT *in vitro* toxicity testing was performed on all root fragments after washing them three times in distilled water, and, after filtration, 10 microliters of each third wash sample was incubated with six enzymes (i.e., phosphorylase kinase, phosphorylase A, pyruvate kinase, phosphoglycerate kinase, creatine kinase, and adenylate kinase) to determine the degree of enzymatic inhibition. The degree of enzymatic inhibition for the root fragments was quantified by using a nucleotide photo-affinity labeling technique.

No control samples were submitted for comparison since that would have required the extraction of healthy, non-root canal treated teeth from patients whose teeth were included in this study.

Results

The results for all root fragments from the 25 extracted root canal treated teeth were calculated. **Figure 1**, (p. 114) provides a sample report from one of the collected specimens. The mean percent of total enzymatic inhibition was calculated from 150 results (six enzyme percent scores X 25 specimens = 150) and determined to be 65.6% ± 16.6.

Figure 1. ALT *in vitro* toxicity testing results for one of the root fragments derived from an extracted root canal treated tooth



ALT bioscience

ALT BIOSCIENCE

235 Bolivar Street
Lexington, KY 40508
Phone: (859) 388-9445
FAX: (859) 388-9645
E-mail: info@altcorp.com
www.altbioscience.com

Laboratory Director: Doris Baker, PhD, HCLD, MT
Laboratory Supervisor: Meg Crellin, BS, MT, ASCP
CLIA ID #: 18D0944754

REPORT OF IN VITRO SAMPLE TOXICITY

(Assessed by nucleotide photoaffinity labeling of purified enzymes treated with sample extract)

Patient		Doctor	
Name:		Name:	Dr. Stuart Nunnally, DDS
Sex: F	DOB:	Address:	2100 Hwy 1431
Sample:	Extracted Tooth # 3		Marble Falls, TX 78654
ALT#:		Phone:	(830) 693-3646
Date Sample Analyzed:	1/11/08	FAX:	(830) 693-4061

Percent Inhibition of Purified Enzyme Activity Relative to a Control with No Extract

Enzyme Assayed	% Inhibition	Toxicity Level	0	1	2	3	4	5
Phosphorylase Kinase	81.4%	5 = extreme						X
Phosphorylase A	79.5%	5 = extreme						X
Pyruvate Kinase	72.9%	4 = severe					X	
Phosphoglycerate Kinase	65.3%	4 = severe					X	
Creatine Kinase	75.0%	4 = severe					X	
Adenylate Kinase	54.8%	4 = severe					X	
Average	71%						X	

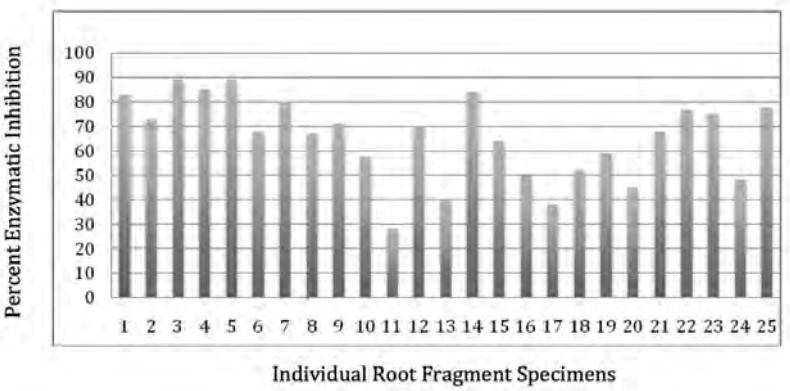
Toxicity Scale

0 = < 5% inhibition, no observable toxicity to these particular enzymes though others may be adversely affected
1 = 5-20% inhibition, slight toxicity
2 = 21-35% inhibition, mild toxicity
3 = 36-50% inhibition, moderate toxicity
4 = 51-75% inhibition, severe toxicity
5 = >75% inhibition, extreme toxicity

Comments:

Date results reported: 1/16/08 Sample analyzed by: MC

Figure 2. Calculated enzymatic inhibition for individual root fragments derived from 25 extracted root canal treated teeth



The percent of enzymatic inhibition for all collected specimens ranged from a low of 28% to a high of 89%, with a median of 68%. (**Figure 2**, p. 114).

Discussion

Since no control group was used, it is difficult to know if these *in vitro* results have significant clinical relevance. It is impossible to know if root fragments from properly matched non-root canal treated teeth would produce less enzymatic inhibition compared to root fragments derived from root canal treated teeth. It is also difficult to correlate these *in vitro* findings to a patient's clinical health status. It is also possible that the root fragments were contaminated by mercury or other substances even though samples were carefully chosen to minimize these effects. None of the root fragments were analyzed or cultured. These results, therefore, can only be considered very preliminary in nature. More studies are certainly needed, which must include a control group, a more precise analysis of the root fragments, and the ability to better correlate a patient's clinical health status to root canal treated teeth and to *in vitro* enzymatic inhibition.

Notwithstanding the significant limitations of this study, there is an increasing awareness among health care providers and the general population that infected teeth and periodontal disease can have profound systemic implications. For example, periodontal disease has been cited as one of the greatest influences in predicting a stroke.[11-13] Infected teeth have been linked to cancer, brain and lung abscesses, heart disease, disorders of the eyes, sinuses, digestive tract and virtually every other systemic organ.[14-19] Price demonstrated repeatedly that autoimmune diseases such as rheumatoid arthritis could be caused or exacerbated by infected teeth.[1,2] Anecdotes abound of people who have had an infected tooth extracted only to have their joint pain "magically" disappear within days.

There is also a general misperception among dental practitioners that root canal treated teeth are devoid of pathogens and toxins. The bacteria which reside within the tubules and accessory canals of root canal treated teeth (there are an estimated three miles of untreated microscopic tubules in a single rooted incisor[20]) become producers of potent toxins. Thus, the working (i.e., unproven) hypothesis is that the bacteria and toxins within root canal treated teeth inhibit critically important enzymes essential for human life, which leads to negative health outcomes. The enzymes tested for inhibition by ALT Laboratory are necessary for life because they are associated with the cell's production of adenosine triphosphate (ATP).

Dentists have assumed that the success of root canal treatment is measured in terms of longevity of the treated teeth, yet the findings of Price and others and these preliminary results suggest concerns over the possible systemic effects associated with root canal treated teeth.

Conclusion

Root canal therapy has proved to be an effective way of treating and retaining endodontically diseased teeth, yet research has demonstrated that root canal therapy does not render the tooth sterile. These preliminary results suggest that root canal treated teeth inhibit the action of critically important enzymes that generate cellular ATP.

Competing Interests

The author declares that he has no competing interests.

References

1. Price WA: Volume I, *Dental Infections, Oral and Systemic.* Cleveland, OH. Penton Publishing Company. 1923.
2. Price WA: Volume II, dental Infections and the degenerative diseases. Cleveland, OH. Penton Publishing Company. 1923.
3. Oguntebi BR: Dentine tubule infection and endodontic therapy implications. *Int Endod J,* 1994; 27: 218-222.
4. Torabinejad M, Handysides R, Kahdemi A, et al: Clinical implications of the smear layer in endodontics; A review. *Oral Surgery Oral Med Oral Pathol Oral Radiol Endod,* 2002; 94: 658-666.
5. Retamozo B, Shabahang S, Johnson N, et al: Minimum contact time and concentration of sodium hypochlorite required to eliminate Enterococcus

faecalis. *J Endod,* 2010; 36: 520-523.
6. Estrela C, Silva JA, de Alencar AH, et al: Efficacy of sodium hypochlorite and chlorhexidine against Enterococcus faecalis-a systematic review. *J Appl Oral Sci,* 2008; 16: 364-368.
7. Law A, Messer H: An evidence – based analysis of the antibacterial effectiveness of intracanal medicaments. *J Endod,* 2004; 30: 689-694.
8. Clark-Holke D, Drake D, Walton R, et al: Bacterial penetration through canals of endodontically treated teeth in the presence or absence of the smear layer. *J Dentistry,* 2003;31:275-281.
9. Chavez de Paz LE, Dahlen G, Molander A, et al: Bacteria recovered from teeth with apical periodontitis after antimicrobial endodontic treatment. *Int Endod J,* 2003; 36: 500-508.
10. Chavez de Paz LE: Development of a multispecies biofilm community by four root canal bacteria. *J Endod,* 2012; 38: 318-323.
11. Endodontics: colleagues for excellence. Root canal irrigants and disinfectants. Chicago, IL. American Association of Endodontists. Winter 2011. Retrieved from: [*www.aae.org/uploadedFiles/Publications_and_Research/Endodontics_Colleagues_for_Excellence_Newsletter/RootCanalIrrigantsDisinfectants.pdf*].
12. Desvarieux M, Demmer RT, Rundek T, et al: Relationship between periodontal disease, tooth loss, and carotid artery plaque: the Oral Infections and Vascular Disease Epidemiology Study (INVEST). *Stroke,* 2003; 34: 2120-2125.
13. Grau AJ, Becher H, Ziegler CM, et al: Periodontal disease as a risk factor for ischemic stroke. *Stroke,* 2004; 35: 496-501.
14. Pussinen PJ, Alfthan G, Rissanen H, et al: Antibodies to periodontal pathogens and stroke risk. *Stroke,* 2004; 35: 2020-2023.
15. Health Professionals Follow-Up Study Newsletter. Dental/Oral Health. Boston, MA. Harvard School of Public Health. Winter 2009. Retrieved from: [*www.hsph.harvard.edu/hpfs/pdfs/09News.pdf*].
16. Joshipura KJ, Pitiphat W, Hung HC, et al: Pupal inflammation and incidence of coronary heart disease. *J Endod,* 2006; 32: 99-103.
17. Michaud DS, Liu Y, Meyer M, et al: Periodontal disease, tooth loss, and cancer risk in male health professionals: a prospective cohort study. *Lancet Oncol,* 2008; 9: 550-558.
18. Silva MJB, Kajiya M, AlShwaimi E, et al: Bacteria-reactive immune response may induce RANKL-expressing T cells in the mouse periapical bone loss lesion. *J Endod,* 2012: 38: 346-350.
19. Scannapieco FA: Role of oral bacteria in respiratory infection. *J Periodontol,* 1999;70:793-802.
20. Kulacz R, Levy T: *The Roots of Disease. Connecting Dentistry and Medicine.* Philadelphia, PA. Xlibris Corporation. 2002; 143.

YOU NOW NEED TO LISTEN TO THE IAOMT PODCAST *WORD OF MOUTH* EPISODE ENTITLED “REGENERATIVE ENDODONTICS AND CONTROVERSY OVER ROOT CANALS” WITH ENDODONTIST DR. VALERIE KANTER. THE PODCAST IS AVAILABLE AT https://youtu.be/a-Gvw7e9Dsw.

IF CLICKING ON THE LINK ABOVE DOES NOT WORK, THE PODCAST IS LOCATED ON THE IAOMT WEBSITE (WWW.IAOMT.ORG), AT THE BOTTOM OF THE "RESOURCES" TAB LISTED AS "WORD OF MOUTH PODCAST." ONCE ON THE PODCAST PAGE, FIND "SEASON 1, EPISODE 2.”

UPON COMPLETION OF LISTENING TO THIS PODCAST, YOU WILL NEED TO CONTINUE WITH THE ADDITIONAL REQUIREMENTS FOR UNIT 9.

THE ROOT CANAL AND BREAST-CANCER CONNECTION

ALIREZA PANAHPOUR, D.D.S.

Infected root canals are a common example of the mouth-body connection that dental schools need to teach more about, and that consumers of dental services need to be more aware of. Everyone needs to be alerted to the possibility of a root-canal infection. And everyone should be alerted to the danger of tolerating chronic focal infections in the jaw for any length of time, because of possible ramifications on patients' oral-systemic health.

Chronic oral infections can raise your risk of a variety of illnesses. Foremost are stroke and cardiovascular problems, but also rheumatoid arthritis, diabetes, respiratory infections, cancers, and pregnancy problems. If a person has a root canal and is having any of these issues, he or she needs to make sure that the root canal is not infected. Fighting an infection day after day in a dead root-canal tooth will tax anyone's immune system. If a patient is struggling immunologically, that is a sign of a possible chronic infection, and dentists need to be able to determine if the cause of the immune challenge is in the mouth. Patients also need to be aware of these risks when dentists offer them a root-canal procedure in the first place.

As a systemic dentist, I do not offer root canals to my patients because I am quite well aware that the systemic risks outweigh any benefit. For oral-systemic health, I believe infected teeth need to come out rather than be root canaled and kept in the jaw as a dead tooth. A root-canal tooth is a dead tooth that will attract infection over time because the tooth is made of thousands of micro-tubules that attract anaerobic bacteria. To demonstrate the risks, I want to share experiences that I have had in my practice treating patients with breast cancer who had infected root canals.

Thermography image of infected root canal

Courtesy of the Breast Health and Preventive Education Center

Over time, the physicians I team up with were sending me breast-cancer patients for dental assessment. In these cases, blood panels showed signs of infection but the doctors could not locate a source. When you have a situation like this, the next logical step is to check for possible infection in the mouth.

I began the practice of sending these patients in for thermography, which is a noninvasive way to map the body by temperature. Thermography is an extremely useful diagnostic tool in this regard, although most insurance plans do not cover it.

When I looked at the hot and cold areas of the body in the thermography pictures of the breast-cancer patients, I could clearly see what was going on. In thermography, cold areas reveal not enough blood flow, whereas hot spots reveal areas of possible infection.

In the breast-cancer cases that had been referred to me, I saw hot spots in the jaw suggesting focal infections from root canals that were draining via the lymphatic system straight into the breast area. Thermography allowed me to locate infection in the jaw of these breast-cancer patients that their doctors could not find, even though blood tests clearly indicated an infection somewhere in the body. I could then use digital x-rays of the area to confirm my suspicion.

Could these chronic, focal bacterial infections in the jaw have caused the patients' breast cancers? Not directly, because bacterial infections do not cause cancer. But indirectly, a chronic infection can contribute to the development of cancer because, over time, chronic infections wreak havoc on a person's immune system. A weakened immune system sets the stage for dysfunction in cytochemistry (cell biochemistry) that can lead to cancerous tumor growth and the inability of the immune system to trigger cell death in cancer cells. Cancer (and a host of other diseases) is more likely to appear in a person who is struggling immunologically.

Obviously, people can become overwhelmed dealing year after year, even decade after decade, with chronic infections in the jaw from infected root canals. Often the immune system is so relieved when the

infection is finally removed that the patient rebounds quickly into a greater state of health. I like to work closely with the patient to arrange to see the attending physician the day after oral surgery because patients often experience a huge shift on that day. I find it absolutely crucial that patients are prepared properly to enter each new stage of healing. When surgery is done in a non-traumatic way, after the patient has been prepared properly on all levels – neural, lymphatic, structural, and psychological – the body is so relieved to have the infected tissue out of the jaw that it just shines. Let me give you an example in a case I treated.

CASE STORY

A prominent actress who was very well-off had breast cancer not once, but twice. She had surgery that was followed by radiation and chemotherapy. After the second bout of cancer, she was no longer able to perform, so she retired to the Caribbean to recover her health. She came to me to get a fresh start. She never wanted to have breast cancer again, so she was checking everything, including her teeth. She wanted to know why her breast cancer returned because she had done everything her doctors had told her to do the first time.

I referred her to a naturopathic physician to do a full-body analysis. Her blood test showed signs of infection somewhere in her body. I sent her for thermography, and her thermography report showed hot spots where her six root canals were draining infection into her lymphatic system, right into her breasts. Physically, those infected root canals were weakening her immunity. Energetically, they were causing disturbances in her vitality. Emotionally and spiritually, she was exhausted. She was a strong woman, but her long battle with breast cancer was obviously wearing her down.

This brave woman, who had been through so much, was an intensive researcher and spent hours on the Internet. She was eager for information and that curiosity would provide her salvation. She wanted to know her options, which we reviewed together.

The first option was to completely amputate all six teeth with infected root canals, because those dead teeth were attracting recurrent infections that were wreaking havoc on her immune system's ability to deal with cancerous cells. Mind you, I say amputate very deliberately; it's not really an extraction. It's an amputation when you remove a tooth. As I said before, each tooth is like an organ with a blood supply, neural supply, connecting ligaments, lymphatic supply, and so forth. All of this structure has to be properly removed so that there is no dead tissue left to attract infection.

The second option was to refer her to a root-canal specialist – an endodontist – to redo the root canals and hope that the chronic infections would go away permanently. However, in my experience, this never happens. In a matter of years, sometimes months, sometimes even days, the infection returns. Each time the patient's immune system gets more and more stressed. Gut flora problems can emerge, as the endodontist will typically prescribe antibiotics to treat the infection in the root canal so that he can redo the root canal. The patient feels better in the short term, but pathogenic bacteria can survive the round of antibiotics and become antibiotic-resistant. Meanwhile, the patient's good bacteria are killed off – the very ones that would help keep the bad bacteria in check. The result is that when the infection comes back a second time, or third time, it is often more virulent and the infection is worse, placing even more intense stress on the immune system.

The last resort was to inject ozone around the infected and dead root-canal teeth in order to sterilize the infected areas and give her immune system a break. Dental ozone therapy is an amazing tool for killing anaerobic bacteria on contact, and can provide immediate relief. However, this technique doesn't last forever. In time, the infection will return because the dead tooth with the root canal is like a sponge for pathogenic bacteria – the kind of bacteria that live without oxygen. It is simply impossible to clean out all bad bacteria in a root canal because there are literally hundreds, if not thousands, of microtubules in a dead tooth that cannot be reached.

My patient was adamantly opposed to amputating her teeth. She told me that as an actress, even a retired actress, she needed to keep those teeth in her mouth. Period. Choosing not to amputate left only two options: have the root canals redone or start injecting ozone. She chose the ozone injections. We took a bacterial count of her mouth and measured her biofilm to get a baseline reading.

After her first ozone treatment, we measured her oral bacterial count on a daily basis. By the 28th day, we saw the levels go back up again. She set up a schedule to come in every 30 to 40 days for ozone injections. Sometimes she would go 40 days, but other times she wouldn't make it even 30 days without the return of symptoms. She would fly in on a private jet, limo over to my office, spend a few hours getting ozone injections, and then off she would go. She had the means to do it and the commitment and this was her choice. Between treatments, she used a mouth rinse with ozonated oils and was on a lymphatic drainage program. She also went to a chiropractor to assist lymphatic drainage and followed a nutritional protocol to support her immune system.

It took more than ten appointments for my patient to make her final decision about the best approach to take. After about 10 months, I received an email stating that she had made the decision to have all the teeth with root canals removed. She explained that over the past 10 months, she experienced feeling like a different person right after ozone treatments. As the infection would come back, she witnessed herself change back to the other person. She liked the new person better. Her vanity aside as an actress, she wanted to be that other person. In addition, a grandchild came into her world who made a difference in her life. The joy from that baby made her want to focus on being around for as long as possible. She knew that the root canals were placing a constant stress on her immune system and she did not want to risk another bout of cancer.

With her permission and even enthusiasm, we safely removed all six infected root canals. The patient has remained cancer free.

Dentistry
ISSN: 2161-1122

Lechner and Baehr, Dentistry 2018, 8:3
DOI: 10.4172/2161-1122.1000476

Research Article Open Access

Impact of Endodontically Treated Teeth on Systemic Diseases

Johann Lechner[1*] and Volker von Baehr[2]

[1]Department of Integrative Dentistry, Grünwalder Str. 10A, 81547, München, Germany
[2]Department of Immunology and Allergology at the Institute for Medical Diagnostics in MVZ GbR, Nicolaistr 22, 12247, Berlin, Germany

Abstract

Background: This study compares the radiographic distribution of apical periodontitis (AP) in root-filled and endodontically treated teeth among healthy controls and patients with systemic diseases; the incidence of AP was almost twice as high in the latter group.

Objective: The question arises as to whether the biogenic amines (mercaptan/thioether/hydrogen sulfide) originating from endodontically treated teeth have systemic, subtoxic and immunological effects. Method: In order to determine this, local hydrogen sulfide measurements of endodontically treated teeth were combined with the laboratory serum analyses of modified proteins to assess the relationship of these compounds with type IV immune reactions.

Results: It was found that 42.5% of the group with systemic diseases showed immunological disturbance as a result of root-filled teeth. Furthermore, the presence of AP was almost three times higher than in the control group (17.2% versus 5.9%, respectively).

Conclusion: In summary, the data demonstrates that local pathologies caused by endodontically treated teeth may increase immunological and systemic dysfunction.

Keywords: Endodontic treatment; Root filling; Mercaptan/Thioethers; Systemic diseases

Abbreviations: AP: Apical Periodontitis; HC: Healthy Control; IFN-Γ: Interferon Gamma; IL-10: Interleukin-10; Rft: Root-Filled Tooth/Teeth; Syd: Systemic Disease; Vhc: Volatile Hydrogen Compounds; Vshci: Volatile Sulfur Hydrogen Compounds Indicator

Background

Dentists have learned to treat inflamed and necrotic teeth with root fillings and various endodontic procedures have been developed for this purpose. Those in support of root canal therapy generally hold the view that such procedures are safe and successful, provided that the patient has no complaints concerning pain or problems with their bite. This view is further supported when radiographs show no sign of an inflammatory reaction. Those in favour of root canal treatment contend that with modern treatment methods any systemic immunological effects of root-filled teeth (RfT) can be avoided. However, inflammation only becomes apparent in X-ray images when associated with bone and tissue degradation. The available scientific evidence also indicates that diabetes is significantly associated with a higher prevalence of periapical radiolucencies in endodontically treated teeth [1]. Conversely, critics of root canals hold the view that they may contribute to immunologically based diseases and consider X-ray imaging to be insufficient to determine the possible systemic effects of toxins derived from root fillings. They contend that bacteria and other pathogens can survive in endodontically treated teeth and their metabolic products - mercaptan and thioethers - can produce immunological and subtoxic effects.

AP is a chronic inflammatory disorder of the periradicular tissues caused by bacterial invasion at the apex of the tooth root [2]. Evidence from epidemiologic studies suggests that the association between AP and various diseases is not new as shown in numerous publications [3]. For example, apical infections like AP are associated with increased rates of myocardial infarction, with acute coronary syndromes occurring 2.7 times more frequently in those patients with such infections [3], as well as clinical depression, increased severity of depression and a reduced quality of life [4]. Increased translocation of gram-negative bacteria may also be associated with AP [5,6]. AP causes not only local inflammatory tissue destruction but also systemic inflammatory responses which may ultimately predispose an individual to systemic disease, including cardiovascular disorders [7-9]. A study on a total of 248 patients after acute myocardial infarction and 249 healthy controls underline that patients, who have experienced a myocardial infarction, had more missing teeth and a higher number of inflammatory processes, especially of endodontic origin, than healthy patients [10]. Subjects presenting lesions of endodontic origin or pulpal inflammation had an increased risk of developing coronary heart disease. Chronic oral diseases may be an unconventional risk factor for coronary heart disease [11]. The value for the total amount of bacterial DNA in in the coronary plaque was 16 times higher than that found in their blood samples. Bacterial DNA typical for endodontic infection, mainly oral viridans streptococci, was measured in 78.2% of thrombi, and periodontal pathogens were measured in 34.7%. Dental infection and oral bacteria, especially viridans streptococci, may be associated with the development of acute coronary thrombosis [12]. There is also a significant association between periodontitis and depression [13]. However, there is no data as to whether sulfur hydrogen levels in the root canals of patients with AP may be associated with systemic and immunological diseases. The study presented herein is one of the first to statistically link a patient group with multiple systemic and immunological diseases with endotoxin levels originating from AP. This study showed that there were significantly increased root canal endotoxin levels in patients with AP in comparison with healthy controls

***Corresponding author:** Johann Lechner, Head of Clinic Integrative Dentistry Munich Gruenwalder Str. 10A, 81547 Muenchen, Germany, Tel: 0049-89-6970129; Fax: +49-89-6925830; E-mail: drlechner@aol.com

Received March 05, 2018; **Accepted** March 23, 2018; **Published** March 31, 2018

Citation: Lechner J, Baehr Vv (2018) Impact of Endodontically Treated Teeth on Systemic Diseases. Dentistry 8: 476. doi:10.4172/2161-1122.1000476

(HCs) without periodontitis. The link between AP and increased root canal endotoxin levels may explain previous findings that inflammation in periodontal disease is mediated by macrophage proinflammatory cytokines [14,15]. Increased endotoxin levels activate the toll-like receptor TLR 2/4, thereby increasing inflammatory responses leading to macrophage activation [16].

Study Objective

The aim of the present study was to determine the extent to which X-ray imaging may be used to identify conspicuous and inflammatory reactions in the case of AP in a group of 98 patients with chronic systemic immunological disorders. The results were compared with a second patient group recruited from a university research subject pool; these individuals showed no evidence of any comparable systemic diseases [3].

Materials and Methods

Patient cohort with systemic diseases

This study is a retrospective case-control study that obtained approval waiver by the accredited IMD-Berlin Forensic Institute (DIN EN 15189/DIN EN 17025). All patients provided their written informed consent. The following factors were identified for each patient: age, sex and number of remaining teeth, (excluding the third molars). The sample population in our retrospective cross-sectional study consisted of 98 adult patients (m=45; f=53; average age (years): 54; range (years): 27-75) with a total of 1,783 teeth. On average, each patient in our sample had 18.2 teeth.

All patients underwent medically necessary radiographic examinations of their teeth. The inclusion criterion was the presence of a systemic disease (SyD). Those patients with such a disease were subject to an investigation for AP associated inflammation using three-dimensional (3D) digital volume tomography (DVT) respectively cone beam computed tomography (CBCT). All patients were referred to our practice by treating specialists. The patient group with SyD comprised the following: seven patients with various tumor-related diseases, (two with prostate cancer, two with colorectal cancer and three with breast cancer); 32 patients with chronic fatigue syndrome and systemic immunological exhaustion; 19 patients with rheumatoid complaints; nine patients with degenerative neurological diseases, (four with multiple sclerosis, three with amyotrophic lateral sclerosis and two with Parkinson's disease); 18 patients with atypical facial pain and trigeminal neuralgia; and 12 patients with various intestinal symptoms which may indicate systemic disorders or diseases as yet undiagnosed. The predominant exclusion criteria was bleeding at the gingival margin and/or inflammation of the periodontal socket for two reasons: (i) paper pins used to test for Thio/Merc outgas would be colored red and thus falsify the toxin measurement of the volatile sulfur hydrogen compounds indicator (vSHCI); and (ii) any remaining anaerobic bacteria in the socket may also produce vSHC and thereby falsify the measurement of outgas from root canals.

Investigations with CBTC/DVT

For each tooth the presence of AP and the quality of each root filling were assessed using 3D-DVT/CBCT. This medical imaging technique was selected, rather than two-dimensional orthopantomography (2D-OPG), since a large number of scientific publications examining the problems associated with X-ray diagnostics show that periapical radiographs - the most commonly used method are unsuitable for assessing the success of endodontic treatment. The latter imaging technique is only two dimensional and thus may not provide the necessary information on the orthogonal planes [17]. There are several well-known limitations of 2D-OPG which have been scientifically proven: apical changes cannot be reliably assessed with 2D-OPG and 34% of Aps are not identified [18]. Furthermore, endodontists were found to fail to see at least one root canal in 40% of molar teeth. Thus, one-third to one-half of all 2D-OPG scans are insufficient for dental diagnostics [19]. In dental practice the structure of the jawbone is generally assessed using 2D-OPG, particularly in instances of cortical bone damage. However, as previously shown, there are considerable limitations in the assessment of cancellous bone which must be considered [19-21]. Despite the recent advances in digital X-ray technology and improved imaging modalities, the limitations of imaging cancellous bone persist [22].

Figure 1 demonstrates the critical importance of using both 2D-OPG and 3D-DVT/CBCT to investigate endodontically treated teeth and make a complete diagnosis. Although AP is clearly visible at the mesiobucal root using 3D-DVT/CBCT, the 2D-OPG image is inconspicuous. Following removal of the crown, the dentine was clearly markedly colored by biogenic amines (right panel) which diffuse into the periodontal socket of the tooth and can be made visible using a volatile hydrogen sulfide indicator.

DVT Investigation for systemic diseases

Each patient in our study was X-rayed between February 1, 2016 and June 30, 2016 using 2D-OPG and 3D-DVT/ CBCT; only the CBCT scans were used in this evaluation. CBCT scans were recorded using the KODAK 9000 Extraoral Imaging System X-ray machine (KODAK, Rochester, NY, USA). Scans were evaluated in a darkened room using the KODAK Dental Imaging Software 6.12.11.0® on a 30-inch monitor with a resolution of 2560 x 1600 pixels (Dell 3008WFP; Dell Inc., Round Rock, TX, USA). Our evaluation criteria were based on those used in a comparative study on root fillings [3]. For AP, radiolucency was defined for the apical part of the root; the apical part was more than twice the width of the lateral part of the periodontal ligament De Moore et al. [3]. The patients were not screened for pre-existing periapical pathology before the roots were treated. In the case of multi-root teeth, the root was classified according to the root with the most severe AP. Endodontically treated or root-filled teeth (RfT) were presumed to contain a radiopaque material in the root canals. An root filling was considered to be adequate when it was contained within the tooth, it was not more than 2 mm from the radiographic root tip and no visible cavities were present. A root filling that was more than 2 mm from the radiographic tip containing cavities or where the apical foramen was

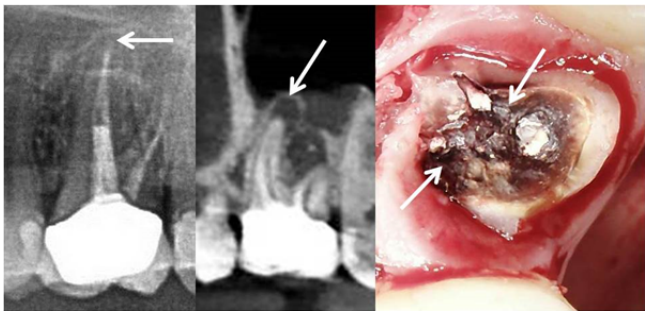


Figure 1: Comparison of two techniques: 2D-OPG and 3D-DVT/CBCT. 3D-DVT/CBCT clearly shows AP (centre panel) when compared to the 2D-OPG (left panel). Right panel shows dentine blackening caused by biogenic amines after removal of the crown.

overfilled was considered inadequate. In the case of multiple-root teeth, the root was categorized according to the most insufficient root filling (Loftus et al., 2005, Siqueira et al., 2005, Tavares et al., 2009, Kalender et al. 2013, Di Filippo et al., 2014) from [3].

Semiquantitative determination of volatile hydrogen sulfides in tooth sockets

The problem associated with the biogenic degradation of necrotized pulp has been extensively investigated and discussed in dentistry. Biogenic amines - like mercaptan, thioether, hydrogen sulfide, all of which are volatile hydrogen compounds (vHC) - have chronic subtoxic effects and their effects upon the immune system may be evident in endodontically treated teeth. A control X-ray image is typically standard practice and the only method used for the diagnostic assessment of RfT. However, X-ray scans are insufficient since chemically defined toxins cannot be visually identified [23,24]. We thus expanded our investigation to incorporate an additional evaluation criterion in order to semiquantitatively determine the presence of volatile hydrogen sulfide compounds [2]. With this chairside test, hydrogen sulfide can be displayed using a volatile sulfur hydrogen compounds indicator (vSHCI). The procedure is painless and simple to administer: a paper tip is inserted into the sulcus of the suspicious tooth and removed after one minute, whereupon it is inserted into the volatile compound reagent container. After 5 minutes, the staining of the reagent is read: the more hydrogen sulfide compounds present in the sample, the more the indicator liquid turns yellow. The scale of yellow intensity ranges from 0 (no load) to 5 (very strong load). The degree of coloration of the reagent may be used to semiquantitatively determine the amount of toxin that can be resorbed in the sulcus (Figure 2).

Determination of immunological sensitization by biogenic amines

To establish a possible relationship between conspicuous X-ray findings on DVT and the presence of disease, a blood test to assess immune system sensitization by biogenic amines was carried out in 73 patients. As was the case in a previously published study [24], the study investigated whether patients' blood cells secreted interferon gamma (IFN-γ) or interleukin (IL)-10 in vitro following contacts with biogenic amines, thereby establishing immunological sensitization. Lymphocytes and monocytes were isolated from the patients' blood by density gradient centrifugation. Thereafter, 1.2 × 106 cells were transferred and the monocytes primed to antigen-presenting cells with granulocyte-macrophage colony-stimulating factor (GM-CSF). Twenty-four hours after having added mercaptans/thioethers to the patients' cells, IFN-γ and IL-10 were analyzed in the cell culture supernatant.

Statistics

Statistical analysis was performed using IBM SPSS, version 19 (IBM Corporation, Armonk, NY, USA). All data was presented as a mean ± standard mean error. Data was considered significant where the value was <0.05.

Results

CBCT findings in the group of patients with systemic diseases. In 98 patients with SyD, a total of 1,783 teeth underwent CBCT. Of these, 324 teeth were endodontically treated (18.10%), while 323 of the endodontically treated teeth showed signs of AP (95.10%) (Figure 3 upper panel). Lower panel shows CBCT findings in the control group.

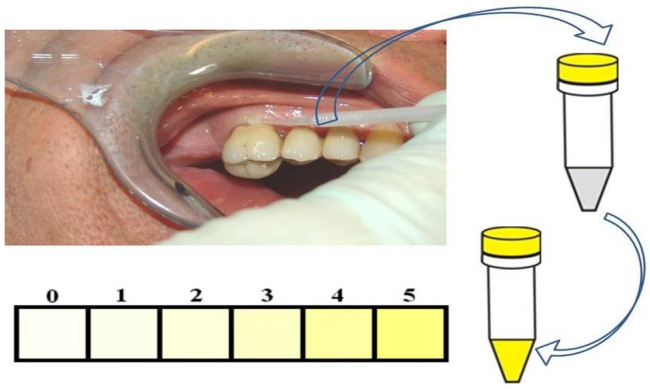


Figure 2: Semiquantitative determination of toxin intensity resorbed by the periodontal socket.

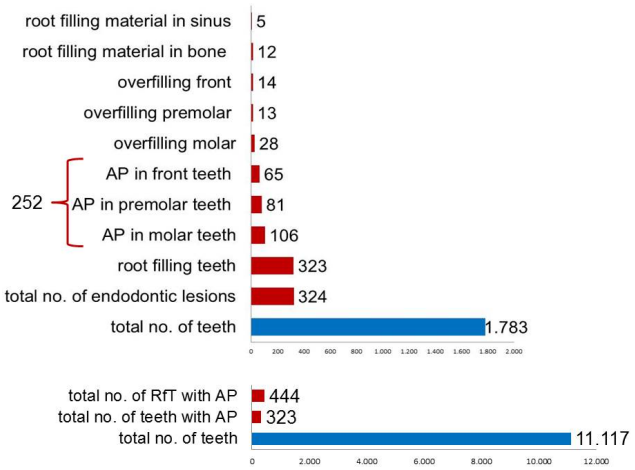


Figure 3: Upper panel shows CBCT findings in the group of patients with systemic diseases (n=98). Lower panel shows CBCT findings in the control group.

X-ray findings in the control groups

At the Leuven University Dental Clinic, 804 patients received a CBCT scan between January 1, 2013 and January 1, 2014. This cohort served as the control group. Control group was chosen from university research because of diagnostic and statistical reliability. The cited study was conducted in a general dental clinic and no SyD were documented for the cohort in which 631 scans of permanent dentition were evaluated with a total of 11.117 teeth [3]. The number of teeth in which AP was present was 656 and the number of RfT with AP was 444.

Intensity of the local excretion of biogenic amines in periodontal sockets

Toxin intensity was measured in 212 RfT of the SyD patient group - seven patients with different tumors, 32 with chronic fatigue syndrome, 19 with rheumatoid complaints, nine with neurological degeneration, 18 with facial pain and trigeminal neuralgia, and 12 with various intestinal symptoms using a vSHCI; the cumulative average intensity was 681 (± 3.3 STDEV). This value corresponds to a grading based on

the 6-point scale employed in this study where scores ranged from 0 to 5 in ascending order of concentration; accordingly, a local toxin release of 3.21 was observed per RfT.

Sensitization of the immune system to biogenic toxins originating from endodontically treated teeth

In 73 of the 98 patients with SyD, an investigation was carried out to determine immunosensitization to tooth toxins. In 13 patients of the SyD cohort (m=7; f=6), a TH1-dominant cellular sensitization, which was identifiable due to elevated IFN-γ values, was observed. These patients had an average IFN-γ value of 39.9 IU/mL ± 4.17 STDEV (normal value: <0.10). An additional 18 patients of the SyD cohort (m=7; f=11) showed IL-10 induction which also indicated sensitization to tooth toxins. The mean value for IL-10 was 93.7 pg/mL ± 72.49 STDEV (normal value: <10.0). In summary, 31 of 73 patients (42.5%) showed signs of immunosensitization to vHC in association with the presence of RfT.

Discussion

The complexity and breadth of the possible causes of SyD require advanced scientific inquiry and investigation. Etiological factors are involved in system integration, such as polymorphisms, epigenetic factors, functional modulations, environmental influences and immunological engrams of the neuro-endocrine and immune systems [25] which are initially triggered and then repeatedly and uniformly released, even in the absence of the primary trigger. It is likely that advanced stages of chronic toxic stress disrupts normal homeostatic processes and this becomes progressively more difficult to reverse [26].

The relationship between endodontic measures and AP are presented and discussed in numerous publications [27-30]. The findings of four relevant studies may be summarized as follows: i) the prevalence of periradicular disorders in RfT remains high in Scottish populations [27]; ii) teeth with AP appear more frequently in patients with RfT than in those without, (39% versus 9%, respectively; P<0.001), and 25% of RfT displayed AP [28]; iii) the technical quality of root fillings in an adult Irish population was poor and consistent with the high prevalence of AP [29]; iv) there was a high incidence of AP in RfT – the total number of RfT was 93, and of these, 60 (64.5%) had AP [30].

To address the objective of this study, we employed a direct comparative study using as a healthy control group (HC) the cohort of 804 patients described in a study conducted in Belgium [3]. Using CBCT scans, the cohort was established as having RfT with AP: 631 CBCT scans of 11,117 permanent teeth were evaluated at the University Clinic of Leuven between January 1, 2013 and January 1, 2014 and no SyD were documented. A total of 656 teeth showed signs of AP, while AP was detected in 444 of RfT.

Data collection was carried out in both study series using DVT scans. In our comparison, the endodontic procedures in both groups were carried out according to the same European good clinical practice standards. Although more than six-fold teeth were examined in the control group (11.117/1.783), the number of cases of AP in the control group was only twice as large as that of the SyD group (656/307); moreover, the number of RfT in which AP was present was closely matched (444/307) (Figure 4a). When comparing the HC and SyD groups of those teeth examined, a ratio of 6:1 was found for RfT in the HC group; conversely, in the SyD group, the ratio of RfT was 4:1. Taking the number of X-rayed teeth of both groups as 100%, the following comparative results were found (Figure 4b):

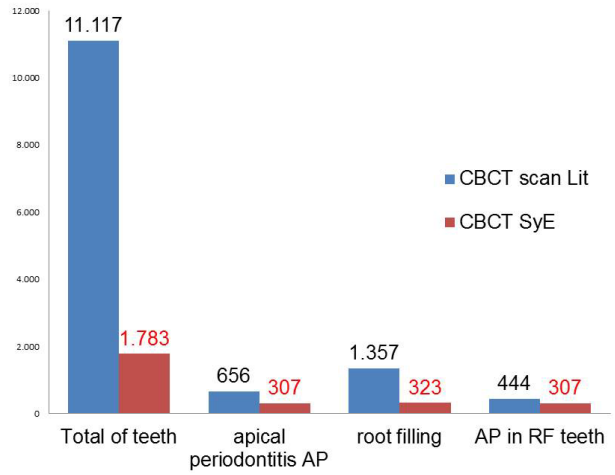


Figure 4a: Comparison of CBCT findings in total numbers of teeth in patients with systemic diseases (n=1.783 in red columns) and healthy controls (n= 11.117 in blue columns).

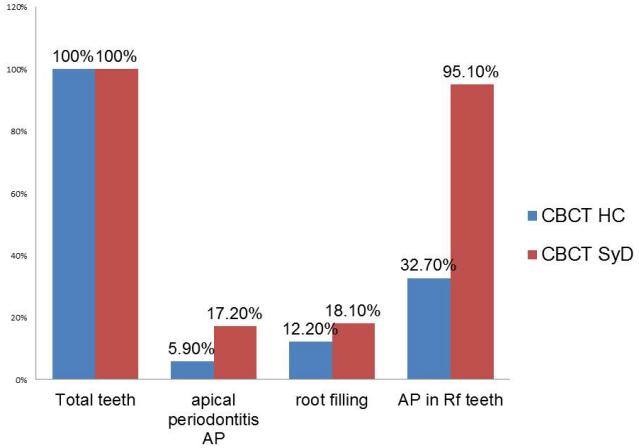


Figure 4b: Comparison of CBCT findings in teeth (n= 11.117) of healthy controls (blue columns) versus teeth of patients with systemic diseases (n= 1.783) as expressed in percentages.

Overall, the SyD group demonstrated an almost three times greater incidence of AP than the HC group (17.2% / 5.9%); AP was evident in 95.1% of RfT in the SyD group, while a rate of only 32.7% was observed in the HC group indicating a triple-fold increase of AP in those patients with SyD. The number of RfT in patients with SyD was only slightly higher than that of the HC group (18.1% / 12.2%).

In the group of patients with SyD, the prevalence of AP was higher than in other epidemiological studies [27-30]. At the same time, the number of RfT showing signs of AP in patients with SyD was three times greater than in the healthy control group.

Discussion of the semiquantitative determination of volatile hydrogen sulfide in periodontal sockets

The field of modern endodontics is aware of the problem of bacterial colonization in the dentine tubules and new procedures are constantly being developed to minimize this problem and any possible associated risks. To date, scientific methods for detecting bacterially produced

toxins have been lacking. Their detection by toxin measurements provide a well-supported answer to the question of whether a RfT in those patients with SyD should be removed or whether it should be revised and refilled, even in the absence of radiographic changes. It is known from numerous publications [31-33] that biogenic amines (mercaptan/thioether/hydrogen sulfide) may emerge from RfT thereby triggering chronic subtoxic and, in turn, systemic and immunological effects. Some of the most well-known studies have presented the comparison between radiographic and histological findings at the root tips of RfT postmortem. For instance, of 19 recorded findings, five (26%) appeared to be radiographically inconspicuous but, nevertheless, showed histological signs of inflammation [34]. The authors of the study state that "these areas often contained bacteria and inflamed or necrotic tissue, although the root canal filling was radiographically impeccable. Moreover, not all periradicular inflammations are radiologically diagnosable and a high percentage are asymptomatic" [35]. The results from additional studies confirmed that AP was present in at least half of the samples; in some cases, inflammation in the periapical tissue area was detected only 30 months after the initial procedure. The findings of these studies are consistent with those of Brynolf (Odontol. Rev., 1967) which reported that only 7% of endodontically treated teeth healed completely. In eight of the 14 samples (57%), filling material was found beyond the apex. These overfillings regularly caused an inflammatory response [36]. Since anaerobic bacteria from AP produce the cleavage product of L-methionine using 2-ketobutyrate as a source of energy [24], they also produce various types of endo- and exotoxins that act as exogenous pyrogens or cause intoxication in the body. These toxins include thioether/mercaptan from the tooth cavity in each RfT. It is important to note that a vSHCI may also be used to detect systemic immunological relationships between volatile reagents and AP [24]. The results that were obtained after using the vSHCI were documented per tooth and rated on an intensity grading scale ranging from 0–5. This method was employed for 212 teeth of patients from the 97 patients in our study. In "Bacterial invasion in the dentinal tubules of human vital and nonvital teeth", Nagaoka et al. [36] reported that in vital teeth with fillings that were exposed for more than 150 days, 1.1% of the dentin tubules were infected with bacteria, whereas in the case of nonvital RfT, 39.0% of the tubules were infected with bacteria.

The systemic immunological role of thioether compounds

Since our investigations show an immunological sensitization to RfT in 42.5% of patients with SyD, it may be concluded that a type IV immune response to modified proteins may be involved in the pathogenesis of such diseases. In sensitized patients, inflammatory cells – primarily lymphocytes – are activated which can cause both local and systemic reactions and the degradation products of biogenic amines may serve as an effective trigger in those patients which test positively for SyD. Figure 5 shows two examples of laboratory findings that were obtained from the group of patients with SyD. A positive result indicates not only that a load was, or is, present but also that mercaptane/thioether-specific TH1 lymphocytes are present in the peripheral blood which can cause inflammation triggered by mercaptane/thioether IFN-γ stimulation (upper panel). Positive IL-10 results are indicative of the mercaptane/thioether-induced activation of immunosuppressive cells, (inhibited immune defense). In Figure 5, the first patient was diagnosed with rheumatoid arthritis, while the second was diagnosed with breast

Reactivity on mercaptan/thioether

IFN-γ stimulated	3.2	IU/mL	< 0.3
IL-10 stimulated	< 10.0	pg/mL	< 10

Interpretation:
The TH1-dominant cytokine response to the protein degradation products metacarpan and thioether. Thus, this finding may indicate the presence of a local or systemic inflammatory reaction.

Reactivity on mercaptan/thioether

IFN-γ stimulated	< 0.1	IU/mL	< 0.3
IL-10 stimulated	230.0	pg/mL	< 10

Interpretation:
The clear induction of the TH2 cytokine, IL-10, by the tested protein degradation products indicates existing cellular sensitization; however, the missing IFN-γ response (TH1) makes the presence of an associated local or systemic inflammatory reaction rather unlikely. We recommend a check at a distance of 2–3 weeks.

Figure 5: Two examples of laboratory findings in two patients diagnosed with rheumatoid arthritis and breast cancer, respectively.

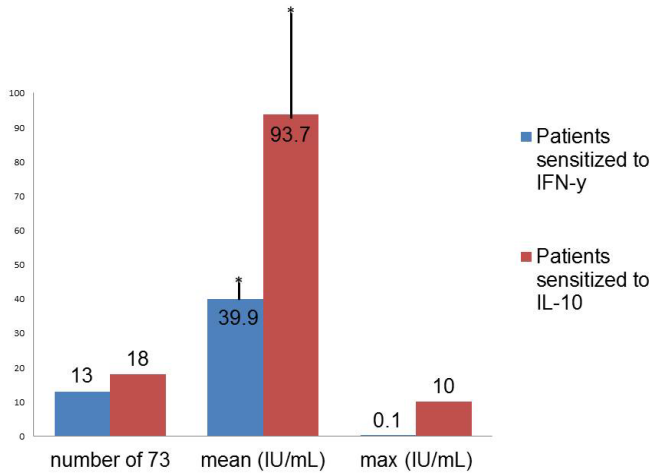


Figure 6: Immunosensitization to vHC in 73 patients of the SyD cohort separated in IFNγ and in IL-10 stimulation.

	Standard	Toxicity Focused Approach
x-ray	+++	++
painless	++	+
absence of bite pressure	+	+
Evaluation of local toxins	-	+++
Syst./immun. sensitization toxins	-	++

Grading of evaluation criteria for successful endodontical treatment:

+++ most important; ++ important; + less important; - non-existent

Figure 7: Evaluation criteria to determine the success of endodontic treatment according to standard practice versus a local and systemic toxicity focused approach.

cancer. Figure 6 shows the immunosensitization to vHC in 73 patients of the SyD cohort separated in IFN-γ and in IL-10 stimulation.

Overview of clinical and diagnostic tools

The panel in Figure 7 compares the different evaluation criteria for successful endodontic treatment in standard dentistry and presents a further developed systemic approach. While the measurement of local vHC on RfT with a vSHCI in standard dental practice for the "successful evaluation" of endodontic treatment is uncommon, the link of such vHC to SyD may be established readily with an immunosensitization test performed by a specialised laboratory.

Conclusion

The present study is among the first to focus on the relationship between radiographically visible pathologies in the dental or jawbone region and the presence of SyD. The data presented here do not prove a cause and effect relation. It could be that the patients demonstrated increased AP due the presence of systemic conditions; an interaction of the systemic conditions vice versa cannot be excluded. Notwithstanding the evidence, the consensus is APs are chronic inflammatory processes and triggering conditions in advance of occurring immune diseases. The comparison made between the HC and SyD groups provides the first indication of the possible connections between RfT and SyD, and indicates that endodontically treated and RfT: (i) may enhance immunological and systemic disturbances, and (ii) may be involved in the development of SyD or vice versa, that is, the presence of SyD may influence in some way local inflammatory reactions such as AP. High local H2S values with the reagent as well as a high frequency of immunosensitization to biogenic amines in patients with SyD amplify this relationship. In view of the increasing prevalence of immune system diseases, widespread endodontic measures used in dentistry should either be assessed more critically or classified as "successful/unsuccessful" with reference to additional measurement methods. For practitioners, the semiquantitative, local measurement of volatile compounds, (such as hydrogen sulfide) *1, as well as systemic studies on the sensitization of the immune system by biogenic amines (thioether/mercaptans) via increased IL-10 and IFN-γ are proposed. More broadly, practitioners performing endodontic procedures should be aware of the relationship between the outcome of endodontic treatment and systemic diseases.

Conflict of Interest

There is no conflict of interest.

Acknowledgments

English-language translation and editing of this manuscript were provided by Ilaria Floris. Additional editing was provided by Natasha Gabriel.

References

1. Segura-Egea Jj, Martín-González J, Castellanos-Cosano L (2015) Endodontic medicine: connections between apical periodontitis and systemic diseases. Int Endod J 48: 933-951.
2. Nair PNR (2006) On the causes of persistent apical periodontitis: a review. Int Endod J 39: 249-281
3. Van der Veken D, Curvers F, Fieuws S, Lambrechts P (2016) Prevalence of apical periodontitis and root filled teeth in a Belgian subpopulation found on CBCT images. International Endodontic Journal 50: 317-329.
4. Gomes C, Martinho FC, Barbosa DS, Antunes LS, Póvoa HCC, et al. (2017) Increased Root Canal Endotoxin Levels are Associated with Chronic Apical Periodontitis, Increased Oxidative and Nitrosative Stress, Major Depression, Severity of Depression, and a Lowered Quality of Life. Molecular Neurobiology Springer Nature 55: 2814-27.
5. Berk M, Williams LJ, Jacka FN, O'Neil A, Pasco JA, et al. (2013) So depression is an inflammatory disease, but where does the inflam- mation come from? BMC Med 11: 1-16.
6. Herath TD, Darveau RP, Seneviratne CJ, Wang CY, Wang Y, et al. (2016) Heterogeneous Porphyromonas gingivalis LPS modulates immuno-inflammatory response, antioxidant defense and cytoskeletal dynamics in human gingival fibroblasts. Scientific Reports 6: 1-15.
7. Socransky SS, Haffajee AD (2000) Periodontal microbial ecology. Periodontol 38: 135-187
8. Amar S, Han X (2003) The impact of periodontal infection on systemic diseases. Med Sci Monit 9: 291-299.
9. Kinane DF, Lowe G (2000) How periodontal disease may contribute to cardiovascular disease. Periodontol 23: 121-126.
10. Willershausen I, Weyer V, Peter M, Weichert C, Kasaj A, et al. (2014) Association between chronic periodontal and apical inflammation and acute myocardial infarction. Odontology 102: 297-302.
11. Pasqualini D, Bergandi L, Palumbo L, Borraccino A, Dambra V, et al. (2012) Association among Oral Health, Apical Periodontitis, CD14 Polymorphisms, and Coronary Heart Disease in Middle-aged Adults. Journal of Endodontics. Elsevier BV 38: 1570-1577.
12. Pessi T, Karhunen V, Karjalainen PP, Ylitalo A, Airaksinen JK, et al. (2013) Bacterial Signatures in Thrombus Aspirates of Patients With Myocardial Infarction. Circulation Ovid Technologies (Wolters Kluwer Health) 127: 1219-1228.
13. Kumar A, Kardkal A, Debnath S, Lakshminarayan J (2015) Association of periodontal health indicators and major depressive disorder in hospital outpatients. J Indian Soc Periodontol 19: 507-511.
14. Hasturk H, Kantarci A, Van Dyke TE (2012) Oral inflammatory diseases and systemic inflammation: role of the macrophage. Front Immunol 3: 118-138
15. Ara T, Kurata K, Hirai K, Uchihashi T, Uematsu T, et al. (2009) Human gingival fibroblasts are critical in sustaining inflammation in periodontal disease. J Periodont Res 44: 21-27
16. Lucas K, Maes M (2013) Role of the toll like receptor (TLR) radical cycle in chronic inflammation: possible treatments targeting the TLR4 pathway. Mol Neurobiol 48: 190-204.
17. Liljestrand JM, Mäntylä P, Paju S, Buhlin K, Kopra KAE, et al. (2016) Association of Endodontic Lesions with Coronary Artery Disease. Journal of Dental Research SAGE Publications 96: 234-234.
18. Patel S, Dawood A, Mannocci F, Wilson R, Pitt Ford (2009) Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. Int Endod J 42: 507-515.
19. Bumann A. Der aktuelle Stand bildgebender Verfahren¸ Wissenschaft und Fortbildung BZB November 09 59.
20. Schwartz SF, Foster JK (1971) Roentgenographic interpretation of experimentally produced bony lesions. I. Oral Surg 32: 606-612.
21. Ardran CM (1951) Bone destruction not demonstrable by radiograph. Br J Radiol 24:107.
22. Bender IB, Seltzer S (1961) Roentgenographic and direct observation of experimental lesions in bone. I and II. JADA 62: 152-160.
23. Birchwood G (1996) Osteoporotic bone. Understanding osteoporosis and its treatment: a guide for physicians and their patients. New York: The Parthenon Publishing Group 8-11.
24. Lechner J, von Baehr V (2015) Stimulation of proinflammatory cytokines by volatile sulfur compounds in endodontically treated teeth. Int J Gen Med 9: 109-118.
25. Kirkpatrick CJ, Fuchs S, Peters K, Brochhausen C, Hermanns MI, et al. (2006) Visions for regenerative medicine: interface between scientific fact and science fiction. Artificial Organs 30: 822-827.
26. Godin PJ, Buchman TG (1996) Uncoupling of biological oscillators: a complementary hypothesis concerning the pathogenesis of multiple organ dysfunction syndrome. Crit Care Med 24: 1107-1116.
27. Dutta A, Smith-Jack F, Saunders WP (2014) Prevalence of periradicular periodontitis in a Scottish subpopulation found on CBCT images. International Endodontic Journal 47: 854-863.

28. Huumonen S, Suominen AL, Vehkalahti MM (2016) Prevalence of apical periodontitis in root filled teeth: findings from a nationwide survey in Finland. International Endodontic Journal 50: 229-226.

29. Loftus JJ, Keating AP, McCartan BE (2005) Periapical status and quality of endodontic treatment in an adult Irish population. International Endodontic Journal 38: 81-86.

30. Segura-Egea JJ, Jiménez-Pinzón A, Poyato-Ferrera M, Velasco-Ortega E, Ríos-Santos JV (2004) Periapical status and quality of root fillings and coronal restorations in an adult Spanish population. International Endodontic Journal 37: 525-530.

31. Claesson R, Edlund MB, Persson S, Carlsson J (1990) Production of volatile sulfur compounds by various Fusobacterium species. Oral Microbiology and Immunology. Wiley-Blackwell 5:137-142.

32. Carbonero F, Benefiel AC, Alizadeh-Ghamsari AH, Gaskins HR (2012) Microbial pathways in colonic sulfur metabolism and links with health and disease. Front Physiol 3:448.

33. Attene-Ramos MS, Wagner ED, Plewa MJ (2006) Evidence that hydrogen sulfide is a genotoxic agent. Mol Cancer Res 4: 9-14.

34. Green T, Walton R, Taylor J, Merrell P (1997) RadiographicRadiographic and histological periapical findings of root canal treated teeth in cadaver. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 83:707-711.

35. Piannotti R, Lachette S, Dills S (1986) Desulfuration of cysteine and methionine by Fusobacterium nucleatum J Dent Res 65: 913-917.

36. Nagaoka S, Miyazaki Y, Liu H-J, Iwamoto Y, Kitano M , et al. (1995) Bacterial Invasion into Dentinal Tubules of Human Vital and Nonvital Teeth; Journal of Endodontics 21: 70-73.

YOU NOW NEED TO TAKE THE UNIT 9 TEST AT https://www.cvent.com/d/2vq54j.

IT IS AN OPEN BOOK TEST AND CONSISTS OF 25 QUESTIONS. YOUR SCORE WILL BE AUTOMATICALLY CALCULATED AND SENT TO YOU VIA EMAIL.

UPON COMPLETION OF THE UNIT 9 TEST, YOU WILL NEED TO CONTINUE WITH THE REST OF THE ACCREDITATION REQUIREMENTS. ACCESS THE MATERIALS FOR UNIT 10 BY USING THE LINK TO THE IAOMT COURSE PDFs AT https://iaomt.org/accreditation-materials/.